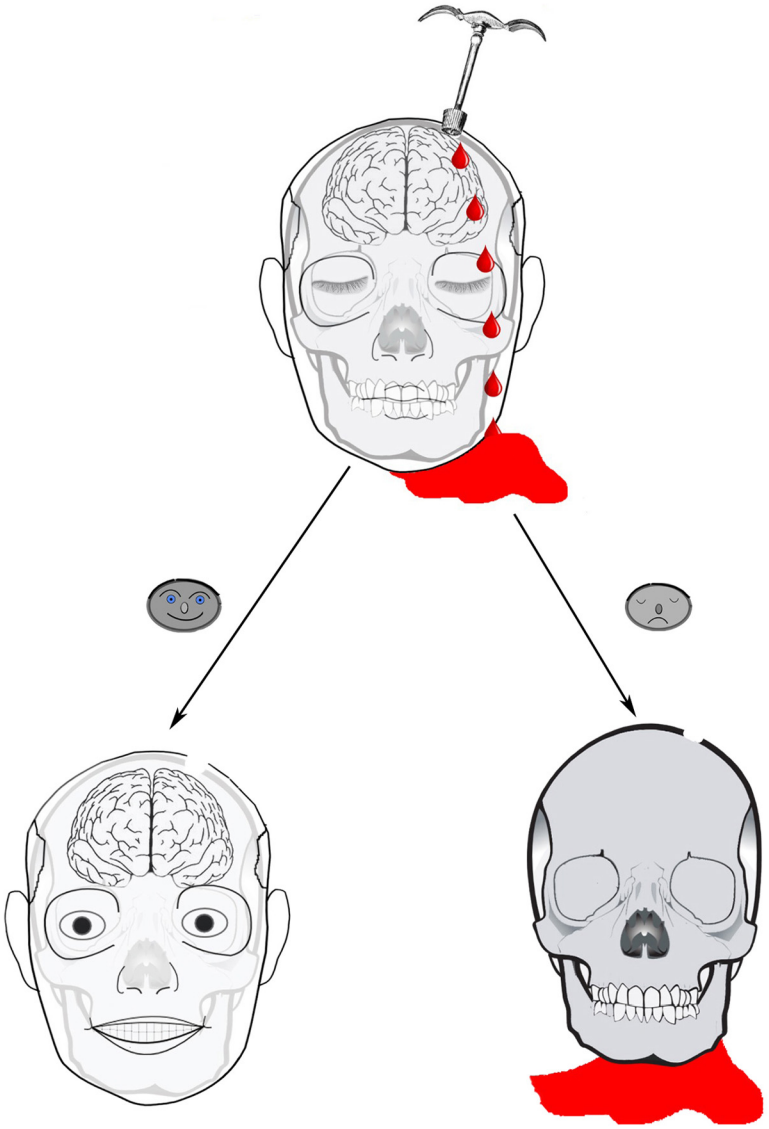
Neurosurgery before Science

Taking A Chance



Jeremy C. Ganz

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By

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PREFACE

There are many books in which the history of surgery is either the sole topic or is part of a more general history of medicine. Surgery involves skill, risk, pain, and frustration. It has been both desired and feared and there have been concerns about maintaining standards and regulation. This book is concerned with the evolution of cranial surgery from ancient times to the beginning of the nineteenth century when modern safe surgery developed. Some of the topics concern the cranium alone reflecting the author's area of experience. Some affect the whole body of which the cranium is a part. The preparation for this book has made the author aware of two characteristics of surgery. The first is, no matter how much effort is put into controlling it and limiting it, there remains a spark of curiosity which returns to maintain and improve it. The second in contrast with the first is the perpetual desire for the safety of rejecting what is new and clinging to what is known.

Over and above the successes and errors in surgery's struggle to survive and improve there has been another area of confusion. This has been retrospective and concerns the interpretation of the past through the prism of the present. It did not affect the past while it was happening but has distorted our current understanding of the past. It mainly applies to infection which was such an unavoidable complication of surgery prior to antisepsis and asepsis.

The earliest part of the book traces the origins of surgical practice and training from pre-history and Ancient Egypt up to the end of the Roman Empire. This is followed by material about the changing priorities and patterns of practice from the Middle Ages to the late eighteenth century. The final section of the book deals with specific topics some of general and some of neurosurgical interest to outline the quirkiness of the development of our understanding.

Writing this book has emphasised for the author the importance of Claude Bernard's statement that:

> "Man is by Nature metaphysical and proud'. He has gone so far as to think that the idealistic creations of his mind, which correspond to his feelings, also represent reality".

This is realistic but negative because the persistence of surgery in spite of Bernard's characterisation reflects the words of Robert Browning:

"Ah but a man's reach must exceed his grasp or what's a heaven for?".

This book is concerned with the interplay between these two behaviour patterns of safety and adventure. It is hoped the reader will find it as exciting and fascinating as has the author.

Finally, the book is not a sequential narrative. It considers a diversity of factors which influenced the practice of pre-scientific surgery. Each chapter is a short essay on different influences which affected the evolving practice of surgery and in particular neurosurgery. As each chapter can be read as an isolated essay, there is inevitably some repetition. The text is very much from the point of view of a surgeon rather than an historian. The author fully realises the book lacks the historical authority required by the use of primary sources. On the other hand, it is hoped that insights arising from a lifetime of experience as a surgeon may also prove of value.

ACKNOWLEDGEMENTS

During the course of preparing this text the author has had the benefit of seeking the advice of two leading experts in the field. Professor Vivian Nutton has been most generous with advice about the history of surgery. Professor Michael McVaugh has also been quick with advice about the medieval surgeons concerning whom he is perhaps the leading expert in the world. It should be emphasised that any residual errors in the text are the sole responsibility of the author. Also, the author is at best an amateur historian and is grateful to Professor Sir Geoffrey Lloyd for his consistent encouragement.

Most importantly the author wishes to express his gratitude to his wife Annie Gao without whose patience and support no book would have been possible.

CHAPTER 1

WHAT MAKES A SURGEON?

Introduction

The Oddity which is Surgery.

Nobody wants an operation if it may be avoided. The possibility of pain free surgery has only been available for just over 170 years. The techniques for controlling infection following surgery have only been available for just over 150 years. Yet surgery antedates literacy with evidence that it has been carried out since 10,000 BC (Rose 2003). From that time on, virtually every society of which we are aware has engaged in surgery. With even the speediest and most superficial consideration this is odd. It means that for all of history and before history, people were prepared to undergo painful procedures of dubious therapeutic worth and accompanied by many complications. Yet, beyond question, that is what happened, and it remains inexplicable. It is not the purpose of this book to try and explain the inexplicable. Instead, it is proposed that examination of the changing reality of the surgical profession and how they coped with the many difficulties of their practice may at least expand our understanding of one of the strangest aspects of human behaviour.

Before Hippocrates

The oldest evidence of surgery is provided by the numerous trepanned skulls dug up in many countries around the world. In many cases they came from a time prior to literacy so there is no means of knowing what gave someone the right to drill holes in other people's heads. Moreover, there is no evidence from these skulls which unequivocally show why the operations were performed. The Egyptian Edwin Smith papyrus describes surgical cases showing a sensible grasp of anatomy and reasonable suggestions on how to treat patients. However, the language of the papyrus would not be available outside Ancient Egypt until Breasted's translation in 1930 (Breasted 1992). It would thus have no influence on the development

of surgery in subsequent millennia. It also gave no clue as to the path the authors of the papyrus had taken to become in a position to manage injured patients.

Classical Times

Hippocrates ca. 460 BC – ca. 370 BC

Hippocrates, the Father of Medicine, was the son and grandson of physicians, known as Asklepiads because they followed the teachings of Asklepios, the Greek god of medicine who was possibly a real person around 1250 B.C. (Singer and Underwood 1963). However, there is no record of how Hippocrates came to be accepted as an independent practitioner. He advised that physicians should be exemplary citizens in all ways. In his time medicine and surgery were undertaken by the same individual and he made no separate annotation of the qualities required of a surgeon. In 'The Physician' he specified the requirements for a clinician in the opening paragraph.

> "The dignity of a physician requires that he should look healthy, and as plump as nature intended him to be for the common crowd consider those who are not of this excellent bodily condition to be unable to take care of others. Then he must be clean in person, well dressed, and anointed with sweet-smelling unguents that are beyond suspicion. For all these things are pleasing to people who are ill, and he must pay attention to this. In matters of the mind, let him be prudent, not only with regard to silence, but also in having a great regularity of life, since this is very important in respect of reputation; he must be a gentleman in character, and being this he must be grave and kind to all." (Hippocrates 1995a).

There is advice in this text on details of operative technique.

> "Where surgery is performed by a single incision, you must make it a quick one; for since the person being cut usually suffers pain, the suffering should last for the least time possible…. When many incisions are necessary, you must employ a slow surgery for a surgeon that was fast would make the pain sustained and great, whereas intervals provide a break for the patients." (Hippocrates 1995a)

Nonetheless, there is another book in the Hippocratic Corpus entitled 'Surgery' (Hippocrates 1995b). This text contains practical advice for the surgeon's person and his behaviour in the operating room.

> "The nails should be neither longer nor shorter than the points of the fingers: and the surgeon should practice with the extremities of the fingers, the index-finger being usually turned to the thumb." (Hippocrates 1995b)

> "The operator whether seated or standing should be placed conveniently to himself, to the part being operated upon and to the light." (Hippocrates 1995b)

> "Operative requisites in the surgery; the patient; the operator; the assistants; the instruments; the light, where and how placed; their number which he uses how and where; the patient's person and the apparatus; time, manner and place" (Hippocrates 1995b).

There follow more details including how the patient and the assistants help to place and steady the patient during an operation. An assistant may present the surgeon with the required instruments. It may be mentioned that the largest part of the text on 'In the Surgery' is devoted to bandaging.

Thus, Hippocrates described in broad outline the social requirements for success in medicine. In addition, he described some of the requirements of the place where operations would be undertaken. He did not specify the personal qualities required by a surgeon as opposed to a physician.

Celsus (ca. 25 BC – ca. 50 AD)

There were a number of Roman men of substance who were teachers of medicine, but one towers above all the others; Aulus Cornelius Celsus. Little is known of his private circumstances, but his name indicates an aristocratic family, since the Cornelians were a most superior Roman House. He is famous to all medical students for being the first person to characterize inflammation. His description of rubor, calor, tumor and dolor holds good today. Celsus wrote a multi-volume encyclopaedia on agriculture, warfare, rhetoric, medicine, and jurisprudence. Only the text on medicine remains; 'De Medicina'. After his death it disappeared until the sixteenth century. There was an opinion expressed by Pliny the Elder not that long after Celsus' death. He stated: (Marganne and Sanchez 2014)

> "if medical treatises are written in a language other than Greek they have no prestige even among unlearned men ignorant of Greek, and if any should understand them they have less faith in them".

This may in part be the reason for the loss of Celsus' work. It may be assumed that Celsus was just as aware of the prestige of Greek as Pliny. He must have been conversant with Greek because of his familiarity with the

works of Hippocrates. It may be that he wrote in Latin to make his work more accessible to less well-educated Romans than himself. Whatever the reason, it is unfortunate given the quality of his writings that they remained unavailable until the fifteenth century. In 1478, De Medicina became the first medical text to be printed with the new printing press.

In the present context, it was Celsus who described the essential mental and physical characteristics required by would be surgeons. In translation the statement reads: (Celsus 1938)

> "Now a surgeon should be youthful or at any rate nearer youth than age; with a strong and steady hand which never trembles, and ready to use the left hand as well as the right; with vision sharp and clear, and spirit undaunted; filled with pity, so that he wishes to cure his patient, yet is not moved by his cries, to go too fast, or cut less than is necessary; but he does everything just as if the cries of pain cause him no emotion.".

This would inspire surgeons in later generations who quoted or paraphrased the above statement.

Galen (ca 130 AD – ca 210 AD)

There is plentiful evidence of Galen's expertise as a surgeon. He had a lengthy education including time in Alexandria. It is well known that his first clinical appointment was in Pergamum where he was employed to treat the injuries sustained by gladiators. Nutton suggests that this appointment could partly have been the result of his contact network amongst distinguished citizens known to his family but that Galen's expertise in surgery was also important (Nutton 2013). He characteristically boasted of how the mortality amongst gladiators fell after he was put in charge of treating their injuries (Mattern 2013). However, the greatest evidence of his skill has to be his physiological experiments as detailed in 'Galen on Anatomical Procedures' and 'Galen on Anatomical Procedures, The Later Books' (Galen 1956, 2010). His vivisections illuminated with sunlight alone and with no modern methods of haemostasis available are little short of miraculous. Nonetheless, he regarded the surgery of patients as a last resort and only to be undertaken when all else failed. Despite his surgical skill he remained a physician at heart. As Nutton puts it:

> "After all, the best physician was the one most capable of treating surgical conditions by means other than the knife, and particularly by diet and drugs" (Nutton 2013).

To date no statement of Galen's has been found about what was required of a surgeon equivalent to the statements of Hippocrates and Celsus.

Paul Ægineta (ca.625 – ca.690)

It was a Christian empire into which Paul Ægineta was born in around 625 AD on the island of Ægina, just over 30 km south of Athens in the Saronic Gulf, which was within the Byzantine Empire (see figure 1.1). Paul was a physician and surgeon of both great repute and seemingly great skill. It is thought he was educated and worked in Alexandria in Egypt. He did not add new concepts to the teaching of the Ancients. Nonetheless, he assembled a large medical text which is noteworthy for its clarity and simplicity of expression. It is largely influenced by Hippocrates and Galen. What Paul wrote was essentially an encyclopaedia about medicine and surgery: since the same person was still both physician and surgeon.

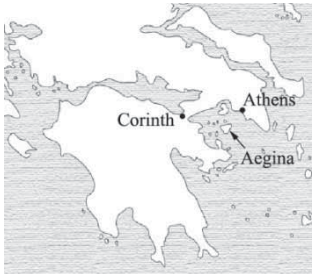

Figure 1.1
A map of the outline of Greece showing where Paul Ægineta came from

Paul's work would be immensely influential in the years to come. He provided elegant descriptions of situations where surgery was required and in addition the techniques involved. He did not however make any statement on what qualities were necessary for a person wishing to practise surgery.

Medieval Surgery

The Roman Empire in its last years was a vehicle for the spread of Christianity. When it disintegrated the Christian church survived and would slowly evolve into the institution responsible for academic pursuits. These inevitably became coloured by the prime requirement of the Church which was obedience to the tenets of the religion it subserved. An authoritarian religion is not the best background for innovative thought which rather died out for a few centuries. However, it could not be extinguished for ever and with regard to surgery it began to re-merge in the tenth century. The first of the new authors was Albucasis.

Albucasis (936 – 1013)

Figure 1.2
Map of Spain showing Cordova's location.

Abū al-Qāsim Khalaf ibn al-'Abbās az-Zahrāwī known as Albucasis was born, lived and died near Cordova in Spain (see figure 1.2). He wrote the first textbook limited to surgery alone. His book was also unique in having the first illustrations of surgical instruments, even if the illustrations are not really very helpful (see figure 1.3). It may be mentioned that for Albucasis the working end of the instrument was the source of his focus (Wangensteen 1974). Albucasis began his text with a comment on the fallen status of his profession (Albucasis 1973a).

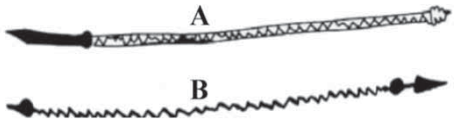

Figure 1.3
This shows the limited value of the illustrations. 'A' represents a chisel and B represents a drill.

> "After finishing for you, my sons, this book which is the part of knowledge dealing with medicine in its entirety; and having made it as clear and explicit as possible, I thought it well to complete it for you by adding this treatise which concerns surgical operating. For the skilled practitioner of operative surgery is totally lacking in our land and time; so that the knowledge of it is on the point of being blotted out and it remains lost; and there is nothing left of it except a few traces in the books of the Ancients; where, however, it has been so corrupted by the hands of scribes, and subjected to error and confusion, that its meaning has become obscured and its value diminished. Therefore I decided to revive this art by expounding, elucidating, and epitomizing it in this treatise; and to present the forms of the cauterizing irons and other operative instruments, since this is an adjunct to explanation and a vital necessity."

He was thus the first to comment on what would become an important element in the development of the profession of surgery, lost status. He did not comment on the qualities required of a surgeon. Nonetheless, his book

had great influence so that three centuries later another distinguished surgeon, Guy de Chauliac quoted him (Chauliac 2007a).

Another two centuries would pass before new studies in surgery began to emerge. There was however a change in emphasis concerning what mattered to these 'modern' surgeons. Over and above their clinical work, the main concern was the need for a formal academic education which was worthy of a study such as medicine and which required books as part of the learning process. They were united in their criticism of practitioners who did not meet these fine standards to whom they applied the unpleasant epithet '*ydioti*'. The period under advisement was the time when universities and hospitals were being founded. There follow various surgeons' comments on the need for book reading.

On Academic Training

Bruno da Longoburgo (died 1286)

Bruno travelled from Longoburgo in Calabria in the south of Italy through a number of locations which remain undetermined. He ended up in Padua where he established a practice and where eventually he died. On academic training he wrote the following.

> "Surgeons should be fond of reading and they should learn from someone who has had his own book-learning. I cannot condone the belief that someone who is unfamiliar with the surgical literature can learn surgery" (Tabanelli 2003).

This is a clear enough statement of intent.

Theodoric Borgognoni (1205 – 1298)

Theodoric was born in Lucca (figure 1.4). He may have been the son of a famous surgeon who left no writings called Hugh of Lucca. Theodoric clearly admired him and praised him repeatedly in his text on surgery. Theodoric was an outspoken supporter of academic surgery as indicated by the quotation below. He wrote:

Figure 1.4
A map of the outline of Italy showing the locations relevant for medieval

> "Damascenus...says, the native talent of a physician aids his skill, and on the other hand, his control of natural forces. They must needs be well-read, and even if they be aided sometimes by experience, yet frequently will they fall into error and into confusion. I scarcely think that anyone can understand surgery without schooling." (Theodoric 1955)

This is a powerful statement supporting the need for surgeons to receive academic training and includes what is a fairly characteristic contempt for those who do not reach the standards laid down by the writer.

William of Saliceto (1210 – 1277)

William was born in a small village near modern day Piacenza. He was educated in Bologna. He had a tremendous reputation as the finest surgeon of his time (Malgaigne 1965). He again emphasised the need for theoretical education for surgeons. He stated the following:

> "Surgery is a science that teaches the principles behind the procedures for manual operations on the soft tissues, nerves and bones…Yet, it is held to be true that one can learn surgery without ever having performed an operation (ie by following the general principles). However, that body of knowledge, along with others, is united with the basics of Surgery by a practical experience in the performance of particular operations in particular cases." (Saliceto 2002)

This author again required the need to combine learning with practical experience but without the contempt of Theodoric.

Lanfranc (1250 – 1306)

Lanfranc was born in Milan. His training was in Bologna, but he set up practice in his home city (Malgaigne 1965). Falling foul of the authorities in Milan he left and set up eventually in Paris. His major teacher was William of Saliceto, but he may well have known Theodoric. His description of the requirements for surgical education is a lot less verbose than those of his predecessors. He simply states:

> "He should be well-lettered in philosophy and logic and have a clear knowledge of the Scriptures"

> "Heed what the Great Masters say, They who preceded us, and who Left a trail of disciples who wrote down What the Masters taught" (Lanfranc 2003).

These two statements emphasise that a surgeon could not be an unlettered technician.

Henri de Mondeville (1260 – 1316)

Henri was born in Mondeville a small village near Caen. He was trained by Jean Pitard, a celebrated French surgeon who left no written text. He was also influenced by Lanfranc, Theodoric, and Hugh of Lucca. He wrote two of a planned five-volume textbook on surgery. It was not completed and not properly published until centuries later. A possible explanation is that the Black Death distracted people from this work which did not receive the attention its contents deserved (Malgaigne 1965). He wrote the following about the required education for a surgeon.

> "Surgery is not just operating. Coming before the handwork is a theoretical science, something no lay surgeon ever will learn. And, beyond just knowing theory, one's confidence is bolstered and one is better prepared to learn and to understand the technical aspects if he knows the concepts behind them. He knows the etiology (ie of the diseases) and the rationale for doing precisely such and such and not something else. Furthermore, if the cleric (ie the educated surgeon) is intelligent and has good physical attributes there is no reason why he can't operate even more skilfully than the lay man." (de Mondeville 2003).

It may be noted that while Henri is verbose and authoritarian, he does not exclude the possibility of lay surgeons.

Jehan Yperman (ca. 1260 – ca. 1331)

Yperman is thought to have been born in Poperinge near Ypres in Belgium. He was most probably trained in Paris and he acknowledges his debt to Lanfranc in his book on surgery. The following statement is to be found in his text.

> "The surgeon should be broadly educated beyond the realm of medicine. He should have studied the books of science and philosophy, including grammar, logic, rhetoric, and ethics. With a background of knowledge in those four subjects he will have learned to assess rationally all that he will face." (Yperman 2003).

Here it is emphasised that a broad education is a requirement, not just the acquisition of the science on which surgery is based.

Guy de Chauliac (ca. 1300 – 1368)

Guy was born in the village of Chauliac in south central France (see figure 1.5). The date of his birth is uncertain as is his training. There is evidence that he received instruction in Montpellier, Toulouse, and Bologna. His book on surgery came to be a standard text for generations to come. His succinct comments on surgical education were as follows.

Figure 1.5
A map of the outline of France showing the locations relevant for medieval and early Renaissance surgeons.

> "Therefore, the surgeon must be well educated, not only in the principles of surgery, but also in the theory and practice of medicine" (Chauliac 2007b).

Thus, it may be seen that the education of surgeons was a major consideration for these medieval practitioners. Surgery had come back to Europe with a lost reputation which was commented upon by especially Albucasis and Guy de Chauliac (Albucasis 1973b; Chauliac 2007a). With the exception of Jehan Yperman, all the surgeons mentioned in this section were ordained priests. The significance of this will be considered in more detail in the next chapter. However, the need to educate surgeons with book learning in addition to practical instruction was important in relation to practitioners' prestige and probably in the last analysis the fees they could charge. It is of interest that the surgeons of this period, under social threat from physicians with their superior social standing found it necessary to state what was required to make a surgeon. This would change.

Renaissance and Later

Up to the Renaissance all books were in the form of manuscripts, so that their production was time consuming, and they were necessarily very expensive (Malgaigne 1965). The introduction of the printing press in 1450 changed all that. Thereafter, surgical texts could be produced in large numbers at an affordable price. It would seem that the nature of surgery and its practitioners had become clear and accepted so that only twice thereafter is there mention of the requirements of a surgeon. Ambroise Paré, that most distinguished and respected of French barber surgeons wrote:

> "For my part I very well like the saying of Celsus; A Chrirugeon must have a strong, stable and intrepid hand, and a minde resolute and mercilesse; so that to heale him he taketh in hand, he be not moved to make more haste

> than the thing requires; or to cut lesse than is needful; but which doth all things as if he were nothing affected by their cries; not giving heed to the judgement of vaine common people, who speake ill of Churgions because of their ignorance" (Johnston 1649).

This is the modest Paré who stated of a patient:

> "I dressed him. God cured him".

Even so he stands apart from the criticism of 'common people' understanding how a surgeon must on occasion harden his heart if his patient is to benefit from the operation. Another sensible remark in the same vein is from Heister, a celebrated eighteenth-century German surgeon, whose original textbook on surgery, published in German was translated into a number of languages including Latin and Japanese. He paraphrased Celsus thus:

> "for the Number wounded, on the Side of the Hollanders only, amounted to above five thousand. I had here therefore an ample Occasion to extend the Bounds of my Practice, and was obliged to put on that Intrepidity of Mind which Celsus requires as an essential Qualification in a Surgeon, and for want of which some, who are in other Respects skilful Operators, do frequently miscarry" (Heister 1743).

All these surgeons seem to agree that in the surgeon patient relationship, it was the surgeon who was the leader and who must not become too familiar with the patient. Thus, surgeons must be confident on the one hand without slipping from confidence to arrogance. It is probably impossible to be totally successful in this endeavour but the effort to keep the right balance must never be relaxed.

Quotations

A few quotations are included to give a flavour of the life of a surgeon. The profession of surgery is complex and involves all sorts of complicated relationships between the practitioner and patients, colleagues, employers, the public and politicians. These relationships are unfamiliar to non-surgeons.

Surgeon	Quotation
	Principles
Max Thorek (1880 – 1960)	The surgeon should always remember that operation is not synonymous with surgery, and that the primary aim of surgery is not operation, but the cure of the patient.
Anon	Fast surgeons do not hurry, they save time by not wasting motions.
	Communication
Ambroise Paré (1510 – 1590)	Always give the patient hope, even when death seems at hand
	Learning
Joseph Lister (1827 – 1912)	You must always be students, learning and unlearning till your life's end, and if, gentlemen, you are not prepared to follow your profession in that spirit, I implore you to leave its ranks and betake yourself to some third-class trade
Richard Wiseman (1621 – 1676)	I have thought it no disgrace to let the world see where I failed of success, that those that come after me may learn what to avoid: there being more instructiveness often in an unfortunate case than in a fortunate one
	Teaching
Harvey Cushing (1869 – 1939)	The best any of us can do as successful teachers of medical students is to instill principles, arouse interest, put the student on the right track, give him methods, show him how to study, and early to discern between essentials and the unessential
	Relations with the Public
J Chalmers Da Costa (1863 – 1933)	Any surgeon, who looks for repute to the general public, rather than to his own professional brothers, has the spirit of the quack.

Table 1.1
Comments by distinguished surgeons down the years which illustrate some of the qualities needed.

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CHAPTER 2

REGULATION OF SURGICAL PRACTICE

Introduction

In the modern world, the regulation of surgical practice is strict and formal. Its components are as follows. Firstly, a would-be surgeon must obtain a qualification in general medicine which will include information on the diseases treated by surgery and observation of some operations. That is however the limit of undergraduate surgical education. Following qualification, the candidate for a surgical career will undergo a lengthy training first in general surgery and then in the speciality of his/her choice. This will include taxing examinations and a many year apprenticeship during which operative technique will be taught. At the end of this training, the successful candidate will receive an official license to practice their surgical speciality. The final step in the process is to apply for a job as an independent practitioner in the relevant speciality. At this stage, the opinion of those who trained him/her will have considerable influence on the success of the application. Finally, the surgeon's independent practice will be under constant assessment by colleagues, employers, professional bodies, and patient protection organisations. It was not always so.

The Earliest Regulation

It must have been obvious from earliest times that while surgery might provide benefit, it was also a high-risk procedure. Thus, from earliest times societies have found it appropriate to write laws to direct surgical practice, which given the risks is very understandable. The oldest regulations of which we are aware came from ancient Babylon. The Code of Hammurabi (1811 BC - 1750 BC) consists of 282 laws. Of these laws 215 to 223 relate to surgery. They are as follows: (Ascaco and Huerva 2013; Hammurabi 1904)

> If a physician operate on a man for a severe wound (or make a severe wound upon a man) with a bronze lancet and save the man's life; or if he open an

> abscess (in the eye) of a man with a bronze lancet and save that man's eye, he shall receive ten shekels of silver (as his fee).
>
> If he be a freeman, he shall receive five shekels.
>
> If it be a man's slave, the owner of the slave shall give two shekels of silver to the physician.
>
> If a physician operate on a man for a severe wound with a bronze lancet and cause that man's death; or open an abscess (in the eye) of a man with a bronze lancet and destroy the man's eye, they shall cut off his fingers.
>
> If a physician operate on a slave of a freeman for a severe wound with a bronze lancet and cause his death, he shall restore a slave of equal value.
>
> If he open an abscess (in his eye) with a bronze lancet, and destroy his eye, he shall pay silver to extent of one-half of his price.
>
> If a physician set a broken bone for a man or cure his diseased bowels, the patient shall give five shekels of silver to the physician.
>
> If he be a freeman, he shall give three shekels of silver.
>
> If it be a man's slave, the owner of the slave shall give two shekels of silver to the physician.

Five shekels was equivalent to the yearly rent of a good type of house and represented 150 times the daily wage of a workman. However, Hammurabi´s Code might have discouraged the pursuit of a career in Ophthalmology given the severity of the penalties for surgical misadventure. It is noteworthy that the penalties were related to the socioeconomic status of the patient. So, even at this early date, surgical practice was to be guided by the law of the land, and the guidance was stringent.

Of Celsus there is no record that he ever was medically or surgically qualified. However, he wrote like a professional and the process of qualification at his time is simply not known. There is no record on how the celebrated surgeons of the ancient world were perceived to be qualified. For Hippocrates there is no clue as to his training. Galen underwent a lengthy education but his appointment as surgeon to the gladiators in Pergamum seems to have been at the discretion of the priest in charge, the high priest or (Archierius) who likely belonged to the same privileged class as Galen’s father (Mattern 2013). So, while there is no information about the selection process it might reasonably be assumed to be influenced by social position and contacts.

The Fall of the Roman Empire

Roughly half a millennium later another society found it necessary to write regulations, to guide the work of surgeons which have survived (Scott 1910). The fall of Rome was the work of so-called barbarians. These folk were Goths, specifically Visigoths who were the Western Goths, the Eastern Goths were called Ostrogoths. They are thought to have arisen from southern Scandinavia. In the late fourth century they converted to Christianity. In 410 AD under the leadership of Alaric I they sacked Rome. At the beginning of the sixth century, a successor Alaric II (458 – 507) promulgated the Breviarium Alaricianum, a body of laws compiled mainly from the Codes of Justinian and Theodosius. Over a century later between 649 AD and 652 AD, the Forum Judicum, or Visigoth Code was formed. It contains a few short paragraphs relating to medical professionals.

> I. No Physician shall Presume to Bleed a Woman, in the Absence of her Relatives.
>
> Absence of her Relatives. No physician shall presume to bleed a freeborn woman without the presence of her father, mother, brother, son, uncle, or some other relative, except urgent necessity should demand it; and where it happens that none of the abovenamed persons can be present, the woman must be bled in the presence of respectable neighbours or slaves, of either sex, according to the nature of her illness. If a physician should do this without the presence of any of the aforesaid persons, he shall be compelled to pay ten solidi to the husband or the relatives of said woman; for the reason that it is not at all improbable that, on such an occasion, wantonness may sometimes occur.
>
> II. No Physician shall Visit Persons Confined in Prison.
>
> No physician shall presume to enter a prison when governors, tribunes, or deputies, are excluded therefrom, without being accompanied by the jailer, lest the prisoners, influenced by fear, may obtain from said physician the means wherewith to commit suicide; for should any poison be furnished or administered by physicians, under such circumstances, the course of justice would be greatly obstructed. Should any physician be guilty of this offence, he shall be liable to punishment for the same.
>
> III. Where a Physician Treats Disease under a Contract.
>
> Where any person demands that a physician treat him for disease or cure his wound under a contract; after the physician has seen the wound, or diagnosed the disease, he may undertake the treatment of said sick person

under such conditions as may be agreed upon and set forth in an instrument in writing.

IV. Where a Sick Person Dies, while a Physician is Treating him under a Contract.

Where a physician undertakes the treatment of a sick person under a contract reduced to writing, he must restore said sick person to health; and, if the latter - should die, the physician shall not be entitled to the compensation stipulated in said contract, and no liability shall attach to either of the parties to the same.

V. Where a Physician Removes a Cataract from the Eye.

Where a physician removes a cataract from the eye of any person, and restores the invalid to his former health, he shall be entitled to five solidi for his services.

VI. Where a Freeman or a Slave Dies from Being Bled

Where a physician bleeds a patient, and the latter is greatly weakened in consequence, said physician shall be compelled to pay him forty solidi. If the patient should die as the result of being bled, the physician shall be delivered up to the relatives of said patient, to be disposed of at their pleasure. Where the patient is a slave, and is seriously weakened, or dies, the physician must give his master another slave of equal value, in his stead.

VII. Concerning the Compensation to be Received for the Instruction of a Student in Medicine.

Where a physician receives a slave for the purpose of instruction in medicine, he shall be entitled to twelve solidi by way of compensation.

VIII. No Physician shall be Imprisoned without a Hearing.

No physician shall be imprisoned without a hearing, except in case of homicide. Where he is charged with debt, he must provide a surety.

The penalties would appear to be somewhat milder than those of Hammurabi, although the risks outlined in paragraph one, suggest that sexual impropriety was more expected than it had been in Babylon. However, once again there is no suggestion that surgery was carried out by anyone other than qualified professionals who were subject to the above laws. Paragraph III specifically states: ‘after a physician has seen the wound or diagnosed the disease’. Since wounds require surgical management this statement alone seems to justify the combined functions in one individual.

Moreover, it establishes that in the history of Europe, there have been periods when surgery would be guided by laws for the protection of the public. It is worth noting, that the translator uses the word physician and not surgeon. In the seventh century AD the two professions were still undertaken by the same person. The solidi mentioned were the gold coins of the Byzantine Roman Empire from the time of Constantine up to the tenth century. A soldier's annual pay would be around twelve solidi, so that the financial punishment for misbehaving with a woman or the fee for instructing medical students were both close to the annual income of a soldier.

The above texts outline the efforts of the state to regulate surgical practice. They do not however enlighten us on how a given person could qualify as a surgeon, only the consequences of his professional practice. As time passed the regulation of surgeons would become intimately associated with the way in which they were educated.

Early Middle Ages

Contemporary with the Visigoth Code were the writings of Paul Ægineta (ca.625 – ca.690). After him medical education gradually fell into the hands of the church since the clergy were responsible for all education from the parish school to the monastic or cathedral school (MacKinney 1955; Malgaigne 1965). There was a gradual move from the scientific spirit of Galen to preference for authoritative texts (Temkin 1956), which would be highly acceptable to the church. Surgery was not a priority in this education.

There was nothing new written on the subject of surgery until the eleventh century AD when Albucasis (936 – 1013) wrote the first textbook ever devoted to surgery alone (Albucasis. 1973a.). This text largely based on the writings of Paul Ægineta was also the first with illustrations, albeit not very useful ones (see figure 1.3). Paul's text had been translated from the Greek into Arabic by Hunayn ibn-Ishaqw, who had also translated works of Galen and Hippocrates, who are both mentioned in Albucasis' text (Johna 2002). From available information today, nobody knows the nature of Albucasis' qualifications to practise surgery though he certainly would seem to have been proficient.

Early Medical Schools

A century later, surgery began to return to Europe in earnest, starting in Salerno and subsequently involving Bologna, Padua, Verona, Milan, Paris, and Montpellier. In the ancient world medicine had been a skill learned by apprenticeship (Temkin 1956). There arose a succession of surgeons who were motivated to demonstrate that surgery was a science requiring the book learning of its principles as well as manual skills (McVaugh 2006): as related in the previous chapter. This movement occurred at the time when centres of education were changing their format with the founding of universities. It has been pointed out that three things changed medical education at this time. They were the translation of ancient texts, the rise of urban centres and the formation of universities (Temkin 1956). In the context of the regulation of surgical practice, the formation of universities was crucial. They did not arise in a vacuum but were mostly evolved from existing schools which the church took over (Malgaigne 1965). After all, at this time most learning was an ecclesiastical monopoly.

The most distinguished medical schools at the beginning of this period were at Salerno and Bologna. The evolution from school to university was different in the two places but the end result was the same. Universities included an organisation and a set of processes ending in the granting of a confirmation of the acquisition of knowledge on which a professional career might be based. This confirmation was called a degree. There was a graded importance of university employees from those qualified to teach up to those qualified to grant a degree. Salerno lay within the realm of the Kingdom of Sicily and in 1231, King Frederick II commanded that nobody could qualify in the field of medicine without a degree granted by the University of Salerno. In Bologna the control of medical practice began with the appointment by the city of a surgeon to the community, Hugo of Lucca (Rashdall 2010). This appointment was made in 1214 (McVaugh 2006). However, the foundation of a School of Medicine was not established until 1260 (Rashdall 2010). The importance in the current context is that surgery was included in the subjects taught and these administrative changes meant that a would-be surgeon had to satisfy a public authority of his competence before receiving a license. In the laws of Frederick II, the surgeon had to undergo a study of anatomy but the story that human dissection was a component of this process is not supported by the evidence (Kristeller 1945).

The less well-defined qualifications whether by traditional apprenticeship as in the classical world or by acceptance within a religious community were now a thing of the past (Temkin 1956). However, the changes mentioned above were not specific for surgery but for all of medicine. A consequence of these new academic medical studies was the introduction of a new word for an academically qualified doctor. This word was 'Physicus', which means natural philosopher but later evolved into the term 'Physician', which came into use with the development of the university medical schools and emphasises the role of academic learning in the equipment of medical professionals (Temkin 1956).

The Influence of the Church

The medieval church was an authoritarian institution. The establishing of universities required the authority of the Pope or the Holy Roman Emperor (Rashdall 2010). The teachers were for the most part ordained clergy and the Church attempted to control their activities. Thus, the authority of the Church was an important background influence during the period under discussion. The following canons indicate the intentions of papal authority on medical practice. Firstly Canon 9 from the second Lateran Council of 1139 states: (Tanner 1990)

> "Moreover, the evil and detestable practice has grown, so we understand, whereby monks and canons regular, after receiving the habit and making their profession, are learning civil law and medicine with a view to temporal gain, in scornful disregard of the rules of their blessed teachers Benedict and Augustine. In fact, burning with the fire of avarice, they make themselves the advocates of suits; and since they have to neglect the psalmody and hymns, placing their trust in the power of fine rhetoric instead, they confuse what is right and what is wrong, justice and iniquity, by reason of the variety of their arguments. But the imperial constitutions testify that it is truly absurd and reprehensible for clerics to want to be experts in the disputes of law courts. We decree by apostolic authority that lawbreakers of this kind are to be severely punished. There are also those who, neglecting the care of souls, completely ignore their state in life, promise health in return for hateful money and make themselves healers of human bodies. And since an immodest eye manifests an immodest heart, religion ought to have nothing to do with those things of which virtue is ashamed to speak. Therefore, we forbid by apostolic authority this practice to continue, so that the monastic order and the order of canons may be preserved without stain in a state of life pleasing to God, in accord with their holy purpose. Furthermore, bishops, abbots and priors who consent to and fail to correct such an outrageous practice are to be deprived of their own honours and kept from the thresholds of the church."

This is strong stuff, emotionally expressed but a detail must be mentioned. It applies to monks and canons regular, that is to stay priests, resident in a religious order who were not supposed to be in contact with the outside world. This regulation encouraged men to stick to their commitments and was not of itself primarily aimed at the medical profession.

However, in 1215 at another Lateran Council things had changed. There are two canons which had a direct bearing on the profession. Canon 18 states: (Tanner 1990)

> "No cleric may decree or pronounce a sentence involving the shedding of blood, or carry out a punishment involving the same, or be present when such punishment is carried out. If anyone, however, under cover of this statute, dares to inflict injury on churches or ecclesiastical persons, let him be restrained by ecclesiastical censure. A cleric may not write or dictate letters which require punishments involving the shedding of blood, in the courts of princes this responsibility should be entrusted to laymen and not to clerics. Moreover no cleric may be put in command of mercenaries or crossbowmen or suchlike men of blood; nor may a subdeacon, deacon or priest practise the art of surgery, which involves cauterizing and making incisions; nor may anyone confer a rite of blessing or consecration on a purgation by ordeal of boiling or cold water or of the red-hot iron, saving nevertheless the previously promulgated prohibitions regarding single combats and duels."

The problem with this regulation is that at the time it was virtually impossible to gain a place in an institution of higher learning without being ordained. This most important regulation took surgery away from the universities and physicians and into the hands of barbers and surgeons. (Amundsen ; Zimmerman and Veith 1967c), thus adding to the distance between physician and surgeon mentioned in the previous chapter. A further regulation affected all medical practitioners.

It was Canon 21 of the same council which stated: (Tanner 1990)

> "As sickness of the body may sometimes be the result of sin — as the Lord said to the sick man whom he had cured, Go and sin no more, lest something worse befall you — so we by this present decree order and strictly command physicians of the body, when they are called to the sick, to warn and persuade them first of all to call in physicians of the soul so that after their spiritual health has been seen to they may respond better to medicine for their bodies, for when the cause ceases so does the effect. This among other things has occasioned this decree, namely that some people on their sickbed, when they are advised by physicians to arrange for the health of their souls, fall into despair and so the more readily incur the danger of death. If any

> physician transgresses this our constitution, after it has been published by the local prelates, he shall be barred from entering a church until he has made suitable satisfaction for a transgression of this kind. Moreover, since the soul is much more precious than the body, we forbid any physician, under pain of anathema, to prescribe anything for the bodily health of a sick person that may endanger his soul."

However, moral the intention, this regulation moved the nature of medicine away from the scientific, observation-based teachings of Hippocrates and Galen and back to notions infused with the influence of the supernatural. However, it should be remembered that the education of priestly surgeons continued through the period supposedly to be governed by the decrees of the Lateran Councils. Indeed, Malgaigne made the point that the apparent need to restate or emphasise decrees aimed at excluding the clergy from performing surgery was an indication as to how ineffective these decrees were, no matter how draconian the language (Malgaigne 1965). After all, Theodoric, William of Saliceto, Lanfranc, Henri de Mondeville and Guy de Chauliac were all ordained.

Contempt for Lay Surgeons

As noted in chapter one, most of the texts of these medieval surgeons emphasised the need for book learning as a vital adjunct to manual practice during the training of a surgeon. However, what is not mentioned is the status of academic surgeons who could demand fees way beyond the reach of the common illiterate populace. Yet this populace suffered surgical diseases and needed treatment. Someone had to fill the gap, and this would be practically trained but academically unqualified practitioners. Such people were regarded with scorn by the academic surgeons as the following quotations indicate.

Bruno da Longoburgo (died 1286)

> "Those (illiterate) healers, as Almansor (Rhazes) calls them, have neither proper motives nor intelligence. Further, he refers to those who practice in such a way as idiots, ruffians, and oafs. As a result of that stupidity they make the sick even sicker, including those whom they kill. They operate without knowledge or common sense, simply case by case as it comes to them. They know not the basic causes nor even the names of the diseases they undertake to treat." (Tabanelli 2003).

Theodoric Borgognoni (1205 – 1298)

> "Now Almansor contends that the practitioners of this art are indeed for the most part uncouth and unfeeling ignoramuses, and by reason of their stupidity most unfortunate things can happen to people. Generally, also, when their operations are not performed with a sure diagnosis, nor done with a plan, people are killed by reason of their lack of skill. They do not really recognize the causes nor yet the names of the diseases which they claim to cure." (Theodoric 1955).

William of Saliceto (1210 – 1277)

> On the other hand, the latter, (practical operations) taken alone, has become the way for many to practice surgery. They operate without rational motives and often with faulty techniques. They are the unlearned ones who have learned from other ignorants; they have had no instruction from Masters nor have they had any formal study of anatomy and they do not know the proportions and the disposition of the parts of the body, nor have they learned the signs of diseases. They cannot recognize nor even suspect the significance of what is manifest to their senses. They may uselessly terminate a life simply because they are ignorant of the necessary principles of our Art." (Saliceto 2002a).

Henri de Mondeville (1260 – 1316)

> "that the kind of surgery which is only a hands-on activity, such as is surgery by an illiterate peasant, which is purely mechanical and not properly guided by theory, is not truly a science nor an art" (de Mondeville 2003a)

Guy de Chauliac (ca. 1300 – 1368)

> "Two chief sects of operating surgeons: persist to this time: the Logical or Rational and the Empirics, of whom Galen disapproved in his Book of Sects and in his Therapeutics" (Chauliac 2007c)

Statements on Practical Training

Despite the contempt in which the lay surgeons were held by their academic 'superiors', those same superiors made statements which apply to lay surgeons as well as to themselves. These are principles which will apply to any surgeon at any time so that the academic surgeons are involuntarily contributing to defining the right way for surgeons to train in the pursuit of their technical art.

Bruno da Longoburgo (died 1286)

> "It is required of those who would practice surgery that they go to places where good surgeons are at work, there to observe operations at length and diligently" (Longoburgo 2003)

Theodoric Borgognoni (1205 – 1298)

> "It behoves practitioners of surgery to frequent the places where skilled surgeons operate, and to attend these operations diligently and commit them to memory" (Theodoric 1955)

William of Saliceto (1210 – 1277)

> "The surgeon must have observed successful operations and had a long experience with an excellent teacher. The operations cannot be explained clearly (i.e. in books) without actual demonstrations." (Saliceto 2002b)

Lanfranc (1250 – 1306)

> "A surgeon must seek formal operative training by spending a long time at centers where experienced surgeons perform operations. They must observe attentively and engrave what they learn in their memories. Then they should perform operations under the supervision of Masters, until they are ready to be on their own. Those who obey the precepts will become well-trained and able surgeons." (Lanfranc 2003)

Henri de Mondeville (1260 – 1316)

> "A surgeon who wishes to operate according to established methods must attend, while in training, those centers where experienced surgeons are busily occupied. He should observe, closely and attentively, and fix in his memory what he has learned.." (de Mondeville 2003b)

Guy de Chauliac (ca. 1300 – 1368)

He quotes Avenzoar (1094 – 1162), a celebrated Arab physician.

> "Every physician should know things (ie been taught) and then learn from his own experience with them Rhazes said the same in his Almansor and Halyabbas agreed." (Chauliac 2007b)

Thus, it may be seen that these six surgeons are consistent in their requirement for a trainee surgeon to serve an apprenticeship with a master and continue until his competence is enough to venture out on his own.

However, as noted above, this apprenticeship had to be controlled by a public authority to be valid. This was new.

Guilds

A lay surgeon in the Middle Ages would come to require two elements to qualify. The first was an agreement amongst teachers that he was competent to practice. The second was an agreement from the state or local authority providing a license to practice within a given location. Guilds would be the organizations which fulfilled this need.

The word guild derives from two earlier similar words one of which means association and one of which means payments (Guild - Definition 1972). Guilds were first found in Europe before spreading to Britain. There were two main kinds: Merchants' Guilds and Craft Guilds. The Merchants' Guilds came first and one of the earliest in Britain was a Merchants' Guild in Winchester mentioned in 856 AD in the reign of one Æthelwulf (McNee 1959), who had as an advisor Swithin Bishop of Winchester; the patron saint of Winchester and whose Saint's Day (July 15th) is supposed to predict the weather for the subsequent forty days.

A qualified guild member would be a 'Master' and apprentices would train under his guidance and at the end of the apprenticeship would be examined and if found adequate, would then be promoted to journeyman (Stefon 2010). A journeyman would work for a master and receive pay. With adequate merit he could in time become a master himself and then be allowed to set up his own shop and take apprentices. The earliest organisation of barbers and surgeons was in guilds. The earliest mention of an English Craft Guild is that of Weavers who were mentioned as follows (Harding 2020).

> "the Pipe Roll of 1130 has an entry of a payment of £16 by Robert Levestan on the Weavers' behalf"

(The Pipe Roll was a roll of parchment on which payments into the Exchequer were noted.)

The question arises why the two groups of barbers and surgeons should join each other. The answer is in fact mundane. On the one hand public bathing was popular and bath keepers were responsible for shaving, dressing, and perfuming their clients. They also treated fractures and dislocations, performed simple dentistry, and performed cupping and

bloodletting. On the other hand, military surgeons were accustomed to shave their men. Thus, there was an overlap of function (Parker 1912). Naturally, there were more barbers than surgeons. The first mention of a barber guild in London was in 1308 when a Richard le Barber was sworn in at the Guildhall (McNee 1959; Dobson 1974). In 1312 a surgeon was admitted to the guild (Dobson 1974). Nearly one and a half centuries later in 1451 the Masters of Barbery were granted Arms. In 1462 the Guild of Barbers acquired a Royal Charter, thereby obtaining the state's recognition of the right to care for and maintain the standards of practice of its members. While from the beginning the barbers dominated the guild by virtue of numbers, its incorporation was mostly concerned with the practice of surgery. There were also surgeons who practised in an unincorporated guild who cooperated with the guild of barbers.

In 1540, during the reign of Henry VIII the Guild of Barber-Surgeons were finally incorporated as

> "The Masters or Governors of the Mystery and Commonalty of Barbers and Surgeons of London." (Dobson 1974).

One of the consequences of this new acceptance was the need to arrange for the teaching of anatomy, which had not previously been formally undertaken by the Guild of Barbers (Dobson 1974). Over the subsequent two centuries the significance and earnings of the surgeons increased so much that there was a concomitant irritation with the role of barbers in their affairs. This conflict was finally solved in 1745 with the formation of the Company of Surgeons. In 1800 this would become the Royal College of Surgeons of London and in 1843 the Royal College of Surgeons of England. Similar guild formations were being formed and evolving in the rest of Europe.

Early Distinguished Barber Surgeons

The education of surgeons varied geographically within Europe. Further north meant greater opposition to letting surgeons train in universities. In Italy they were still allowed to do so (Bullough 1959). However, with the passage of time surgeons would lack ordination. More than that, they would lack the skills at Latin which were such an important part of priestly education. In consequence, their works would increasingly be written in the vernacular and be available only to those who shared the same language. The term barber-surgeon to a modern and even to a contemporary ear leaves an impression of lack of sophistication and education. It will be seen in what

follows that no matter how true that might be it was by no means an inevitable characteristic of those who were labelled in this way.

John Arderne (1307 – 1377)

One of the first of distinguished lay surgeons was John Arderne. Few details of him are known although from an account of the people he knew and who were his patients, he was socially well connected (Zimmerman and Veith 1967b). Arderne's biography in the Oxford Dictionary of National Biography contains some essential points. He was educated and had mastered adequate if not elegant Latin. He never went to a university but was trained as an apprentice to a master. It states he regarded himself as learned in contrast with the barbers (Jones 2004). It also confirmed that a man with a barber-surgeon's education could rise to the top of his profession as a surgeon.

Hans von Gersdorff (ca.1455–1529)

This gentleman was the third of three German surgical writers between the end of the fifteenth and beginning of the sixteenth centuries. He was medically speaking the most significant of the three. His training was by apprenticeship, travel, and military service (Zimmerman and Veith 1967a). He took advantage of the invention of the printing press to publish his book employing the first surgical illustrations in the form of woodcuts. This made the book far more dramatic and appealing. The illustrations are striking and impressive. In addition to compelling illustrations, the book was written in German (von Gersdorff 1517). The text has been stated to have been copied from Guy de Chauliac (Chauliac 2007a). It is fair to say that von Gersdorff was very intrigued by the application of mechanical apparatuses for use in operations, even if not all of this apparatus was sensibly designed (Ganz and Arndt 2014). Unfortunately, there is no modern English text of this book and the early flowering of surgery in Germany declined into obscurity again. Biographical information about von Gersdorff is lacking.

Giacomo Berengario Da Carpi (1460–1530)

Da Carpi was a formidable surgeon and the son of a barber-surgeon. He was also an anatomist and correctly observed errors in the teachings of Galen which continued to be ignored for several centuries. Although he studied and later taught at Bologna medical school, he had poor Latin, which could have hindered the dissemination of his work. He acquired the rank of Master of Arts and Medicine on 3rd August 1489 at the age of 29. Interestingly, the roll recording his success had the note "*hic evasit magnum*

anatomicum" meaning '*this was the beginning of a great anatomist*' (De Santo et al. 1999); a prescient comment indeed. Da Carpi is another example of a man without the formally acceptable education of the clergy and yet who was much sought after by even the most exalted persons in the land. He might have a barber-surgeon's education, but he succeeded as a surgeon and had a more than solid grounding in the essential study of anatomy.

Thomas Vicary (ca. 1500 – 1561)

Thomas Vicary was probably a native of Kent born around 1490 to 1500, the precise date is uncertain. He died however in 1561. He was a GP in Maidstone until 1525 when he successfully treated Henry VIII for a leg ulcer, for which service he was appointed a Royal Surgeon at an annual salary of £20. (According to the Bank of England that was equivalent to just under £20,000 in 2020 (Anon 2021)). In 1530 he was elected master of the Guild of Barbers and following the formation of the Barber-Surgeons he was again elected as Master in 1541, 1546, 1548, and 1557, more times than any other person. In many ways an obscure individual, Vicary was nevertheless an important man who brought stability to the practice of surgery in London (Dobson 1974; Bagwell 2005).

Figure 2.1
An outline of the UK showing where Henry VIII met Thomas Vicary.

Ambroise Paré (1510 – 1590)

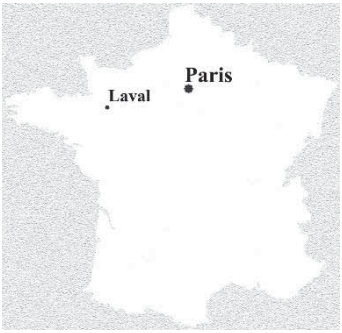

Figure 2.2
Shows where Paré came from

Paré was born in a village which now forms part of the city of Laval, lying around 300 kilometres west of Paris. Attempts to teach him Latin with a local priest were not successful. His brother was a barber surgeon, thus like Da Carpi there was a practitioner in the family who could have influenced his choice of career. One biographer is at pains to emphasise how much barber surgeons were better educated in surgery than university trained surgeons who learned little and did less, in spite of their Latin

(Malgaigne 1965; Packard 1921). The important point is the evidence of Paré's biographers that barber-surgeons were not underinformed amateurs but trained and conscientious professionals. Paré remained at the top of his profession throughout his life, despite his lack of Latin and formal education.

In Summary

Surgical training has passed through a series of stages. In the classical world, the pattern of education and qualification is not known. Following the fall of Rome, the academic texts required to train a student became generally unavailable. Beginning in the twelfth century, these texts became available again through translation and rediscovery. This access to academic learning led to the development of university academic departments where surgery was taught but whose graduates would only be of use to a small section of the population due to their high fees. This education was also associated with the introduction of the formalisation of the requirements for qualification including the formal assent of the training surgeons who could furnish a degree as evidence of a trainee's competence. This degree provided access to a state license to confirm that the competence was publicly accepted by the authorities.

The lay surgeons who were despised by the academics remained a necessity, but they too needed to have a system of training and licensing which was achieved by the formation of guilds. From the time of the Renaissance there has been no fundamental change in the principles guiding the regulations for training in surgery though the details have evolved to reflect the changing requirements of changing times. At all events, nobody can practice surgery today without thorough regulation of their competence to do so.

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CHAPTER 3

ANATOMY

Introduction

It must be obvious that if you are going to open up a structure to effect repairs, it will be essential to have a detailed accurate knowledge of the components of this structure. The name for this area of knowledge in animal organisms is anatomy and its study has been plagued through the ages by difficulty. The principles outlined in this chapter relate to anatomy in general. However, the illustrations and examples used apply to the central nervous system (CNS). This is because while the principles are general the author's experience is with the CNS. It will be shown how frequently accepted knowledge was preferred to personal observation. Moreover, the demonstration of new ideas and information could just as well be forgotten as preserved. It is surprising how resistant researchers can be to correct what they have been taught in favour of what they can see by personal observation. This may apply to any research. However, a particular problem with the study of anatomy is the inhibition of that study due to irrational, social prejudice.

Yet the study of anatomy needs all the help it can get. Living organisms including mammals, of which humans are an example, have an exceedingly complicated structure which consists of a mixture of a rigid supporting skeleton to which everything else, called soft tissue is directly or indirectly attached. The soft tissues are not only soft but, in many cases such as the brain and its connections they are very fragile.

The earliest stages of the acquisition of anatomical knowledge were not aimed at anatomy as a topic worthy of research. Rather, in a variety of situations an instinctive understanding of some anatomical detail could be of practical value. A superb example is to be found in the British Museum; a bas relief of the lioness shot in the back (see figure 3.1). The arrow has passed thought the spine resulting in paralysed back legs, thus making the animal easier to approach and kill.

Figure 3.1
A bas relief from ca. 600 BC from Nineveh in Mesopotamia. The arrows through the back are associated with paralysed back legs. The figure is remarkably life-like (On display in the British Museum and used here with permission)

Anatomy studies in Ancient Times

Ancient Egypt provided other possibilities for acquiring anatomical knowledge since certain corpses were mummified. This required drying the corpse, fixing it, and embalming it with suitable ointments. Part of the process involved removing the soft wet tissues from within the body leaving a casing consisting of muscle, bone, cartilage, and fat. The heart being also a muscle was left in the body. The brain was removed through an opening in the roof of the nose using a hook. The dorsum sellae (a small piece of bone at the top of bony wall behind the cavity which contains the pituitary gland) that would often be broken off and lie free inside the skull after the preparation was complete (Wildsmith 2008) This brain extraction was elegantly performed through an opening in the roof of the nose of not more than 2 cm diameter (Nunn 2000). The brain was not kept with the body as it was clearly deemed not to be important for the afterlife (Finger 1994a). Other ancient societies also considered the brain to be unimportant. The ancient Chinese believed it to be the marrow of the skull (Finger 1994b). The point about the embalmers not learning anatomy is that it was not the point of their work. In a sense like a chef preparing a fish, the first stage is to disembowel the creature without thinking too much about the removed tissues but making certain that all are removed. The same chef will be expert at the relationships between bone and muscle because that is necessary for filleting and no customers want bones in their fillet. So, this kind of anatomy is only learned within the narrow focus of the job in hand. Some have believed that there was little contact between embalmers and indeed those

who opened the abdomen were considered unclean and had to flee after completing their job (Guthrie 1960). However, another author while admitting that this was the case in the earliest periods, considered that in later times there was contact, and an embalmer could even be related to a doctor (Nunn 2000).

Classical Studies

Hippocrates

Hippocrates described a skull that consisted of several bones joined together in a three-dimensional jigsaw. He was also aware of the meninges inside the skull and of course the brain. In his treatise on head injury, he advised that trepanation could be performed adjacent to sutures but should not include them. The precise reason is not given. Leaving aside the treatise on cranial trauma there is little about anatomy in his work. Indeed, the treatise 'On Anatomy' is the shortest in the Hippocratic Corpus and consists of just twelve sentences, none of which refer to the brain (Craik 1998).

Alexandria

In Ancient Greece and the Rome which followed it, dissection of the human body was not allowed. However, there was a short period when this taboo was lifted and that was in Alexandria during the fourth century BC (Lassek 1958b). Alexandria, founded in 331 BC, was a city built at the instruction of the Macedonian conqueror Alexander the Great (356 – 323 BC) who was actively involved in its design. It constituted a gateway into Africa and would serve as a military base for the Eastern Mediterranean. Alexander the Great died without ever seeing the completed city. In the subsequent division of his empire, one of his generals, also a Macedonian, Ptolemy (367 – 283 BC) later called Soter or Saviour acquired Egypt and hence Alexandria. His reign started in 323 BC eight years after the foundation of the city. While running his own life in accordance with Greek principles and norms he was wise enough to acknowledge the religion of his subjects. He started a dynasty which survived for somewhat over 300 years to the time of the Roman Empire. In the academic literature there is argument about what he did and how much value it had but certain elements of his reign are broadly agreed. He acquired the body of Alexander the Great, brought it to Egypt and had it transferred to Alexandria where it lay in a sarcophagus and was visible to all. This added to his prestige and the authority of his rule. Moreover, during his reign the famous museum and library were founded, Thus, the foundation of the most distinguished

university of the Hellenic world took place in Ptolemy Soter's city and during his reign (Chapman 2001). Moreover, his work was continued by his son Ptolemy II – called Philadelphus (Brother loving) (309BC – 246 BC). Herophilus of Chalcedon (325-255 BC) (von Staden 2007c) and Erasistratus of Ceos (304BC – 250BC) were the leading medical scientists in Alexandria at that time.

Herophilus was the first to perform systematic human dissection and described much cerebral anatomy for the first time. He had been born in Chalcedon, then a small city on the Asian side of the Bosporus (von Staden 2007c) but which is now a suburb of Istanbul (see figure 3.2). He went as an adolescent to Kos around 65 years after Hippocrates had died and was taught there by Praxagoras one of Hippocrates followers (Acar et al. 2005). At around 300 BC he moved to Alexandria.

Figure 3.2
Map of the Mediterranean Sea showing the location of the important academic and medical centres of the ancient classical world.

Before proceeding it is necessary to consider the concept of the souls as perceived by the majority of the inhabitants of Alexandria in the second century BC, that is to say the Egyptians and the Greeks. The Egyptians believed that there was a separate immortal soul which survived death.

Thus, damage to a corpse could hinder the soul's journey beyond the grave. There were a variety of arguments and procedures which were used to justify mummification within this intellectual framework, but scientific examination of a corpse was forbidden and in consequence the Egyptians gained little knowledge of anatomy (Lassek 1958a). These concepts meant that human dissection was taboo.

The Greeks too had believed in the separation between body and soul since before the time of Homer (7th Century BC). However, the nature of this relationship varied. During the later evolution of ideas, Plato held a dominant place, believing that the soul was immortal and left the body at death to be reunited with some primitive spiritual origin (Lorenz 2009; Santoro et al. 2009). Aristotle (384 – 322 BC) on the other hand considered the soul to be the essence that animated living matter and that it was mortal and died with the organism that contained it. In the current context this was important because it could mean that Aristotle's authority made the practice of human dissection more acceptable, even if direct evidence to support this notion does not exist (von Staden 2007a). However, if this is a correct interpretation then his ideas would gain added weight in a world dominated by Alexander the Great, since Aristotle had been his tutor. Even so, the Greeks considered any handling of a corpse was unclean and taboo. Thus, the necessary processes associated with the death of a person involved careful regulations and procedures to ensure the retention of cleanliness after contamination from a corpse. This attitude meant that human dissection was forbidden. (Lassek 1958a; von Staden 2007a)

Human Dissection

The first two Ptolemies possessed a set of values which permitted them to license the practice of human dissection. They also provided the corpses of criminals for study. Pliny recorded that the pharaohs came to observe (Wiltse and Pait 1998). Thus, there was stimulus from the authorities. In addition, at the working level there was the genius anatomist Herophilus who had been attracted to this prime academic centre which the efforts of these pharaohs had produced. Heinrich von Staden points out that there is no evidence that Herophilus practiced at the museum itself (von Staden 2007b). However, von Staden states the probable reason for dissection in Alexandria most succinctly.

> "The unusual combination of ambitious Macedonian patrons of science (i.e. the Ptolemies), eager scientists like Herophilus, a new city in which traditional values were not intrinsically superior, and a cosmopolitan intelligentsia committed not only to literary and political but also to scientific

> frontiersmanship, apparently made it possible to overcome traditional inhibitions against opening the human body." (von Staden 2007b).

Unhappily, the actual books of Herophilus and Erasistratus have been lost. This is possibly the result of Julius Caesar's Civil War. It had brought him to Egypt, and he had become involved in the internecine strife between members of the Ptolemy family, ending up taking the side of Cleopatra with whom he had a love affair. Caesar was at risk from his enemies in Egypt and in order to minimise that risk he ordered that all their ships should be burned. There seems a degree of probability that the ensuing fire spread to the Alexandrian library causing the loss of a myriad of important texts, including those of Herophilus. However, despite this tragic accident, Galen is said to have had all Herophilus' manuscripts and to have admired him greatly (Wiltse and Pait 1998; Dobson 1925). Since Galen was familiar with the work and since Galen was the main authority on anatomy until the Renaissance it is reasonable to assume Herophilus' findings were included in his teaching. Apart from his assumed influence on the most influential physician of the ancient world, Herophilus has also left his name on the inside of the human skull, at the region where a number of venous sinuses in the head come together. The name for this confluence of sinuses is called the torcula of Herophilus. Torcula is supposed to refer to a winepress. However, it is not easy to see the similarity (see figure 3.3).

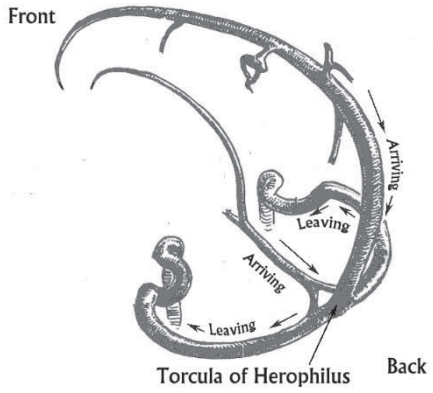

Figure 3.3
This illustrates the major venous sinuses in the head. Basically, the Torcula has blood entering it from two directions and leaving from two directions. It is the junction of four tubes and for the life of me I cannot see how that resembles a wine press.

Herophilus also described a number of intracranial structures including the cerebral ventricles. He gave an accurate description of the floor of the fourth ventricle which he likened to a scribe's pen giving it a name which continues into modern terminology 'calamus scriptorius'. He, like Aristotle distinguished between the cerebrum and cerebellum. He considered that the ventricles were the origin of mental functions.

He also discovered the nerves and noted the origin of motor nerves from the brain and spinal cord. He distinguished between motor and sensory nerves (J. Rocca 2007; von Staden 1992). Herophilus' understanding of neuroanatomy is the more impressive considering he worked on brains in the heat of North Africa without any chemicals to help preserve the cerebral structures.

Galen

Galen was the most gifted anatomist of the classical world whose work is still accessible. However, due to the restrictions of his age he could not dissect humans and his work was based on a combination of human injuries and animal dissections. He studied structures deep within the body as well as the surface. He made two errors concerning the surface relationships of the brain. Firstly, he insisted that the dura could not be attached to the underside of the cranium except at the sutures. His reason for this is quite peculiar to us. He stated that they were simply too different for attachment to be possible (Galen 1968a). This was a significant error not least because Hippocrates had for different reasons stated that penetrating the skull at the sutures was dangerous. The consequence was that until the eighteenth century, surgeons believed that trepanation could not involve a suture and thus would have significantly impeded optimal placement of a trepan for an entirely spurious reason. Another error was Galen's teaching that convolutions could not be related to intelligence, because donkeys have complicated cerebral convolutions but were not intelligent (Galen 1968a). This was an incorrect interpretation but did not have any significant effect on patient treatment in subsequent generations.

Galen also dissected deep in the brain. This is demonstrated by the Great Cerebral Vein which to this day bears his name (See figure 3.4). It is as deep and central a structure in the skull as is possible to imagine. He knew the corpus callosum and the pituitary gland (See figure 3.5). He also gave a detailed description of the ventricular system which included the lateral (anterior) ventricles and the third ventricle located in the softer cerebrum. He described the fourth ventricle located in the parencephalis or cerebellum.

He also knew and named the pineal body, with a name that emphasizes its pinecone like shape.

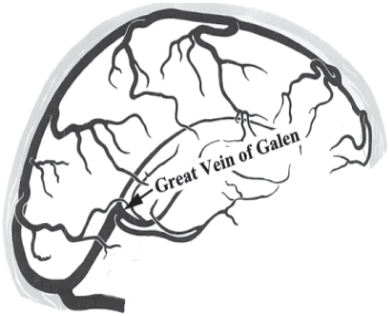

Figure 3.4
The figure demonstrates the central location of the Great Vein of Galen.

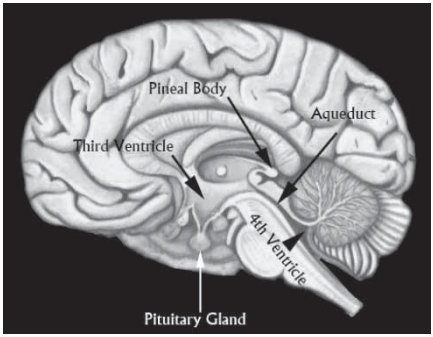

Figure 3.5
This illustration shows the pituitary gland under the brain and the 3rd ventricle above it. It also shows the bunch of fibres connecting one side of the brain to the other. Galen was familiar with it. The author thanks Elsevier for permission to use this image from 'The History of the Gamma Knife' by J.C.Ganz.

Galen was of the opinion that the soul was in three parts, the lusts and appetites were located in the liver, the emotionally driven and moral values were in the heart and the rational soul was in the brain. This rational soul was subserved by psychic pneuma, a mysterious substance elaborated in the rete mirabile and choroid plexuses and stored in the ventricles (Galen 1968a). The rete mirabile was a network of arteries lying between the dura and the bone giving off branches to the meninges and the brain. It exists in most mammals but not in man, but Galen could not know that. Thus, from his animal dissections he deduced a rete in humans and the error persisted. It was not of any practical importance since intracranial surgery was not possible in Galen's time and would not become so until the late nineteenth century AD. One other deep structure he described was the pineal gland as noted above. He attributed a function to it, considering it involved in the movement of the psychic pneuma stored in the anterior ventricles facilitating its passage to the ventricle in the cerebellum (See figure 3.5). However, the passage through which this pneuma is moved is not the Aqueduct of Sylvius, the actual communication between the third and fourth ventricles, but via some notional passage above the midbrain (Galen 1968a). The anatomical knowledge of which Galen demonstrated familiarity could only have been obtained by detailed dissection. This would for the structures

outlined above have involved the dissection of dead brains, since dissecting these structures in living animals is not compatible with survival.

Over and above his dissection of the brain he followed the courses of the branches of the various cranial nerves including the course of the recurrent laryngeal nerve from the brain stem to the larynx. This must have been an exercise in superb surgical technique (Galen 1968b). Figure 3.6 gives an outline illustration of the passage of the nerve but does not show all the other structures through which the nerve must pass. However, Galen had enough talent to demonstrate the loss of voice produced in pigs when the nerves were identified during vivisection and ligatures were placed round them. The voice could then be made to go and return when the ligatures were tightened and loosened. This was all accomplished using vivisection on a struggling pig. Humane by modern standards it was not. It was however a magnificent demonstration of superb surgical technique and for its time revolutionary and detailed anatomical knowledge. In the context of the latter achievement, he made a comment indicative of his technique. He wrote:

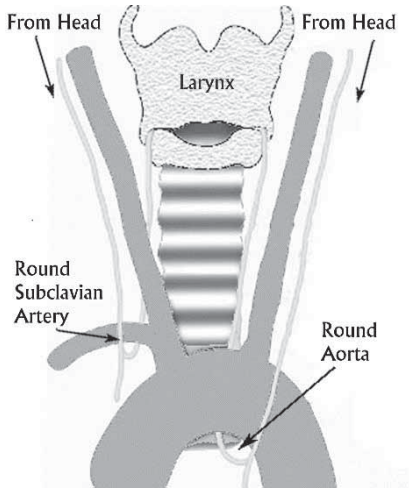

Figure 3.6
Diagram of the complex course of the recurrent laryngeal branch of the vagus nerve.

> "I say that to one who through practice has acquired dexterity in exposing the vagus nerve it will become so easy that he will be able to complete the task with a single stroke of the knife. And this is not something which I alone can accomplish, for it is performed by many of my colleagues also. To do the same in his turn is easy indeed for anyone who is present when one performs it and who sees it with his own eyes. But to describe it in words is very difficult" (Galen 2010c).

He then goes on to describe his technique in words which are unusually easy to follow. This portion of his writings is pleasantly lacking in the prolixity and bombast which characterises so much of his work.

Galen acquired a thorough knowledge of the macroscopic anatomy of the brain and cranial nerves through the dissection of dead and living animals which must have required elegant surgical technique. This of itself does not however bespeak advanced *neurosurgical* technique. There were however a series of operations on animals to investigate the function of the cerebral ventricles which required living subjects.

In 'Anatomical Procedures'. he noted changes in the level of consciousness, which he recorded as stupor following pressure to the anterior (lateral), intermediate (third) and posterior (fourth) ventricles (See figure 3.7). The stupor was more profound the more posteriorly the pressure was applied. The same was the case with incisions into the ventricles (Galen 2010b). The crucial point in terms of surgical technique is that some of the animals returned to normal following the experiments (J Rocca 2008). This suggests sophisticated neurosurgical skill. Producing reversible loss of consciousness by pressure or incisions in the brain tissue was an important element in Galen's concepts of brain function. He, like Hippocrates and in disagreement with Aristotle considered the brain as the location of intellectual and mental function and that element peculiar to life, the soul. He did not declare any certainty as to the precise location of the soul. However, he reasoned that if the stupor produced in his experiments reflected a loss of the soul following incision of the ventricles there could be no recovery. Since recovery occurred there must be a different mechanism. He suggested therefore that what is lost and regained after the stupor is in fact the psychic pneuma. Since the animal recovered the pneuma could only be a vehicle for communication with the soul and not the soul itself, which in turn resided within the cerebral substance, without being certain as to its precise location. (J Rocca 2008). He considered the components of the intellect to be imagination, cognition, and memory. He was unsure as to their location but favoured the brain parenchyma (J Rocca 2008). This opinion would be modified during the Middle Ages.

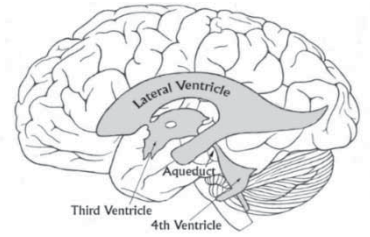

Figure 3.7
This figure shows the configuration of the brain's ventricles as understood today. Galen seemed to be aware of most of these cavities but not the Aqueduct. The author thanks Elsevier for permission to use this image, from Intracranial Epidural Bleeding by J.C.Ganz.

Let us consider some of the skills he had to employ. It is implied that the handling of the skin was adequate to control scalp haemorrhage. This could have been done by the means that were

available which were pressure, styptics, ligature, cautery (Wilkins 1997) and twisting vessels with a hook (Galen 2010b). These techniques could not be used on the brain, especially in some of the small animals involved. Thus, he would have been obliged to operate within the dura without causing haemorrhage. Moreover, as he pressed on and incised the fourth ventricle parts of the brain would have had to have been retracted to gain access. This would have required instruments of which we do not know, and it would also have involved delicacy of touch. In respect of incising the fourth ventricle and achieving a surviving animal, needs a further consideration. His only source of illumination was the sun or perhaps candlelight. The approach to the 4th ventricle that he used is not known but it would have involved retraction and/or elevation of otherwise inaccessible structures since there is no line of sight from the surface to the fourth ventricle in the normal brain. To do this with the then available technology and then incise the roof of the fourth ventricle and even so achieve survival is remarkable.

The accuracy of Galen's findings at experimental craniotomy were impressive, prescient and largely ignored. In passing we may note that he showed evidence of humanity with an initial remark. He preferred vivisection of pigs or goats. Thereby he could

> "avoid seeing the unpleasing expression of the ape when it is being vivisected" (Lloyd 1991)

What is fascinating is his observations of the condition of the dura covered brain when an opening is made in the cranium.

> "Then turn your attention to what you see plainly happening in the brain together with the dura mater. For you see that the whole brain, so long as the animal does not cry out, rises and sinks slightly with a movement which resembles that of the pulsation of all beating blood vessels, that is of the arteries. And if the animal cries out, then you see that the brain heaves itself up further, so that it is quite clear to observe that it rises up higher than and overtops the skull" (Galen 2010b).

Every neurosurgeon knows that the healthy brain at surgery should pulsate. Failure to do so together with a tense extruding dura indicates a serious elevation of intracranial pressure. The significance of these brilliant observations would have to wait nearly two millennia before understanding would be reached. It is all too easy to forget that the science of mechanics and statics with which we are all familiar from school was not formulated mathematically until the Renaissance. Thus, Galen will have looked on the above-mentioned observations of pulsation and extrusion very differently

than we do, which goes some way to explaining why the observations were not interpreted in ways which would be relevant today.

Medieval Studies

Galen died around 216 AD. Over the ensuing two hundred years the Roman Empire gradually collapsed while there was a concurrent increase in the influence of the institutions of the Church. The Church was against the dissection of God's creation, the human body. Since sensible surgery is based on an accurate knowledge of anatomy, serious creative academic surgery fell into desuetude. This did not prevent officers of the church having views on human anatomy. Towards the end of the fourth century AD a book called the 'On the Nature of Man' was written by one Nemesius. He was Bishop of Emesa which sadly is the city of Homs so badly damaged in the Syrian civil war of the twenty first century. Galen as stated above had refrained from specifying the location of the rational soul but Nemesius had no such inhibition and placed its components in the cerebral ventricles. Imagination was located anteriorly. Cognition had an intermediate position and memory was located posteriorly. This is well demonstrated in figure 3.8. It was a model of cerebral function that would persist until and even beyond the anatomy of Vesalius (Whitaker 2011). It was called the 'Cell Doctrine' (Clarke and Dewhurst 1972b). From this time at the end of the fourth century to the twelfth century the study of anatomy stagnated.

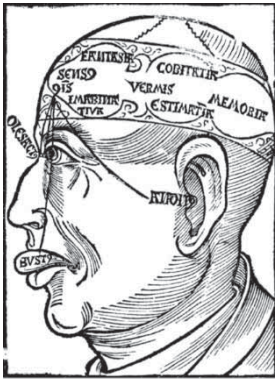

Figure 3.8
The Cell Doctrine. The labelling from the front to the back is clear to read, Fantasy, Sensory Imagination. Cogitation and Estimation and at the back is Memory.

Dissection

For whatever obscure reason, the desire to perform surgery and curiosity about the structure of the human body, could not be suppressed indefinitely; not even something as controversial as human dissection. Despite its prohibition first throughout the period of Roman domination and thereafter by the Christian church (van den Tweel and Taylor 2013), stirrings of interest started to emerge. The earliest mediaeval case was undertaken on the command of a Norwegian king, one Sigurd I Magnusson (the Crusader).

He had led the Norwegian Crusade. He arranged for one of his dead soldiers to be eviscerated in Constantinople on the way home to assess the cause of death. The appearances of the liver were similar to those of a pig marinated in the same wine the soldier had been drinking and it was considered the wine contributed to his death (van den Tweel and Taylor 2013). The year was 1111.

In 1231, Frederick II the ruler of Sicily and southern Italy and subsequently Holy Roman Emperor, commanded that a doctor could only be licensed after five years of studies which included surgery and had been approved by the teaching masters of Salerno (Nutton 2009). It has been related that it was decreed that a human body should be dissected at least once in every five years for anatomical studies and attendance was made compulsory for everyone who was to practice medicine or surgery (Ghosh 2015). However, the evidence would suggest that the true intention was that students should learn about human bodies in class, but that dissection would be performed on animals (Kristeller 1945). Even so, it was another step along the road to the study of anatomy.

The next evidence of the study of human anatomy was in Cremona in northern Italy. Here during an epidemic in 1286, which had affected chickens and humans, a monk called Fra Salimbene performed a human autopsy. He described an abscess in the same place as in the hens. Emphasis is placed on the casual way this was described, suggesting that it was not an uncommon practice (O'Malley 1964). Nonetheless, the formal acceptance of autopsies seems to have begun with William of Saliceto (1210 – 1277), who examined a man post-mortem for legal reasons in around 1275 (O'Malley 1964). Charles Singer noted that in William's book on surgery, within the anatomy section there is a description of the contents of the thorax which could only have been acquired after a post-mortem examination. Singer believed that marked the beginning of formal anatomy study (Singer 1972; Saliceto 2002).

The Renaissance

Mondino de' Luzzi (ca. 1270 – 1326)

Mondino de' Luzzi a native of and a medical student and later a Professor in Bologna wrote an anatomy textbook 'Anathomia', published in 1316. Figure 3.9 is taken from that book. As the figure shows, Mondino sat above the class while an assistant did the actual dissection. There has been debate about whether he ever dissected himself, with critics claiming that

he did not. However, a recent paper casts light on the debate. It quotes one of his pupils, Guy de Chauliac no less, who claimed Mondino dissected multiple cadavers. It would seem this was most likely early in his career and with increasing seniority he retired to the chair above the proceedings. He would read from Galen and his assistant pointed at the relevant structures with a wand (Mavrodi and Paraskevas 2014). If the findings did not match Galen's descriptions it was regarded as a morphological transformation: such was the power of accepted authority (Frati et al. 2006).

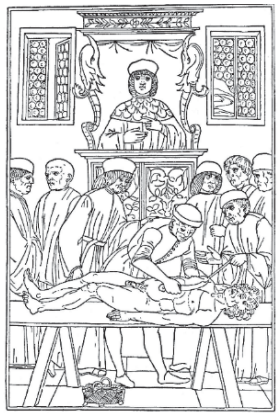

Figure 3.9
This figure shows Mondino supervising an anatomy class in Bologna. It should be noted that he sits above the class while junior associates do the actual dissection.

While the 'Anathomia' may not be an accurate text it was still an indicator of progress in the study of anatomy. It contained clear descriptions on the procedures of dissection. Thus, whatever his errors, Mondino had pioneered dissection as a component of teaching anatomy, both in the lecture theatre and in his publication. Let it be remembered that he was the first man to have performed human dissection to study and teach anatomy in over 1700 years. Thus, dissection was being undertaken in Bologna, no matter whether permitted or not. Then, in 1405 the procedure received official approval in the University statutes (Singer 1972). This was however still before the printing press using moveable type was invented in 1440.

Berengario Da Carpi (1460–1530)

The first anatomy text available using a printing press was Berengario da Carpi's Isagogae Breves published in 1522. It contains a number of fairly accurate but subsequently ignored findings concerning CNS anatomy. He mentioned the rete mirabile which was observed by Galen but declared that there was no rete mirabile in humans. He was the first to note this. He also had opinions about the nature and relations of cranial sutures. He stated that the dura was attached equally over the inside of the cranium and was not limited to attachment at the sutures as Galen had taught.

Figure 3.10
Figure from Berengario's Anatomy text 'Isagogae Breves'.

He discussed the side of paralysis following cranial trauma. He commented that Avicenna stated that paralysis was ipsilateral, and spasms (seizures) were contralateral. This localisation of seizures was in keeping with the teachings of Hippocrates. However, Da Carpi insisted that lateralisation can be the reverse of Avicenna's writing with ipsilateral seizures and contralateral paralysis. Even so, this insight would continue to be ignored by contemporary and subsequent colleagues.

He systematically studied anatomy in cadavers and published the results of his studies in the above mentioned Isagogae Breves. Figure 3.10 shows a printed woodcut from that book where the overall accuracy of the form and its perspective is demonstrated, even if the detailed accuracy of the anatomy is not of the same quality. This illustration is superior to any other previous anatomical illustration. Berengario's recommendations were thus better informed than any of his predecessors. Nonetheless, it would become clear that his insights and findings were ignored after his death so his knowledge did not have the impact it might have had.

Perspective

Human anatomy concerns the complex structure of the organism and not least the accurate inter-relationship of its multiple components. This is a study in three dimensional relationships and if these are to be recorded on paper, they must be realistic to be useful. This requires the use of a technique called perspective which presents a pictorial image on two surfaces so as to appear to be three dimensional. There is reason to believe that there were medical illustrations in the works from Alexandria from the fourth century BC. These had a specific form of five crouched figures demonstrating arteries, veins, nerves, muscles, and bones. These drawings were scholastic and schematic rather than realistic (Herrlinger 1970). However, during the early Renaissance, a new technique to employ perspective in painting was discovered and drawings could be more realistic. This is called linear perspective and requires that all lines within a painting will meet at some point. This technique was of great importance in the construction of

anatomy textbooks because the figures for the first time could show the correct relationships between the components of the body.

Andreas Vesalius (1514 – 1564)

The application of perspective to woodcuts produced by members of Titian's School of Art were essential in the production of a vital book in the mid sixteenth century which would form part of the basis for modern medicine, and which would enable escape from the stranglehold of the church supported authoritarian learning of the ancient world. This book was Vesalius' monograph 'De Humani Corporis Fabrica' published in 1543.

Every physician learns that modern anatomy began with Vesalius. However, we are not routinely taught about how this came about. Vesalius was born into a distinguished medical family in the Netherlands with contacts with royalty and universities. He started his formal education in Louvain in 1528 at the age of 14 and his major studies were the languages of Latin, Greek and Hebrew. It is recorded that while his Latin was fluent his Greek was patchy and his Hebrew non-existent (O'Malley 1964). Nonetheless, fluent Latin gave him access to a wide range of knowledge. In 1533 at the age of nineteen he moved to Paris to begin his formal medical education. Paris was prestigious but conservative and dissection, which had become legal, was only rarely practiced. Medical knowledge came from Arabic sources and from Arabic translations of the ancient masters. However, this was the time of the appearance of new translations of Galen directly into Latin which meant that a better quality of writing became thereby available. It is widely believed that Vesalius was opposed to Galen's teachings, but this is not the case. Rather he refused to accept them slavishly as gospel and rather tested them against the results of observation and noted discrepancies. While there was little dissection in Paris in his three years there, he increasingly took part in the presentation of dissections. In the tradition established two hundred years earlier in Bologna by Mondino and continued in the same place at the beginning of the 16th century by Giacomo Berengario da Carpi, he performed his own dissections and based his writings on what he observed personally.

Vesalius and his colleagues visited the Gibbet of Montfaucon where executed bodies were brought to rot to a condition where they could be disposed of. It was haunted by crows and pariah dogs but was a rich source of material for avid anatomists. There was also the Cemetery of the Innocents whence, as Vesalius remarked, there was "an abundant supply when I first studied the bone" (Catani and Sandrone 2015). This is so incredibly far

removed from the conditions of study in a modern medical school, where the corpses used for dissection are contained within sterile carefully maintained systems of storage.

Vesalius moved back to Louvain because of war and in 1537 completed his baccalaureate. By December of that year, he had moved to Padua where he was examined for the degree of Doctor of Medicine which he obtained with the highest distinction. The following day he was appointed professor of surgery in Padua at the tender age of twenty-three (Catani and Sandrone 2015).

This was an appointment which required the teaching of anatomy as well. He was well liked and influential because he did not delegate dissection to others but undertook it himself. This was novel and popular, and his classes were crowded. Moreover, he wrote down and published his anatomical findings with elegant illustrations because printing was available and because he had access to first rate artists trained in the laws of perspective. He found that his students welcomed these illustrations and in 1538 he published six large plates called the Tabulae Sex illustrating the skeleton from front, back and side together with the veins, arteries, and liver in a way to illustrate the physiology of Galen (Saunders and C.D. 1982).

It may be mentioned that he dissected the brain in situ taking horizontal sections from above downwards. It could take six heads to produce brain illustrations because the brains decomposed so quickly (Catani and Sandrone 2015).

Vesalius remained a thorough student of Galen and contributed to the publication of the old master's works in Latin in 1541. If nothing else, this is evidence that Vesalius did not oppose all Galen's teachings. Nonetheless, like Berengario Da Carpi he was willing to believe the evidence of his own eyes rather than the teachings of the past. Vesalius is credited with much improved illustrations of the brain, but he described two anatomically important errors, one concerning the arterial supply to the brain and the other concerning the classification of the cranial nerves. In his Tabulae published in 1538 he perpetuated the error that arterial blood reached the brain via a marvellous network or rete mirabile, which is not present in humans.

It should be remembered that Berengario Da Carpi had denied the presence of a rete mirabilis in his anatomy book 'Isagogae Breves', published fifteen years before Vesalius' 'Tabulae'. Five years later, in the

Fabrica, Vesalius had corrected this error (Russell 2013; Clarke and Dewhurst 1972c). Thus, he was learning from observation as time passed.

Modern No.	Modern Name	Galen	Vesalius
1	Olfactory	Not a nerve	Not a nerve
2	Optic	The soft eye nerves	1st pair of nerves
3	Oculomotor	The nerves moving the eyes	2nd pair of nerves
4	Trochlear	No Mention	3rd pair of nerves - Trochlear and Sensory Trigeminal
5	Trigeminal	3rd and 4th pair of nerves	4th pair of nerves Motor Trigeminal
6	Abducent	Combined with Optic	5th Pair of nerves facial acoustic complex and abducent nerve
7	Facial	Fifth pair of nerves	5th Pair of nerves facial acoustic complex and abducent nerve
8	Stato-acoustic	Fifth pair of nerves	5th Pair of nerves facial acoustic complex and abducent nerve
9	Glossopharyngeal	Sixth pair of nerves	6th and 7th pairs are a mixture of the glossopharyngeal, vagus and accessory nerves
10	Vagus	Sixth pair of nerves	6th and 7th pairs are a mixture of the glossopharyngeal, vagus and accessory nerves
11	Spinal Accessory	Sixth pair of nerves	6th and 7th pairs are a mixture of the glossopharyngeal, vagus and accessory nerves
12	Hypoglossal	Seventh pair of nerves	Not mentioned

Table 3.1
The table is an attempt to show the variations between Galen's and Vesalius' classification of cranial nerves compared with modern understanding. While the classifications of Galen and Vesalius were not identical, they were nonetheless much more like each other than like the modern classification.

Vesalius also described seven cranial nerves which look similar to the descriptions in Galen's 'On Anatomical Procedures' (Galen 2010a). The easiest way to explain this is by means of table 3.1 and figure 3.11. Explanations are given in the legends.

Base of the Brain

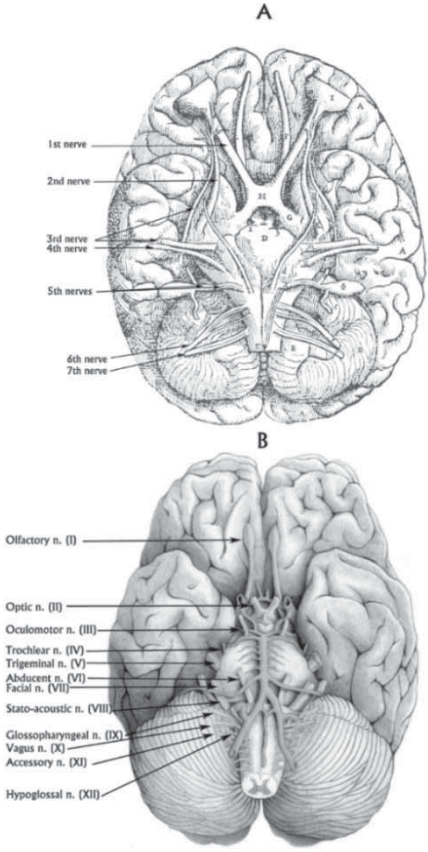

Figure 3.11
A: The base of the brain according to Vesalius
The first nerve is the optic, the second nerve is the oculomotor. The third nerve is the sensory root of the trigeminal with the trochlear nerve combined. The trochlear nerve is incorrectly attached. The fourth nerve is the motor trigeminal. The fifth nerves are the facial and stato-acoustic in combination. The sixth and seventh are the glossopharyngeal, vagus and accessory nerves mixed up together. The pons is particularly badly drawn.

B: The base of the brain today
There is no way to compare the Vesalius base of brain with that of Galen, because medical texts in the ancient world did not include illustrations. However, as seen in Table 13.1 the textual description of the two brain bases is similar and much more like each other than like the structure with which we are all familiar today. It remains obscure why such an accomplished observer as Vesalius could produce something so inaccurate. It has been furthermore pointed out how poorly the convolutions are drawn.

Thomas Willis (1621-1675)

The next advance on the understanding of the anatomy of the brain was the result of work by Thomas Willis in Oxford. He was fortunate, in the tradition of Vesalius, to obtain a great artist, Sir Christopher Wren, to illustrate his work ‘Cerebri Anatome’, published in 1664. One illustration in particular has been treated with great praise. It is shown in (figure 3.12) with modern labelling of the individual cranial nerves.

Modern No.	Modern Name	Galen	Willis No.	Willis Name
I	Olfactory	Not a nerve	I	Olfactory nerves
II	Optic	The soft eye nerves	II	Nerves of visual perception
III	Oculomotor	The nerves moving the eyes	III	Nerves moving the eyes
IV	Trochlear	No Mention	IV	Pathetic Nerves of the eyes
V	Trigeminal	3^{rd} and 4^{th} pair of nerves	V	Trifacial nerve: Sensory Branch and Motor Branch
VI	Abducent	Combined with Optic	VI	Pair of small nerves moving the eyeball
VII	Facial	Fifth pair of nerves	VII	Facial and auditory nerve
VIII	Stato-acoustic			
IX	Glossopharyngeal	Sixth pair of nerves	VIII	Wandering or Vagus nerve
X	Vagus			
XI	Spinal Accessory			
XII	Hypoglossal	Seventh pair of nerves	IX	Motor nerve of the tongue

Table 3.2
The table is an attempt to show the variations between Galen's and Willis' classification of cranial nerves compared with modern understanding.

Table 3.2 shows the differences between the modern classification, the classification of Galen and that of Willis. Like Vesalius and Berengario da Carpi, Willis was concerned with the findings of personal observation and experiment rather than the scholastic teachings of authorities from the past.

An edited version of the Wren drawing shown in figure 3.13 emphasises the arterial anastomoses which bear Willis' name. As so often, in situations where different investigators report differing findings from each other, the reason is due to differences in methodology. Instead of removing the brain slice by slice, Willis removed the brain in toto and then fixed it using

alcohol, thus gaining much more time in which to examine and described its structure (Arráez-Aybar et al. 2015).

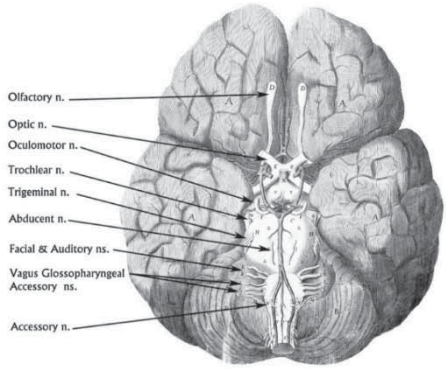

Figure 3.12
Base of the Brain Willis and Wren.
The labels are modern. The anatomy while not wholly accurate is a great improvement on the illustration in Vesalius. There are nine nerves recognised (see table 3.1). The pons is certainly much better drawn. The cerebral convolutions are rather diagrammatic illustrating that they really only serve as background. So, while a great improvement this illustration, despite its fame is by no means completely accurate compared with figure 3.11 B.

Figure 3.13
The arteries highlighted in black show the description of the circle of anastomoses which constitute the Circle of Willis. This drawing once and for all put paid to the notion there was a rete mirabile under the brain in man.

Samuel Thomas Soemmerring (1755–1830)

The son of a physician, Soemmerring was born in Thorn in what was then East Prussia but is now Torun in Poland. He would grow into a man of great ability, described as a polymath with contributions in anatomy, draftsmanship and inventions. Towards the end of his medical studies, he accurately described the twelve cranial nerves, a classification which remains in force today. This was published in 1778 one hundred and fourteen years after Willis. This shows great independence of mind since it was an attack on accepted teaching. Even so, he remained infected with

Galenic notions believing that the CSF was the organ of the soul (Pearce 2017).

Cerebral Convolutions

From ancient times it had been known that the brain was soft and covered with meninges. Certain obvious structures had been observed and named like the cerebrum, cerebellum, the ventricle system, the brainstem, the cranial nerves, some of the veins and the arteries of the Circle of Willis. Two other regions required improved observation and classification. These were the surface of the brain and the basal ganglia. It is hard for us to understand in the twenty first century but up to the late fifteenth and early sixteenth centuries, anatomical illustration in effect did not exist. Anatomy was taught on bodies by lecturers but there were no pictures or diagrams to help as 'aides de memoire'.

This brings us to another phenomenon. Claude Bernard was at pains to emphasise in the first chapter of his book 'Introduction a L'Étude de la Médecine Expérimentale' that scientific observation is an active process (Bernard 1957). Passive observation, for example looking at the surface of the brain without any questions as to its nature and function could easily lead to misrepresentation and inaccuracy. It is not unreasonable to suppose that in the absence of any clear notion of the function of the cerebral surface that its observation might have lacked analytical insight. Yet another reason for lack of interest and attention to the anatomy of the cerebral cortex could have lain in the repeated observation that loss of brain tissue was not necessarily followed by loss of function. This had been noted over the centuries by many observers as shown in table 3.3. In addition, Galen had, as noted above, determined that the cerebral surface could not be important.

Surgeon	Dates	Observation
Galen (Galen 1968a)	ca 130 - ca 210	Saw a patient in Smyrna who survived injury to the ventricle
Bruno da Longoburgo (Longoburgo 2003)	ca 1200 – 1286	Fractures with visible brain may survive
Theodoric (Theodoric 1955)	1205 - 1298	A Chair Maker with head injury and great brain loss Memory retained – Skill lost
Guy de Chauliac (de Chauliac 2007)	1300 - 1368	Head Injury with extruded brain – retained some memory
Lanfranc (Lanfranc 2003)	ca 1250 - 1306	Brain loss can be survived. Ventricle injury cannot.
Henri de Mondeville (De Mondeville 2003)	ca 1260 - 1316	Removed bits of brain adherent to arrows in patients who survived
Berengario da Carpi (Carpi 1990)	1460 - 1530	Saw several survive brain loss some but not all with a paralysis
Ambroise Paré (Johnston 1649)	1510 - 1590	Saw a page boy with a depressed fracture who lost a hazelnut of brain yet survived
Richard Wiseman (Wiseman 1734)	1621 - 1676	Showed an awake patient the brain substance removed from his wound
Willhelm Fabry (Turner 1736)	1560 - 1634	Saw a maid with a head injury and extensive brain loss who could continue with her duties
Daniel Turner (Turner 1736)	1667 - 1741	Saw a little girl with frontal depressed fracture and much brain loss who became a wife and mother

Table 3.3
This table demonstrates that eleven distinguished surgeons from the ancient world up to the eighteenth century had seen patients with severe injuries and brain loss, who were able to function more or less normally afterwards. Since there was no thought that different parts of the brain had different functions, it was easy to conclude that the brain had limited if any clinically recordable function.

Figure 3.14 shows pictures of the surface of the brain demonstrating how as late as the eighteenth century it was being drawn with little focusing on its real structure. The first step towards gaining an understanding of the surface came once again from Thomas Willis. He introduced a new concept denying the ‘Cell Doctrine’ which placed intellectual functions in the ventricles. He was still influenced by the physiological concepts of the past, so he expressed himself in terms of psychic pneuma. He considered that entity was produced not in the rete mirabile or cerebral ventricles but in the cerebral and cerebellar cortex (Clarke and Dewhurst 1972a). Thus, memory

Figure 3.14
Outer Surface of the Cerebral Hemisphere
A: Vesalius (1543)
The surface shown is poorly drawn and lacks specific features.
B: Vicq d'Azyr (1781)
Again, the surface shown is poorly drawn and lacks specific features.

and the will were to be located in the cerebral gyri, while imagination was delegated to the corpus callosum. In addition, the basal ganglia were thought to be involved in sensation and movement (Finger 1994c). Despite Willis' notions directing attention to the importance of the cerebral gyri, in Wren's drawing of the base of the brain the gyri are loosely drawn when considered against the detail of the arteries and nerves. They serve more as a background than structures of interest.

Franciscus (De Le Boë) Sylvius (1614 - 1772)

Sylvius was a most distinguished physician and scientist who was appointed to the chair of Practical Medicine in the University of Leyden. This is the oldest university in the Netherlands having been founded by William the Silent in 1575. Later incumbents would include Herman Boorhaave, that most famous of teachers of medicine and in recent times Albert Einstein. Sylvius was one of the first professors to teach medicine at the bedside. He promoted the controversial teachings of Harvey on the circulation of the blood. Like Willis, he emphasised the need to rely on observation and to depart from the theoretical scholasticism on which Galen's teachings had come to be based (Parent 2016b). He was a noted anatomist dissecting around three hundred cadavers. He dissected the brain out of the head and described two structures which bear his eponymous name, the aqueduct (see figure 3.5), and the fissure (see figure 3.15). It should be noted that the Rolandic fissure is not depicted. That would come much later.

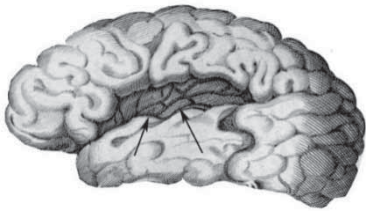

Figure 3.15
Outer Surface of the Cerebral Hemisphere
For the first time an image is published which shows the Sylvian Fissure which is such a prominent and consistent part of cerebral anatomy. The fissure is indicated by the two arrows.

René Déscartes (1596 - 1650)

Déscartes, the French philosopher and mathematician published a number of books the first of which was 'A Discourse on Method'. He wished for scientific thought to be based on secure and irrefutable knowledge. He basically doubted all information and when challenged indicated the only thing of which he could be certain was his own thought, encapsulated in the famous Latin version 'Cogito ergo sum'. The basis of his method was four principles (Déscartes 1912):

1. Accept nothing as true before excluding all ground for doubt.
2. Divide difficulties into as many parts as possible.
3. Proceed from the simple to the complex.
4. Make enumerations complete and reviews general.

He believed that the natural world could be expressed in mathematical terms which led him to invent Cartesian geometry. A book of his called 'L'Homme' was published in 1662, twelve years after his death. The delay was because the atheistic nature of much of its contents caused the Roman Catholic church to ban all Déscartes' books. Man was presented as a combination of complex interacting physical components. However, Déscartes was a devout Catholic Christian, and this required him in addition to an account of the soul. He solved this dilemma by proposing that the body was made up of two types of substance, physical and mental. The latter could not be examined and had no dimensions. The soul of course was a mental substance and Déscartes located it in the pineal gland.

He made one further important contribution, the notion of the reflex. This was an automatic response of the body to a stimulus without the intervention of the will. He believed the underlying mechanism involved messages passing along the nerves (Wickens 2015).

Niels Stensen (1638-1686)

A less well remembered figure in debates about neuroanatomy in the seventeenth century was Niels Stensen more often referred to by his Latin name of Steno. He was a Dane, born in Copenhagen. A war between his country and Sweden compelled him to go on his travels. In the early 1660s he was working in Leyden where he received instruction from the celebrated Sylvius. He left Leyden, as family matters required his return to Denmark in 1663. When these were sorted out, he left Denmark and obtained a post in Paris as an anatomist. There he dissected cadavers in a variety of locations

and also performed experiments on living animals. He became a member of a group of like-minded research orientated colleagues and in 1665 he presented a lecture 'Discours sur l'Anatomie Du Cerveau' or 'Lecture on the Anatomy of the Brain'. This was one year after the publication of Willis' 'Cerebri Anatome' and three years after Déscartes' 'L'Homme'. It contained a number of criticisms of these influential and seminal works. Moreover, the criticisms were well reasoned and appropriate. Firstly, he had great respect for Déscartes' 'Discourse on Method'. What he objected to was Déscartes' failure to apply his own method to the study of the brain. He admired the reflex theory but thought that the pineal gland was not an interface between the mind and the body. He demonstrated that Déscartes' description of pineal gland anatomy was incorrect and inconsistent with Déscartes' view on how the mind body interaction could work.

Steno was also critical of the work of Willis. He proposed quite rightly that Willis had no evidence to support his notions that common sense was located in the basal ganglia, that imagination was in the corpus callosum and that memory was located in the cerebral gyri. He was also quite rightly critical of inaccurate anatomical illustrations which copied errors from book to book (Parent 2016a). A celebrated Viennese medical historian Max Neuberger wrote of Steno's 'Lecture on the Anatomy of the Brain'.

> "These words, which are among the finest of the medical literature of the seventeenth century, formulated a program of research aimed at a precise physiology of the nervous system, applicable not only at that time but even today. Just like lightening flashing in a dark night and illuminating the clouds' turmoil with sudden brightness, so Steno towered over his contemporaries, who believed their gross errors to be the truth; and he endeavoured to remove the blindfold from the eyes of the select few who were capable of seeing" (Neuberger 1981).

Luigi Rolando (1773 – 1831)

Rolando was a quiet man whose life was characterised by unusual difficulties. His father died before he was born. He was living in Turin, the capital of the province of Piedmont when this was annexed by Napoleon. The court of Piedmont decamped to Sardinia. Rolando was offered a post in Sardinia but could not leave the mainland because a Yellow Fever epidemic placed the port in quarantine. All these chance elements played a part in delaying his work. However, it was only delayed. At that time there was a debate about the nature of cerebral function. One group thought the brain operated holistically without anatomical location of function. Others, including Rolando insisted that functions were separated in specific

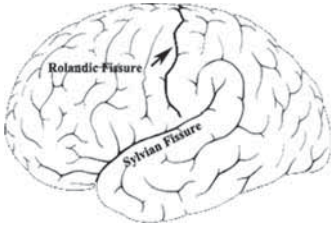

Figure 3.16
Outer Surface of the Cerebral Hemisphere
For the first time an image is published which shows the Sylvian Fissure which is such a prominent and consistent part of cerebral anatomy. The fissure is indicated but the arrow.

locations. He then noted that there were a series of gyri that rose almost vertically from the Sylvian Fissure with a constant fissure between them. This came to be called the Rolandic Fissure, with motor function in front and sensory function behind (see figure 3.16). This finding was published in 1829 (Caputi et al. 1995).

In Summary

This chapter traces the convoluted pathway by which brain anatomy came to be understood. The difficulties delaying the acquisition of anatomical knowledge are outlined at each stage. Thus, before anatomy was studied as a subject worthwhile in its own right, there were plenty of examples showing how anatomical knowledge, which was useful for a particular purpose, like slaying a hunted animal, did exist though probably barely at a conscious level.

The ancient Egyptians seem to have been observant and noted many findings which would remain hidden in view of the loss of their documents and language until the twentieth century. Hippocrates while aware of structures in the skull was not really a student of anatomy as such. He had his own ideas, one of which was that it was dangerous to include a suture in a trepanation opening. This teaching compounded by Galen's notions that for different reasons the sutures should be avoided must have been a significant limitation of what was possible. However, another potent force for the persistence of disinformation, namely the preference to believe the accepted truth at the expense of personal observation maintained the teaching for centuries.

Another potent agency for preventing anatomical study was social distaste for dissecting corpses which apart from a brief period in Alexandria, plagued all anatomical research until the Renaissance. Galen alone was a persistent and brilliant anatomist. Unfortunately, he could only work on animals which led to errors where animal and human anatomy differed.

The rise of a Christian Church which came to have great social authority discouraged research and attempted to stop it by publishing harsh regulations. This authoritarian scholasticism was underpinned by Galen

who wrote repeatedly about how the creator had made everything optimally fit for purpose.

At the beginning of the Renaissance, Mondino in Bologna presided over human dissection. The hold Galen had on medical teaching meant that where the dissector found something that was not in keeping with Galen, the finding was said to be an anomaly. Berengario da Carpi made a number of observations not in keeping with Galen but they were ignored; a prime example of how the authority of the accepted could override personal observation and experience. Vesalius, while producing the single most important text in the history of academic anatomy, still followed Galen and initially described a rete mirabile but in fairness admitted the error in later writings. Even so, Vesalius' description of and illustration of the brain stem is a long way from the actual anatomy. On the other hand, Vesalius had access to a technology denied earlier writers. The printing press and the possibility of demonstrating anatomy with expert artists familiar with the illusion of perspective in painting, greatly improved the author's ability to illustrate and spread his ideas.

It would take a long time before the base of the brain was properly illustrated. Willis of Oxford used a new technique of fixation which permitted a much greater time for the examination of brain structure. Even so his description of the cranial nerves was not entirely accurate, and more than a century would pass before the errors in the description of these structures were finally determined.

It is fascinating how scientist after scientist reviewed and arranged drawings of the cerebral cortex without really seeing it. It took from 1543 when Vesalius published his anatomy text to 1829 before an accurate rendition of the cerebral surface was possible; an appearance which has remained essentially unchanged to this day.

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CHAPTER 4

BLOODLETTING

Introduction

The origins of bloodletting go back to Hippocrates with its application potentiated by Galen. However, it would seem that the principles underlying its use was not limited to the classical medicine of Greece and Rome. Taking of blood by scarification is mentioned in the Ebers papyrus. Cupping was mentioned by Herodotus and there were references to it in the Talmud (Parapia 2008).

However, the origin of the tradition which followed through Galen to affect European medicine up to the twentieth century lies with Hippocrates. It all began innocently enough and with the best of intentions. Hippocrates believing that diseases were natural phenomena and not the result of supernatural or divine intervention required a mechanism which would explain the nature of his observations. There were no means for performing scientific analysis of his thoughts and indeed the intellectual milieu which would permit such analysis would have to wait upon the Renaissance nearly two millennia after Hippocrates' death.

The ideas start with Empedocles (ca. 490BC – ca 430 BC) who had studied with Pythagoras (ca. 570 BC – ca. 495 BC) and may well have been influenced by the importance of the number four in Pythagoras' scheme of things. Whatever the reason, he came up with the idea that matter was composed of four elements, air, earth, fire, and water. Their interactions were governed by two forces of love and strife (Kingsley 2020). His concepts are pleasingly modern involving notions equivalent to conservation of mass and energy. It was his contention that the four elements were present in unchanging amounts. They were made of different qualities so that air was wet and hot, water was wet and cold, earth was dry and cold, and fire was dry and hot. From these notions a system of physiology developed most probably by Hippocrates.

The humours were blood, phlegm, yellow bile, and black bile. Blood was hot and wet, phlegm was cold and wet, black bile was cold and dry and yellow bile was hot and dry. The concept behind the humours was that they should be in balance in a healthy patient. This was a state of eucrasia = eu (normal) + krasis (mingling). Excess of one humour led to imbalance and sickness. The word was dyscrasia from dys (abnormal) + krasis (mingling). The word dyscrasia has persisted into modern times being used only a few years ago as part of the terminology of blood disorders.

In the event of disease one or more of the humours must be deficient or in excess and the way to rectify this imbalance was to remove humours from the body by means of inducing vomiting, defaecation or by removing blood, which would become by far the most popular. This is because the amount of blood removed, and the speed of removal was so easy to control. This well-meaning idea led to untold damage and unnecessary suffering for the next two thousand years. The purpose of this chapter is to outline in a little more detail the extent of the problem. It may be mentioned that Hippocrates' attitude to bloodletting was hardly enthusiastic, though he did describe the technique.

Celsus (ca. 25 BC – ca. 50 AD)

While as previously stated, the work of Celsus would be unavailable until the fifteenth century, he remains the first author after Hippocrates to pronounce on the subject of bloodletting. The method would become popularised by Galen so that the lack of Celsus text would have had limited influence on the practice of subsequent surgeons. Celsus sets the scene for his attitude to bloodletting as follows.

> "To let blood by incising a vein is no novelty; what is novel is that there should be scarcely any malady in which blood may not be let" (Celsus 1938).

He is however not indiscriminate in his application of the technique. He considered dark blood should be removed but if the blood was red then bloodletting should cease. Diseases for which Celsus advocated it included, pestilence, chronic epilepsy, persistent severe headache, facial palsy, tetanus, dyspnoea, pleurisy, and intestinal obstruction. Celsus is also at pains to mention that in the hands of incompetent practitioners it can be a risky procedure. He wrote:

> "Now blood-letting, whilst it may be very speedily done by one practised in it, yet for one without experience is very difficult, for to the vein is joined an artery, and to both sinews. Hence should the scalpel strike a sinew, spasm

> follows, and this makes a cruel end to the patient. Again, when an artery is cut into, it neither coalesces nor heals; it even sometimes happens that a violent outburst of blood results. As to the actual vein, when completely divided by a forceful cut, its two ends are pressed together, and do not let out the blood. Yet if the scalpel is entered timidly, it lacerates the skin but does not enter the vein; at times, indeed, the vein is concealed and not readily found. Thus many things make difficult to one who is unskilled what to one experienced is very easy." (Celsus 1938)

Galen (ca 130 – ca 210)

Galen was enthusiastic for bloodletting. In his early days in Rome, he ran into conflict with physicians who avoided phlebotomy. He wrote three texts on the subject reviewed in a recent book. He cited Hippocrates as his source, but it would seem that while Hippocrates performed bloodletting, a review of the Hippocratic corpus found only around seventy references to it and most of them just a few lines in nine large volumes (Brain 1986b). However, the author of the review points out that Galen tended to invent the Hippocrates which suited him.

It would seem that Galen developed quite a complex set of notions to guide the would-be phlebotomist. Details would include the quantity of blood to be removed. The physician must decide if blood should all be taken at one time. In that case it was mentioned that the blood could be removed until the patient lost consciousness. Alternatively, smaller amounts of blood could be removed in stages. There was a need to decide which vein to use and to match the choice of vein to the condition of the patient. The pulse was checked during the procedure and changes in volume or rhythm could lead to stopping the removal of blood. He also mentioned arteriotomy, but this is a less common procedure (Brain 1986a). What is important is that Galen's enthusiasm would imprint the need for the method right up to the time when scientific medicine arrived many centuries later. The above-mentioned review does not contain a concise list of indications for the method. It does however recount that there were multiple situations where Galen recommended phlebotomy for pain.

Aretaeus

The works of Aretaeus who is believed to have been a fairly close contemporary of Galen have been translated by that inexhaustible interpreter of ancient medical texts, Francis Adams. In this translation there are descriptions of the various diseases for which bloodletting was appropriate.

The list is enormous and includes the following, Encephalitis, Lethargy, Apoplexy, Acute Epilepsy, Tetanus, Quinsy, Enlarged Uvula, Tonsillitis, Pleurisy, Pneumonia, Haemoptysis, Syncope, Ileus, Liver Disease, Acute Disease of the Aorta and of the Vena Cava, Kidney Inflammation, Hysterical Convulsion, Satyriasis, Cephalea, Vertigo, Chronic Epilepsy, Melancholy, Urolithiasis and Elephantiasis (Aretaeus 1856).

Description of the Procedure for Surgery

Medieval surgeons had much to say about bloodletting. The most comprehensive information about its use was provided by Henri de Mondeville. He starts off with an account of who should perform the procedure. He states:

> "Phlebotomy is a medical measure that uses a surgical operation. A physician determines the need and the surgeon carries it out; both of them have the same goal, the health of the patient. Long ago the physicians ceased doing it themselves as beneath their dignity, so they say, and ceded it to the surgeons. More recently, the surgeons have ceded the operation to barbers, with two excuses. 1. It does not pay well. 2. It requires little skill."

He proceeds to define the necessary characteristics of those who perform phlebotomies.

> "He should be of middle-age, have sturdy limbs and steady hands. His eyesight should be good so he can identify the veins commonly used for phlebotomy and recognize arteries and the nerves that lie beneath them so he can avoid them. He must not bleed a sick person unless that has been requested by a physician or a credited surgeon. Nor should he bleed a child or a domestic or other kind of servant, nor the mistress of the house without her husband's permission, especially if he is a rich or famous or noble person. He should own a good supply of sharp, clean and polished lancets with narrow blades set at angles of various degrees. He must be able to use all of them skillfully, as suited for each case. He should profess himself to be as skillful in the procedure as any other, or at least state that one cannot find another phlebotomist as capable as himself because he then will be trusted above others. He should make that claim before performing the phlebotomy and other simple and commonly performed operations. In that way the patient's imagination and confidence will help, and will assure success without doing any harm."

The list of indications was as follows:

> "We bleed patients who suffer from recurring abscesses and boils, from anthrax, fevers and overindulgence with meats and cheeses and wine and

> sweets, and those who are idle and foppish, and those who eat too much broiled food and then generate too much blood and those who drink too much heavy wine, and those who have too much melancholic blood, that is, the red humours which accompany blood as it flows through the body, and those in whom you suspect there may be an internal overheating (i.e. combustion) of humours and the like, or who may have an inflammation on the surface of the body accompanied by a fever, and in those who may have had a prolonged course of treatment of a malady during the warm seasons, and those with strong vital spirits and a sanguinous complexion and who grow bushy hair. We include those who suffer gout and other kinds of inflamed joints, and those with paroxysms that occur with sanguinous disorders, who have continuous fevers and large inflamed internal or external masses or pleurisy or buboes, and those who suffer spasms of repletion and various similar maladies"

It may be seen that virtually anybody could be thought to benefit. There was also a list of contra-indications and not least it was not an appropriate treatment for a child of nine years or less (de Mondeville 2003).

Bloodletting and Cranial Surgery

The previous section gives a clear indication of the prevalence and widespread use of bloodletting, but the question remains what was its place in patients requiring cranial surgery? The first of the medieval surgeons, Roger Frugard makes no mention of phlebotomy or venesection but does occasionally mention 'bleeding' though not in the management of cranial injury. On the other hand, Roland of Parma mentions it in an addendum to Roger's text; for swellings to the head caused by blows (Frugard 2002). In his own book Roland advocates avoiding phlebotomy in patients who are in a desperate condition following cranial trauma, since the extra blood loss may not be tolerated (Parma 2002). It should also be avoided in patients with a full thickness cranial fracture with meningeal or cerebral injury, for fear that the procedure will further weaken the patient. However, if the forehead and face are wounded and initial bleeding is inadequate it may be employed. It should be performed by opening the cephalic vein on the opposite side. This is the first mention of phlebotomy location in patients with cranial trauma.

Theodoric quoted Avicenna as recommending phlebotomy in cases of full thickness scalp lacerations but only when needed without defining how that decision is reached. Theodoric himself used it in cases where the meninges became inflamed (Theodoric 1955). William of Saliceto advocated phlebotomy for blows on the head with a wound, and with or without a

fracture and to sword wounds. The blood should be removed from the cephalic vein on the opposite side. The purpose was to divert bad humours away from a wound (Saliceto 2002a, 2002b).

If the patient with a head wound is strong enough Lanfranc bled him or her from a cephalic vein without specifying which side. He also had a separate chapter devoted to phlebotomy. He identified three groups whose members can benefit from a phlebotomy. The first have routine phlebotomies as a hygienic practice to maintain good health. A second group included people in whom it was performed early as a pre-emptive measure against aches and pains in joints, chronic persistent fevers, quinsies or pleurisies. It might abort the symptoms if applied early. The third group had severe headaches without fever or quinsies or pleurisies, or pneumonia or abscesses and any plethoric disorder. In this group the phlebotomy was not pre-emptive but therapeutic (Lanfranc 2003). He also detailed the correct location for individual phlebotomies.

Guy de Chauliac included a systematic account of the technique and applications of phlebotomy. His definition is that phlebotomy is:

> "an incision in a vein to evacuate blood and its humours".

His practice is based on a set of queries which he calls bases. Five of these from Galen and two he has added himself. The bases are as follows.

1. Is evacuation necessary?
2. Should it be phlebotomy?
3. Can the patient tolerate it?
4. What veins should be opened?
5. How much blood should be taken?
6. What is the right time to bleed?
7. This concerns the choice of phlebotomist and the correct way to perform the procedure before, during and after.

It is considered that phlebotomy serves one of six purposes.

Evacuation: When there is plethora (excess of blood)
Diversion: E.g. in epistaxis from the right nostril bleed from the right hand
Attraction: For example, to induce delayed menstruation
Alteration: In fever bleed almost to the point of heart failure to cool the body

Prophylaxis: In Spring: quinsy, pleurisy, epilepsy, and apoplexy will be avoided.
Alleviation: Useful in periodic fevers, fevers accompanying suppuration.

The prophylactic application was useful in wounds to prevent complications, particularly infection. Therapeutic phlebotomy was particularly directed against fevers and suppuration. It seems fair to say from a modern perspective that this is all nonsense and yet it was passionately believed by a man of de Chauliac's erudition and experience. (Chauliac 2007))

Berengario da Carpi, repeatedly quoting Rhazes and Avicenna advised phlebotomy in the treatment of cranial fractures. The benefits include treatment of abscesses in the wound and post-traumatic headache (Lind 1990).

Ambroise Paré introduces a charming story about phlebotomy claiming:

> "The benefit of Phlebotomie, we owe unto the Hippotamus or River-horse, being a kind of horse, and the Inhabitant of the River Nile; who being a great devourer, when he finds himself surcharged with a great deal of blood, doth by rubbing his thigh against the sharp sands on the bankside, open a vein, whereby the superfluous blood is discharged, which he stoppeth likewise when it is fit, by rowling himself in the thick mud." (Johnston 1649b).

On a more serious note, he wrote:

> "Universal remedies are Phlebotomies.....For Phlebotomy it is not alwayes necessary, as in small Wounds and bodies, which are neither troubled with ill humours, or Plethorick: But it is only required in great Wounds, where there is fear of defluxion, pain, Delirium, Raving and unquietness." (Johnston 1649a).

He went on to advocate phlebotomy for post-traumatic erysipelas, in plethoric patients after cranial trauma and infected meninges. He discussed which side to use. He also repeated that the procedure must be governed in part by the status of the patient and in part by the seriousness of the affliction. With the passage of the centuries the indications for phlebotomy were not decreasing. Paré like many of the later authors did not give specific comments related to cranial surgery. He noted phlebotomy is a universal remedy.

Richard Wiseman on the other hand specified exactly which patients with cranial trauma were subjected to phlebotomy. The diagnoses included

superficial contusion, concussion, simple incised wound, contused wound, traumatic loss of scalp, cranial fissure, depressed fracture. (Wiseman 1734)

Le Dran, the representative of the French Academy whose work introduced the notion that symptoms after cranial injury were due to brain trauma was an enthusiastic user of phlebotomy. He used it for concussion, the lethargy following concussion, contusion of the pericranium, concussion with a fracture, a contusion with an epidural haematoma, a simple wound, a cranial wound infection, and contusion of the cranial bone. (Le Dran 1740)

Percival Pott advocated phlebotomy for small wounds with infections, infection of the meninges, bone contusion, wound contusion, simple fracture, and suppuration. (Pott 1768)

James Hill mentioned it little but suggests it may help reduce symptoms with depressed fractures, with and without infection. It could also be used in concussion. It may be relevant that Hill's friend and physician colleague in Dumfries, Ebenezer Gilchrist was known for his sceptical attitude to bloodletting and cupping (Loudon 2004).

John Abernethy recorded he used phlebotomy in cases with depressed fracture with or without laceration, epidural haematoma, cerebral contusion, and meningeal inflammation (Abernethy 1810)).

The End of Bloodletting

How was it possible for such an ineffective, uncomfortable, and potentially dangerous technique to be taken up and then perpetuated and with such enthusiasm? The answer in part lies as mentioned earlier in the willingness with which people accept what is already accepted. Amongst the patients of more recent years who have been subjected to phlebotomy were George Washington and Napoleon Bonaparte. George Washington had an infection in his pharynx, possibly epiglottitis and or quinsy. On December 13th, 1799, he was bled a total of 2365 ml over twelve hours. Soon after he succumbed (Parapia 2008). Napoleon, suffered phlebotomy and survived It was said that he described doctors as follows:

'Medicine is the science of murderers' (Parapia 2008).

King Charles II died shortly after a phlebotomy following a stroke. Queen Anne had two fits, became unconscious, suffered a phlebotomy, and died two days later. Lord Byron, who died of encephalitis, was bled several times prior to his death. He commented:

> "Come as you are, I see a damned set of butchers. Take away as much blood as you will; but have done with it" (Parapia 2008).

Thus, people who elected to undergo the procedure were by no means necessarily simple minded or stupid and experienced it as distinctly unpleasant. And yet they accepted it, even though it could not have improved their health in any way and on the other hand could easily have made them worse. The persistence of bloodletting remains surprising. It was still being recommended for pulmonary congestion or venous engorgement in the first edition of Davidson's 'Principles and Practice of Medicine' published in 1952.

Bloodletting could in most instances do no good and with proper observation would have been seen to be useless. It was moreover a procedure not without risk and certainly accompanied by potentially great discomfort. Yet once again, the practice was imbued with the mantle of professional acceptance and this was sufficient to persuade even the most gifted citizens to permit themselves to be subjected to it.

In Summary

Bloodletting was derived from a theoretically derived physiology based on the maintenance of the balance of four notional humours. Its theoretical basis was derived by Hippocrates and was followed enthusiastically by Celsus but more especially by Galen. The latter's influence and reputation ensured the placing of bloodletting into the accepted measures of treatment. This chapter gives an overview of the popularity of the treatment and the wide variety of indications.

It has been a basic premise of this book that the tendency to accept the teachings of one's seniors and accepting what is already generally accepted while understandable should really be the object of constant renewed scrutiny. The replacement of teaching by observation has been a hallmark of scientific progress from Galen to the Renaissance and beyond. So powerful is the tendency to accept the accepted that even the most gifted citizens permit themselves to be the subject of standard practice, no matter how little evidence there is to support it.

Finally, it came as a surprise to learn that bloodletting was still being advised in 1952 for the contemporary edition of Davidson's textbook on medicine for students. It was only nine years later that the current author purchased a later edition of the renowned textbook.

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CHAPTER 5

THE PAIN OF SURGERY

Introduction

How do patients and surgeons cope with the pain? We would all agree that the introduction of anaesthesia in 1846 resulted in two major changes. The first and most obvious is the removal of pain itself. The second is it opened the door to longer operations. In time this would be vital for neurosurgeons since their specialty demands lengthy delicate operations which would be impossible for someone in a hurry to complete a procedure.

Relatively little has been written in historical surgical texts about the pain of surgery but there is some material which enables us to gain at least a limited insight into how patients could be persuaded to accept the unavoidable suffering. In part this involved forceful immobilisation and in part it involved the attitude of the surgeons. It is necessary to reflect on certain facts of life before the twentieth century. Today, we live in societies where the automatic response to pain is to seek and apply some form of pain relief. Despite a history of the use of the derivatives of willow bark going back to Hippocrates, aspirin became commercially available only in 1897. Paracetamol became commercially available in 1950. Thus, prior to the beginning of the twentieth century every-day life for the whole of humanity included a lack of painkillers. Accidents and violence accounted for a large proportion of a surgeon's practice and the literature is full of accounts on how to treat injuries resulting from sharp implements including not least how to remove arrows.

We can learn something from Plutarch's biography of the Roman general and seven times consul, Gaius Marius.

> "Both his legs, it is said, had become varicose, and as he disliked this deformity, he resolved to put himself in the surgeon's hands. Accordingly he presented to the surgeon one of his legs without allowing himself to be bound; and without making a single movement or uttering a single groan, with steady countenance and in silence he endured excessive pain during the operation. But when the surgeon was going to take the other leg, Marius

> refused to present it, saying that he perceived the cure was not worth the pain." (Plutarch 1899)

Marius' refusal is easy to understand, and it remains amazing that he permitted the first operation to continue to a conclusion. However, the undoubted fact remains that throughout history, individuals did suffer the tortures of surgery when convinced it was necessary. There seems to have been a greater acceptance of the unavoidable.

One may ask how the early surgeons reacted to the pain they caused. While the first descriptions of patients with surgically remedial conditions were to be found in the Edwin Smith papyrus it was Hippocrates, who wrote the earliest available texts on surgical technique. He died around 370 BC or roughly 2400 years ago.

Surgical Pain and Immobilisation through the Centuries

It seems obvious today that the pain of surgery without anaesthetic would be an important component of any surgeon's life and that there would be adequate descriptions of how to minimise it in any surgical text. This turns out not to be the case. This statement is based on the analysis of a number of historical texts on surgery, quotations from which form the basis of this chapter. The earliest comments are from the work of Hippocrates.

Hippocrates

Hippocrates wrote about certain technical details applicable for surgical procedures.

> "In surgical operations that consist in incising or cautery, speed or slowness are commended alike, for each has its value. In cases where the surgery is performed by a single incision, you must make it a quick one; for since the person being cut generally suffers pain, this suffering should last for the least time possible, and that will be achieved if the incision is made quickly. However, when many incisions are necessary, you must employ a slow surgery, for a surgeon that was fast would make the pain sustained and great, whereas intervals provide a break in its intensity for the patients." (Hippocrates 1995b).

Hippocrates performed trepanations (Hippocrates 1992) and treated haemorrhoids (Hippocrates 1995a) surgically and left detailed instructions on the techniques involved. He did not cut for stone suggesting that it was better performed by those who were expert in the technique (Riches 1968). Nonetheless he mentioned that:

> "Any physician could penetrate the bladder to find a stone through a penis catheter". In addition, he stated: "All symptoms caused by a bladder stone, can only be cured through surgery" (Tsoucalas and Sgantzos 2017)

Anyone who has cared for patients after haemorrhoidectomy will recall the tense, drawn facial expression until the first post-operative passage of faeces. It is never necessary to ask a sufferer if he or she 'has done their business'. The relief shines from the patient's face. It is thus of interest to recall Hippocrates account of the correct way of cauterising piles. He begins:

> "First undertake to find out where the haemorrhoids are; for to incise the anus, to amputate from it, to lift it by sewing, to cauterize it, or to remove something from it by putrefaction – these seem to be dangerous, but in fact will do no harm. I bid you to prepare seven or eight irons, a span in length and the width of a wide probe; bend these at the end like a small obol (? spit ?). Clean the site you are attempting to cauterize beforehand with a medication, have the person lie on his back, and place a pillow beneath the loins. Force the anus out as far as possible with your fingers; heat the irons red-hot, and burn until you so dry he haemorrhoids out that you do not need to anoint: burn them off completely……..Let assistants hold the patient down by his head and arms while he is being cauterized so that he does not move – but let him shout during the cautery, for that makes the anus stick out more." (Hippocrates 1995a).

The above passages outline in a way that is readily understood in the twenty first century that Hippocrates was well aware of the suffering of patients and both attempted to minimise it or where suitable to use it to advantage.

Celsus

As already quoted in chapter two, Celsus defined the qualities required of a surgeon. He wrote,

> "Now a surgeon should be youthful or at any rate nearer youth than age; with a strong and steady hand which never trembles, and ready to use the left hand as well as the right; with vision sharp and clear, and spirit undaunted; filled with pity, so that he wishes to cure his patient, yet is not moved by his cries, to go too fast, or cut less than is necessary; but he does everything just as if the cries of pain cause him no emotion." (7)

Lithotomy had been practised in Alexandria by Ammonius Lithotomos in the middle of the third century BC (Tsoucalas and Sgantzos 2017). The technique was recalled by Celsus who wrote about the correct management

of the pain of lithotomy which involving access via a route between the scrotum and the anus must surely be one of the most terrifying procedures. He wrote:

> “then the operation is carried out in a warm room, and in the following manner. A strong and well-trained man, seated on a high stool, seizes the boy from behind and draws him backwards until his buttocks rest on the man's knees. When the boys' legs have been drawn up, the man orders him to put his hands behind his knees, and to pull upon them as much as he can, and at the same time the man keeps them in this position. But if a stronger person is to be treated, two strong men are seated on stools, side by side, and both the stools and the adjacent legs of the men are lashed together, so that they cannot be separated. Then the patient is seated in the same way as above upon the knees of the two men; and according to their position, one man takes hold of the patient's left leg, the other of the right, whilst at the same time the patient pulls upon his own hams. Whether one or two men hold the patient, they press downwards with their chests upon the patient's shoulders” (Celsus 1938).

It may also be noted that the operation requires the insertion of fingers into the rectum in order to feel and control the position of the calculus.

Once again, the description of the procedure includes detailed advice on how to cope with the pain which if ignored would ensure that the patient moved about so much that accurate surgery would be impossible. Thus, we may see that both Hippocrates and Celsus presented clear documentation of the need for forceful restraint of patients during operations, with descriptions of the agony of surgery and providing a reader with a vivid mental image of the processes involved. Following classical times surgeons steered clear of describing immobilisation techniques.

From Rome to Salerno

It has not been possible to comment on Galen’s attitude to the suffering incurred during surgery. As noted in the chapter on anatomy he preferred to do experiments on live animals which could not demonstrate their torment by means of distressing facial expressions. How he coped with the pain of surgery in humans remains unknown to the current author. However, his works are extensive and only a proportion have been translated, so it may well become possible in the future to learn how he managed. On the other hand it can be stated with confidence that the following surgeons make no reference to the pain of surgery; Paul Ægineta, Roger Frugard and Roland of Parma.

Bologna

While no subsequent surgeon addressed the matter of pain during an operation with the same thoroughness as Hippocrates and Celsus, there are a number of remarks related to the topic. Theodoric is much interested in the use of opium to dull pain. In a section on skull contusions without wounds he wrote

> "And you should know that certain surgeons are overanxious to operate upon the wounded. In order to eliminate the sense of pain they use analgesics, a thing which I do not approve at all, because, since it is impossible to apportion the medication accurately in accordance with the condition of the wounded any such patients receive somniferous medicine and sink into the deep sleep of death" (Theodoric 1955a)

In another place he wrote about the 'soporific sponge'.

> "The composition of a savour to be made by surgeons, according to Master Hugo, is as follows: take of opium, and the juice of unripe mulberry, hyoscyamus, tile juice of spurge flax, the juice of leaves of mandragora , juice of ivy, juice of climbing ivy, of lettuce seed, and the seed of the lapathum which has hard, round berries, and of the shrub hemlock, one ounce of each. Mix these all together in a brazen vessel and, then put into it a new sponge. Boil all together out under the sun during the dog days, until all is consumed and cooked down into the sponge. As often as there is need, you may put this sponge into hot water for an hour, and apply it to the nostrils until the subject for operation falls asleep. Then the surgery may be performed and when it is completed, in order to wake him up, soak another sponge in vinegar and pass it frequently under his nostrils." (Theodoric 1955c)

It is worth mentioning that there was sparse use of ingested opium for analgesia. It was preferred as often as not as an ointment or other form of surface application. William of Saliceto considered this on two occasions. With regard to an abscess, he wrote:

> "When an infection first appears and produces pus and the suffering is intolerable, make use of the familiar defensive ointment with added opium, henbane and white poppies and lay it on thickly around the wound until the pain eases. Do not use it for too long; return soon to the ordinary defensives without the stupefacients." (Saliceto 2002c).

He also mentioned the use of opium during the treatment of puncture wounds of nerves.

> "Pain can be relieved by using narcotics. such as opium, henbane. poppies. populeum ointment. etc. made into plasters and ointments and applied as defensives. The narcotics must not be used for long periods; they are to be prescribed against pain early in the case. If continued too long the damaged part will cool, will mortify and deteriorate and die. Therefore. limit them to brief courses and for severe pain." (Saliceto 2002b).

William of Saliceto has other concerns on minimizing pain. He writes of suturing nerves:

> "You may object that passing a suture needle through a nerve is terribly painful, and I will reply that you can relieve the pain in the sutured nerve by immediately applying the rosat oil-egg-yolk-safron topical." (Saliceto 2002c).

He also mentioned repeatedly how gentle handling of tissues reduces the risk of the infection and reduces the pain.

Paris and Montpellier

William of Saliceto's pupil Lanfranc came from Milan but ended up in Paris. He mentioned pain briefly a couple of times, very much to the point. An early part of his book concerns surgical skills. He stated:

> "No one likes painful treatments, and the surgeon should avoid performing them when the outcome is hopeless." (Lanfranc 2003b)

With regard to wounds in nerves he writes:

> "If the relief of the pain does not come as rapidly as you wish, even then do not change the routines, for there are no better medicines. However, if the pain continues, add some opium to the oil of roses and some bol d'armenie to the (ie defensive) inunction on the surface" (Lanfranc 2003c).

So, he would use opium in ointments when pain was severe and persistent.

Henri de Mondeville's writing was far more prolix than any of his contemporaries or immediate predecessors. But then again, he covered more topics than the others. He described the three different forms of treatment, diet, medicine, and surgery. He continues:

> "The third method (ie operative surgery), causes much more suffering, and is used only when needed. It entails using larger incisions, violent corrosives as eruptors, extracting arrows, etc. or pushing them through-and-through, forcible palpation as in examining for bladder stones per rectum or vaginam,

> and painful manipulations to reduce dislocations and fractures." (De Mondeville 2003a).

He also shows his concern about pain with the remark:

> "When you use the knife, do it as gently as possible for sake of the patient, knowing that pain saps his Vital Forces. Make your incisions as small as possible, just large enough for your purposes. The reason is self-evident." (De Mondeville 2003c).

Guy de Chauliac, unlike his predecessors practised in Europe after the Black Death. For the first time since Celsus, de Chauliac actually mentioned the use of assistants to immobilise a patient during amputation. The segment reads:

> "Distract the soft tissues with a cloth saturated with analgesics and divide the bone with a fine-tooth saw. Here are the details: Wrap separately the healthy proximal limb and the distal dead part with a gap between. Two strong assistants hold steady while you incise in the gap down to the bone which you denude of attached soft tissues. Cover the exposed flesh to protect it while you saw. After you cut through the bone, apply a red-hot cautery to the stump to stop the bleeding, or use boiling oil. Then bandage the stump tightly. Later, treat the open wound as such. You may use the red powder with egg white and other familiar hemostatics later on to control residual bleeding. Some surgeons, as did Theodoric, used soporific medicines to dull the pain, such as opium, the juice of morel, hyoscyamus, mandragore, hedera, cicuta, and lettuce. Soak a fresh sponge with the juices and allow it to dry in sunlight. When needed, wet the sponge with some warm water and place it over the patient's nose. He will nod and then sleep before you start your operation. Later, apply another sponge wet with vinegar over the nose to awaken him. You may apply the juices of rue and fennel over the nostrils, mouth and ears to awaken him.
>
> Other surgeons have the patient drink opium; that is a dangerous action, especially for the young. I have heard that sometimes the patient becomes combative and savage, or manic, and sometimes dies." (de Chauliac 2007a).

Thus, assistants to immobilise the patient are mentioned. Also, Guy allowed opium to be applied in ointments. It could moreover be inhaled, as described by Theodoric and himself using an impregnated sponge. On the other hand, he was unhappy with it being taken by mouth. There was a variety of formulae used to produce a soporific sponge, but Guy's probably became the most familiar due to the large numbers of his book which were published. The sponge was impregnated with a juice of morel, opium, black henbane, mandragora, climbing ivy, hemlock, and lettuce (de Chauliac 2007a). It fell out of use after the seventeenth century for reasons which are

not entirely clear but may in part be because it wasn't very effective (Juvin and Desmonts 2000).

Bologna Again

Bologna was where Berengario da Carpi practised, and he had one particular piece of useful advice for the surgeon planning a trepanation.

> "When this operation is completed the wound should be filled with tow from which tents[1] are made without heat which are the same as those soaked in egg white and placed in the wound in cases where a great flow of blood is not to be feared. I take the white of an entire egg beaten with a moderate amount of rose oil because it soothes the pain better. It should be left in place for one day until the tent is well dried out because when the lips of the wound are more dry they remain more open and the physician can operate better on the open rather than the closed wound and with less pain to the patient. Physicians should always observe this procedure when they intend to perform trepanation or another operation because when the lips are well opened contact with the instruments and thus damage on the lips is avoided. This contact causes pain which is difficult for the patient to bear nor can he endure such operations because he is forced to suffer more and pain may cause his death." (Carpi 1990).

Thus Berengario took care to minimise the pain of surgery during trepanation by making sure to keep the skin opening edges away from the surgical instruments. It may be mentioned that Berengario was the first of the surgeons mentioned here to have access to Celsus 'De Medicina' which had been published with the printing press when he was eighteen years old.

Later Surgeons

The practice of being discreet about the pain of surgery persisted. Three surgeons quoted approximations to Celsus' description of the essential characteristics of he who would be a surgeon. The first was Paré who wrote:

> "For my part, I very well like that saying of Celsus: A Chirurgeon must have a strong, stable, and intrepid hand, and a mind resolute and merciless; so that to heal him he taketh in hand, he be not moved to make more haste than the thing requires; or to cut less than is needful; but which doth all things as if he were nothing affected with their cries; not giving heed to the judgement of the vain common people, who speak ill of Chirurgeons because of their ignorance." (Johnston 1649).

[1] Tents in this context refer to rather bulky, usually linen dressings inserted under the skin to help prevent bleeding and to absorb secretions.

Peter Lowe a slightly younger colleague also wrote of the qualities required by a surgeon. The statement below is a response to a query on the qualities required of a surgeon:

> "There are divers, and first of all as Celsus sayth, that hee bee learned chiefly in those things that appertaine to his art, that he be of a reasonable age, that he have a good hand, as perfit in the left as the right, that hee bee ingenious, subtil, wise, that he tremble not doing his operations, that he have a good eye, that he have good experience in this art, before he begin to practise the same. Also that he has seen and observed of a long time, of learned Chirurgians that he be well mannered, affable, hardy in things certaine, fearfull in thinges doubtfull and dangerous, discrete in judgement of sicknesses, chast, sober, pitifull, that he take his reward according to his cure and the habilitie of the sicke, not regarding avarice" (Lowe 1612).

This is not so much a quotation as a paraphrase of Celsus words with a great deal extra added. Lorenz Heister gives perhaps the most honest account of this material as follows:

> "…partly because cures which are to be performed by the Hand, especially those which are attended with great danger and cruelty in the execution of them, require a singular hardiness of temper and resolution of mind, or as that Cicero of the Physicians, Celsus, speaks: An intrepid Mind void of all Tenderness and Pity, and entirely deaf to the Shrieks and Outcries of the suffering Patients. Which is to be met with in very few, though they may be perfectly well acquainted with every thing that ought to be done." (Heister 1743)

George Young (1692–1757) and Opium

This relatively unknown surgeon was a citizen of Edinburgh in the eighteenth century. He was much involved in the Scottish Enlightenment. In the current context he is noteworthy because of his monograph on opium. In this it is stated:

> "Every considerable chirurgical operation in a timorous delicate person is apt to raise a tumult in the nerves, and sometimes convulsions, during the operation. Opium taken two or three hours before the operation gives courage and steddiness both of body and mind, by which means such convulsions are prevented: it does not abate the pain of the operation, as the patient expected; but it makes him better able to bear it." (Young 1753).

This very precise statement is at odds with the concerns of the medieval surgeons who were afraid that opium by mouth would be followed by itching and potentially dangerous sedation and coma. It is conceivable that

Young was working with preparations where the dose was more precisely defined than had been possible in medieval Europe. However, it remains certain that while opium had been available since the time of Celsus, its use as an analgesic for surgery was practically non-existent. It may also be noted that Young did not comment on the dose.

Benjamin Bell (1749 – 1806) was a younger contemporary of Young and in his day a most famous surgeon. His great grandson inspired Arthur Conan Doyle to create the character of Sherlock Holmes. He wrote an immensely popular 'System of Surgery' which ran to many editions. In it he states

> "Narcotics of every kind might be employed for the purposes of lessening general sensibility; but nothing answers this purpose so well as opium. As this, however, when given in sufficient doses, is apt to induce nausea and vomiting, I seldom venture to exhibit before an operation. In general it proves most useful when exhibited immediately after, and then it vey commonly alleviates the pungent soreness of which patients at this time usually complain; and by continuing to give it in proper doses from time to time, we are often enabled to keep the patient easy and comfortable" (Bell 1802).

The reader will note that Bell specifies the using the correct dose, but he does not specify what it might be. However, thinking in terms of precise dosage may explain why opium could safely be administered in the eighteenth century while it had been considered too dangerous at earlier times. Bell's statement represents the introduction of elements of modern post-operative care.

Patients' Descriptions of an Operation

So just how bad was it to be operated without an anaesthetic? There are two accounts from the nineteenth century. These impressively courageous folk and their recollections clearly provide evidence of the intensity of the agony. One is from the author Fanny Burney (1752 – 1840). She married a Frenchman in 1793, four years after the French Revolution. In 1802 they had moved to France in an attempt to regain property he had lost in the Revolution. In September 1811 Frances had a cancer diagnosed in her right breast and underwent a painful mastectomy, performed by Dominique-Jean Larrey, military surgeon to Napoleon. She was operated and despite the horror of the procedure lived another twenty-nine years dying in 1840 at the age of 87. The following is a small extract from what she wrote of the experience.

> "When the dreadful steel was plunged into the breast – cutting through veins-arteries-flesh-nerves- I needed no injunction not to restrain my cries. I began a scream that lasted unintermittently during the whole time of the incision…Oh Heavens!-I then felt the knife racking against the breast bone – scraping it! This was performed while I yet remained in utterly speechless torture. (Porter 2011)

An equally dramatic account is written by a twenty-five-year-old medical graduate called George Wilson who in January 1843 underwent an amputation of an infected leg which would otherwise have killed him. He left the following description of the experience.

> "I have recently read, with mingled sadness and surprise, the declarations of some surgeons that anesthetics are needless luxuries, and that unendurable agony is the best of tonics. Those surgeons, I think, can scarcely have been patients of their brother surgeons...Of the agony it occasioned, I will say nothing. Suffering so great as I underwent cannot be expressed in words.... The particular pangs are now forgotten; but the black whirlwind of emotion, the horror of darkness, and the sense of desertion by God and man, bordering close upon despair, which swept through my mind and overwhelmed my heart, I can never forget, however gladly I would do so. From all this anguish I should of course have been saved had I been rendered insensible by ether or chloroform...before submitting to the operation" (Adler 2004).

Impact of Culture on Patients' Ability to cope with Pain

The qualities required to be allowed to practice surgery were outlined in chapter one. Here it is necessary to examine how surgeons behaved with patients. Hippocrates set the tone for the behaviour of a surgeon. He required dignity, a healthy plump appearance, clean, well dressed and anointed with a pleasant aroma, prudent, regular, grave, and kind. However, he also referred to the 'common crowd' whose good opinion and respect is sought. While excellent advice it was given by a man who was a surgeon, and it is implicit that he thought surgeons were better than average people. Celsus on the other hand was unusual because while he described the qualities desirable in a surgeon, his writings contain no such patronising remark. Paul Ægineta had nothing to say on the topic of how a surgeon should behave. Roger Frugard does not make any specific comments on the necessary qualities to achieve success at surgery, but he repeatedly comments on the necessity of avoiding incompetent or inexperienced surgeons.

Theodoric does not define the qualities required by a surgeon. He does however speak out on the topic of surgeons with whom he disagrees. Having stated that wounded patients require nourishment he expostulates:

> "And almost all stupid surgeons ignore this, for they prescribe diet and abstinence for the wounded, as if they would allow a fever to continue. For what greater error is there than to impoverish nature through the blood, by which it is necessary to restore what has been lost, to fill up hollows, and to knit together the solutions of continuity?" (Theodoric 1955b)

He further criticises surgeons for not agreeing with him and he castigates surgeons for doing things recommended by others, and regrettably his criticism is without foundation.

> "nor ... is it necessary to generate bloody matter in a wound, as Roger and Roland and many of their disciples teach, and as almost all modern surgeons continue to do.". (Theodoric 1955d)

Nowhere do Roger Frugard or Roland of Parma propose any such thing. A little later he expresses his contempt. He was after all a bishop.

> "And anyone who reads carefully that book which I entitled 'The Daughter of the Prince' will be able by following the authority of the ancients, and the clearest reasoning, and this present doctrine, to refute a large measure of those things which have been written in the surgical texts of the moderns. But still I fear that we are ploughing in the sands, because they will not withdraw from their errors; for it is difficult to relinquish the things to which one is accustomed; and perhaps it is better to let those who are in error to continue to err in their own stupidity." (Theodoric 1955d).

So, Theodoric's comments on the characteristics of surgeons are more about himself than about his patients.

William of Saliceto is the first of the medieval surgeons to lay out the requirements of a surgeon's behaviour. He does this at some length and the following quotations are extracts from a longer passage, but the process of editing has not changed the intention of the original.

> "Those who wish to qualify as true surgeons must fulfill three requirements. First: the surgeon must be present in person to examine the patient as to his general condition and as to the condition of the affected part, wounded or ailing from other causes…. Furthermore, the surgeon should comply with the desires of his patient, and thus avoid criticism if the outcome is complicated.…. The spirit of the patient may be revived by those kind words and assurances and he may gain hidden strength and his inborn Nature will

> acquire a vigorous resistance against the disorder. That alone may produce a cure when all the surgeon's instruments and medications would fail.
>
> Second: The patient should not contradict the surgeon at work with his own opinions nor should he interrupt him during his operations.
>
> Third: The assistants must be supportive of the patient. They should be affable and follow the physician's orders in everything related to the operation." (Saliceto 2002a).

The comments are positive and not critical of others. He also indicates the importance of the surgeon's behaviour and personality in acquiring the patient's trust and willingness to be subjected to the pain of an operation. He is kinder than Theodoric but still insists on a social order where the surgeon is in charge and the patient must cooperate.

Lanfranc's recommendations tend more towards behaviour and ethics than the power of personality.

> "A Surgeon must have a healthy and temperate complexion…He should have well-formed small hands with slender long fingers; he must be free of tremors; he must have a quick mind, aware of the fact that all that belongs in Surgery cannot be found in books…He should conduct himself without bravado and be pleasant in relations with his patients. He should not have a ribald tongue when attending a patient at his home, nor should he offer answers to un-asked questions. He should avoid small talk with the women in the patient's house, and he should not argue with the home folk. He should be courteous with the patient and be optimistic about his recovery even when he himself despairs of it, but he should not hide the bad prognosis from the entourage. No one likes painful treatments, and the surgeon should avoid performing them when the outcome is hopeless. The surgeon should treat the poor pro bono and take generous fees from the rich.
>
> He should not boast about his own successes nor should he criticize the failures of his competitors. He should maintain good relations with his surgical colleagues and the clerical Physicians. and make no enemies among them. He should cloak himself in an aura of virtue which will bring him a good name and fame; his doctrine should be ethical." (Lanfranc 2003a)

There follows a lengthy section on how to balance the humours, the importance of understanding the use of medicaments and the correct diet. He is much concerned about suiting the treatment to the humoral temperament of the patient. His writing leaves an impression of modesty, kindness and concern for the patient with respect for colleagues. He is not as authoritarian as William of Saliceto.

Unsurprisingly, Henri de Mondeville has much to say on this topic with more verbosity than his predecessors. He states:

> "…. the surgeon must be moderately audacious. He must not argue in the presence of the lay people, and he must operate with prudence and wisdom. He should not undertake dangerous operations before assessing ways of avoiding the risks. He must have well-formed upper extremities, especially his hands, with long slender fingers that are limber and without tremors. All of his limbs should be strong to enable him to perform in manly fashion all of the proper operations that he may have to do. He should have an agreeable nature, and he should devote himself entirely to the sick patient, not to overlook anything needed. He may offer a cure to all of his patients, but he will not hide the true risks of the operations from the relatives and friends. He should refuse to treat cases that are too difficult for him and never operate in desperation. He should provide advice to the poor, for the sake of The Lord. He should, when he can, make the rich pay him well. He should work hard in order to acquire a good reputation. He should ease the patient's suffering with comforting words and he should patiently answer their questions when they are confused by his methods.
>
> Patients should heed their surgeons in all matters relevant to their diseases, neither in opposition to the operations or the advices.
>
> What is required of the assistants? To the best of their abilities they should be alert and accommodating in relation to the surgeon and agreeable with the patient in all matters regarding the illness. They should not reveal what the surgeon has said if it would not be agreeable or beneficial. They should not display downcast expressions (ie which reveal bad prognoses). They should not argue amongst themselves or with patients, nor should they mutter." (de Mondeville 2003d).

There is much here but nothing new or different from the writings of his teachers. He is reflecting the teaching of both William of Saliceto and Lanfranc. He does spend much time emphasising the need for surgeons to be familiar with necessary learned texts as well as learning their craft by first observing and then working with experienced colleagues. He shares Lanfranc's humanity in that he emphasises the need to be well paid by the wealthy because he may then be able treat the poor without charge. Another evidence of his humanity comes from his attitude to drunkenness. This is not completely relevant to the current section, but it is too unusual to leave unmentioned.

> "Rather we refer to how the hours (ie and what he does in them) affect the surgeon's work"). For example, he should never perform a serious operation such as making a large incision after he has been drinking. He should do that

only when he is sober, especially when he operates on highly placed persons. There are seven exceptions:

1. When the urgency for action is great, as in treating fractures of the arm or dressing a fresh wound, even after the surgeon has imbibed his usual.
2. When his hands tremble only slightly after he has had his usual weak morning quaff.
3. If the lesion stinks, as with erysipelas or putrid gangrene, etc.
4. If he is an indecisive sort of weakling who needs a little weak wine to give him the courage to act.
5. If he worries that the patient will seek out another surgeon.
6. If he worries that he will have to refund a prepayment.
7. If he thinks that he must operate as soon as a reluctant patient consents, he who had consented after a period of indecision and may again change his mind." (De Mondeville 2003b)

Guy de Chauliac repeats the requirements of surgeon, patient, and assistants succinctly and in keeping with his predecessors.

"Therefore, the surgeon who operates should know the principles of Medicine and have some knowledge of the other arts. The second requirement is skill. He should be an expert when he operates. The third requirement is ingenuity and Common Sense. Haly stated (Book 3 of Techni) 'The surgeon must have a good memory, common sense, proper motives, good vision, and be healthy'. Later he added that the surgeon should be well-made for the job, with slim fingers, strong hands, clear eyes, and lack tremors. The fourth requirement is a good Presence. The surgeon should be daring when the outcome will be assured, but he should tread carefully in face of peril, and he will avoid harmful treatments and other such actions. He should be gracious with his patients and generous with his friends and be wise with his prognoses. He should be chaste, sober, and be sympathetic with those who suffer. He should not connive and seek extortionate fees and he should willingly state in advance fees that are commensurate with his work and the patient's ability to pay, in view of the results of his treatments and in view of his professional status.

> The three conditions required of the patient are: 1. He must follow the surgeon's instructions, much as a peasant obeys his feudal seigneur. 2. He should trust the physician and 3. He should be patient, because patience overcomes fearful thoughts (also Galen).
>
> The four requirements for the assistants: Be gentle, be gracious (agreeable), be faithful, and be discrete." (de Chauliac 2007b)

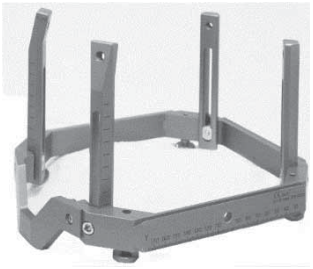

Figure 5.1
Leksell Stereotactic frame which is fixed to a patient's head to permit sub millimetre navigational accuracy. The frame is attached with pins which pass through the holes in the top of the posts as shown in figure 5.2

These four medieval surgeons all insist on the education and virtuous behaviour of the surgeon. Lanfranc does not go beyond this. However, the other three all insist on the almost feudal obedience of the patient to the surgeon. It seems probable that this recommendation while not reducing the pain of surgery could have led to be it being more easily accepted, in the absence of any effective anaesthetic.

Personal Experience

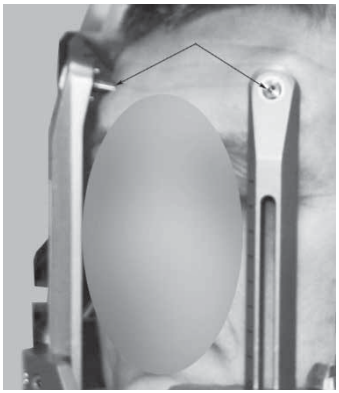

Figure 5.2
This shows the frame in position attached to a patient's head. The thin arrows indicate the screws which are screwed into the head and fix the frame by gripping the skull.

The intangible nature of cultural influences makes them easy to discount. However, I have seen positive evidence of their power. It has been my lot to have to fix stereotactic frames to the heads of people not a few of whom were children. Such a frame is illustrated in figure 5.1. Figure 5.2 shows how the pins are fixed to the head. In Europe and North America, such frames are applied to early teenagers or younger children under a general anaesthetic. In China, Japan, and Egypt this is completely unnecessary. One of the most striking examples of this was an eight-year-old Chinese girl who was to be treated in Guangzhou with radiosurgery. This is a treatment method involving the use of highly focussed radiation directed at targets in the brain. Naturally, the accuracy has to be impeccable, hence the need for a

stereotactic frame. This frame permits the application of a three-dimensional Cartesian system within the confines of the skull. Since the head is within the frame, its contents can be identified with the greatest accuracy. In this specific case, the little girl sat in a simple wooden school type chair. For comfort she grasped the first two fingers on both sides with her small hands. It may be noted we had met the day before and exhausted are linguistic talents. She had said “How do you do?” and I had said “Ni Hao”. So, this is a situation where the child is in the hands of total strangers. One applying the frame and one (me) providing fingers to hold. Thus, both of us were in no way in her intimate circle of trusted adults. During the application of the frame there are two processes which hurt, though none of them severely. The first is the needle prick when the local anaesthetic is administered. The second is the constricting sensation as the screws are tightened into position. Throughout the procedure which took about ten minutes apart from a little squeezing of my fingers she sat calmly on her chair and permitted the application of the frame. Later working which children in Cairo, the same calm was consistently exhibited. The point is that working in a middle eastern and several Asian places it is quite clear that children trust adults in a way which our children do not, which is a clear example of the power of cultural factors on the reaction to pain.

In Summary

No anaesthesia was available until the nineteenth century and many surgeons had a fear or distaste for ingested opium. As noted above, the relationship between surgeon and patient was considered to be necessarily authoritarian. Personal experience confirms the power of social factors in the tolerance of pain, fear, and discomfort. Of course, opium was available from pre-classical times. However, the writings of surgeons prior to the nineteenth century appear to limit its use to surface applications and avoided its ingestion because of difficulties with getting the dose right with concomitant complications.

While not suggesting for a moment that pain was less unpleasant in years gone by there is a fair amount of evidence, outlined in this chapter, to suggest that acceptable behaviour amongst those suffering pain has changed. The medieval surgeons clearly regarded patients terrified of surgery as morally inferior using harsh terms in their descriptions. In addition, from Hippocrates to Ambroise Paré, the profession documents a paternalistic attitude to patients. This is hardly surprising because the relationship between surgeon and patient is of necessity unequal. One party

has a need and the other has the skill to provide for that need. No amount of egalitarianism can change that crucial component of the relationship. In the modern world the surgeon tries to minimise the expression of this inequality, but it will still be there, no matter how good his/her manners are. Thus, it is the suggestion from this chapter that a cultural milieu where any form of analgesia was effectively unavailable, together with acceptance of the authoritarian standing of the surgeons could have helped the unfortunate patients endure their suffering.

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CHAPTER 6

LAUDABLE PUS

Background

The notions concerning ‘laudable pus’ have been misrepresented for many years. What has been said to have happened probably did not. The basis for making such a claim is that the historical material under advisement has been analysed in this chapter in a different way than hitherto, providing different insights. Why make a point of this? Well, humanity in general and the medical profession in particular has a weakness for ancestor worship, and this may be harmless, but it may also be a barrier to finding the truth.

Introduction

Any attempt to write about the surgical practice of earlier generations, requires understanding of the contemporary conceptual equipment with which surgeons approached their work. One of the more irrational notions has been the idea that pus can help to promote healing, an idea encapsulated in the term ‘laudable pus’. One particularly dramatic component of the laudable pus story is that certain medieval surgeons, specifically Theodoric and Henri de Mondeville taught that pus was not necessary for wound healing. Yet the most distinguished Guy de Chauliac, who practised later than Theodoric and Henri de Mondeville, is supposed to have reintroduced the notion that formation of pus was essential to wound healing.

Writers of textbooks of the history of medicine first began to appear in the nineteenth century. The most notable of these were Sir Thomas Clifford Allbutt (1836–1925) in Great Britain and Colonel Fielding H Garrison (1870-1935) in the USA. The two never met but they had a not infrequent amicable correspondence (Rolleston 1929). The personality of the writer inevitably influences what he or she writes. The Royal College of Physicians in London has compiled a dictionary of the biographies of fellows of the college called Munk’s Roll. Its entry on Allbutt describes his personality as follows.

> "His temperament was sanguine and equable, his bearing courtly and aristocratic" (Brown 1925).

On the subject of laudable pus Allbutt wrote as follows.

> "To these points especially — to the withdrawal of the weapon, to the promotion of pus, and to unctuous dressings I would call your attention; for now we are approaching more nearly the controversy which, pale reflexion as it may be of the great surgical regeneration of the nineteenth century, is, historically speaking, of singular interest. Less blessed than we, our fathers determined this controversy the wrong way, and thereby brought upon themselves, and upon their children for many generations, malpractices and tortures which — or so it seems to us — a contrary decision would have averted." (Allbutt 1905).

The underlined words reflect a patronising attitude, not unusual amongst socially successful persons in nineteenth century England.

Garrison also made statements which reflect his attitude to medicine prior to the nineteenth century. It is important to note his comments on the significance of different eras. He stated:

> "In my view, medicine does not really begin to be medicine until after 1850, the time of Virchow, Helmholtz, Ludwig, Claude Bernard, Pasteur and Lister, and today we would rather let the entire historical minutiae of pre-Hippocratic medicine go by the board than lose or miss out (on) the achievements of Roentgen and the Curies, which are the points of departure of modern surgery" (Colman 2004).

He wrote about laudable pus as follows:

> "…Again the heresy imposed by the Arabist commentators of Galen, that "coction" (suppuration) and "laudable pus" are essential to the healing of wounds, made operative surgery a perilous and meddlesome undertaking, all the more dangerous, indeed in that the surgeon, whether scholar or mountebank, stood in jeopardy of life or limb if he operated unsuccessfully on any of the feudal lords of the earth" (Garrison 1921).

It could reasonably be suggested that while Garrison was a great pioneering medical historian, on the topic under discussion here he might not be focussing as intently as he would have done if the topic had been Curie or Lister.

Medical historians like the rest of us show an innate respect for distinguished and celebrated predecessors and Allbutt and Garrison were pioneers of the study of medical history and the founders of what has

become a major intellectual discipline. Thus, the following comments by their eminent successors are hardly surprising. Zimmerman and Keith wrote of Theodoric,

> "The great contribution of this master was the "dry" treatment of wounds. Growing out of comments by Galen, which were distorted in the translations of the Arabs, had come the doctrine that suppuration was necessary for the treatment of wounds.". (Zimmerman and Veith 1967c)

The great Charles Singer wrote:

> "Roger of Palermo….an early surgical 'magister' of the School of Salerno, wrote about 1180 his Practica chirurgiae" in which he described…the unfortunate doctrine of the healing of wounds by 'second intention' with consequent production of 'laudable pus'" (Singer and Underwood 1963).

Douglas Guthrie wrote of Galen:

> "He supported the theory of 'coction' introduced by Hippocrates and apply this to the healing of wounds, he regarded pus as "laudable" an error which greatly retarded the progress of surgery" (Guthrie 1960).

The distinction and authority of all these authors together with the dramatic confidence of their assertions made their writings believable. Yet, as shall be shown, their evidence is based on selected quotations by no means reported in context.

It would seem the story of laudable pus though arising in the Middle Ages came to be a matter of importance in the nineteenth century at a time when temporal power was associated with religious certainty. It was an era of colonisation. It could be considered that that the colonisers could view the colonised peoples as inferior both morally and socially. With this sort of mental default level, it would not be difficult to consider the surgeons practising before the scientific age were also inferior and would accept the notion of laudable pus. Poor creatures! Allbutt's remark about '*less blessed than we*' is evidence of this attitude. However, such patronising sits ill in the twenty-first century. There is no reason to believe that our predecessors were any stupider than we are, and the notion that pus could promote healing is not sensible.

It is thus comforting that a few voices have been raised in recent times which question this account of historical wound management. Michael McVaugh, in his elegant and scholarly text, 'The Rational Surgery of the Middle Ages' wrote:

> "…as far as compound wounds were concerned, Teodorico and Mondeville would have agreed with Lanfranc that in such cases the formation of pus was only to be anticipated, and that provision had to be made to absorb it or to permit it do drain away. Teodorico explicitly states that when it is necessary to generate flesh in a concave wound, Ugo's experience teaches that one need not puncture the cavity to relieve the pus that will form – it is enough to leave a drain from which it can flow" (McVaugh 2006).

The essential point from McVaugh's work is that there are two types of wound, simple and compound.

Another modern author has doubted the doctrine of 'laudable pus'. In a recent review he stated

> "The principles of military wound management have not changed since before antiquity. These are to stop bleeding, prevent infection and help the wound to heal. Effectively, little changed in techniques from Roman times to the start of the middle ages, although there were documented debates about the nature of wound dressings, and the role of 'pus' in satisfactory healing." (Clasper 2016).

In a book by a Dutch colleague the following statement is to be found.

> "With regard to the Salernitan way of wound treatment it is frequently stated in secondary literature that it aimed at suppuration. A closer study of Roger, however, gives a more balanced picture. It appears that the treatment differed depending on the location and the nature of the wound." (de Moulin 1988b).

All the above publications have raised a question about the error of laudable pus, as it is generally understood and has led to a re-examination of the relevant sections of major works on surgery the results of which are outlined below.

The effect of dividing wounds into simple and compound is examined in texts from Hippocrates to Billroth. There are now English translations of very many of the relevant texts which makes this analysis possible for someone who lacks knowledge of the multiple languages involved, including Ancient Greek, Classical Latin, Arabic, Medieval Latin, Italian, French, and Ancient German.

We should begin with a definition of a wound and we could do no better than to go all the way back to the works of Galen who stated:

> "There is one particular class of diseases, dissolution of continuity, which, although it occurs in all parts of the organism, is not similarly named in all of them. Thus, it is called helkos (wound, ulcer sore) in a fleshy part…." (Galen 2011d).

Wounds must be unique amongst pathological entities prior to scientific medicine in that the cause was usually known. They were accompanied by the following known processes, haemorrhage, inflammation, infection, and tissue repair. The basis of these processes is beautifully described in the early pages of Guido Majno's, authoritative work "The Healing Hand" (Majno 1965b). So how did the management of the components of a wound evolve from the ancient world to today?

Writings from Hippocrates to Billroth

Hippocrates (ca. 460BC – ca. 370BC)

While wounds were managed in Sumeria and Ancient Egypt, there is no recorded material which concerns us now. The first texts on wound management are from the school of Hippocrates. The school wrote up thoughts on wounds in 'Ulcers' (Hippocrates 1995). The interpretation is problematical because the Ancient Greek word 'helkos' can mean either wound or ulcer (de Moulin 1988a). The basic concept of treatment was to keep wounds dry. The first line of 'Ulcers' is:

> "Surface lesions should generally not be moistened, except with wine, unless the lesion is at a joint; for dryness is nearer to health, and moistness to unhealthiness, since a lesion is moist, but healthy tissue dry." (Hippocrates 1995).

This notion was to dominate wound healing right up to modern times.

In addition to desiccation, the Greeks applied various substances to assist in the processes of wound healing. These include opium applied topically to reduce pain. Other applications were aimed at reducing suppuration. Some of these were powders of dry metal salts which could be washed away with vinegar (which was painful) and / or wine. Both wine and vinegar have been shown to be effective antibacterial agents (Majno 1965c). Attempts were made to stop bleeding. The injured part was raised, and the neighbouring area was covered with cold compresses. Ligature of individual blood vessels was not known.

Hippocrates' writing gave rise to the notion that pus could be part of the healing process. It is emphasised that Hippocrates noted and characterised the kinds of pus he observed with wounds, but never contended that its presence was advantageous. On the contrary, he favoured a dry wound which would heal.

> "Any lesion that has been produced by a sharp missile or receiving a gash lends itself to the application of a styptic which prevents suppuration by drying. Any tissue that was crushed or severed by the missile treat so that it suppurates as soon as possible, since then it will swell less; it is inevitable for crushed or severed tissues to dissolve and ooze out after they have putrefied and turned to pus, and then for new tissues to grow." (Hippocrates 1995).

The above quotation indicates that clean wounds do not need to suppurate and if they do there are measures to minimise the impact of the suppuration. Two kinds of pus were observed, the bad pus or sanies was thin turbid and malodourous. The good pus was thick and creamy and did not smell bad. Hippocrates, commenting on wound healing, remarked that:

> "if the pus is white, and not offensive, health will follow; but if it be sanious and muddy, death is to be looked for." (Coxe 1846).

Thus, the association of wound healing and suppuration was accurately described, and one may emphasise that nowhere is there a suggestion that suppuration was advantageous. On the contrary, Hippocrates remarks on the advantages of getting rid of pus quickly and his preference where applicable to avoid it. In conclusion, it would seem that Hippocrates was aware of pus-free healing in fresh injuries. He further acknowledged the presence of pus particularly in the presence of contusion, tissue loss or delayed treatment.

Celsus (c. 25 BC – c. 50 AD)

While Celsus was a distinguished writer and much respected after the Renaissance, his writings were lost until the middle of the fifteenth century and so he had no influence on the medieval debate which lies at the core of the current chapter. In the event, suffice it to say that he proposed healing by first intention for clean wounds with no tissue loss. He discussed pus in detail and while there are more and less dangerous forms of pus, they should all be removed. He states:

> "Now blood comes out from a fresh wound or from one which is already healing.... pus from an ulceration already beginning to heal." (Celsus 1938).

His principles of wound healing are similar to those of Hippocrates even if there are differences in technique. Nowhere does he say pus is advantageous. It is just a means to an end in an already complicated wound. He was also the first to mention ligatures to stop bleeding.

Galen (129 – 216)

Galen's contributions to wound care are quite convoluted involving repeated statements of the excellence of his methods. He claimed superiority in wound treatment early in his career as he wrote that he prevented gladiators dying from their wounds as had happened with his predecessors (Mattern 2013). He distinguished between wounds as follows in a manner which could hardly be clearer:

> "It is clear that (we should) begin with the most simple. What is simpler than a superficial wound in a fleshy part? If the wound is simple, the objective of its cure is union. If it has a cavity the objective is twofold in that the condition is also twofold. The wound is a dissolution of continuity, while the cavity is a destruction of some substance proper to the organism" (Galen 2011a).

He advised that wounds where there was only dissolution of continuity without loss of tissue should be treated by conglutination. Conglutination involved apposing wound edges and keeping them apposed while healing occurs. In the same section he stated:

> "when there is division alone, the margins of what has been divided should be brought together; and not only this but, having come together, they should also remain so.". (Galen 2011b)

Sutures or bandaging would be involved. He noticed that wounds could heal without infection. He also developed techniques of haemostasis. His first method was to apply digital pressure to the region of bleeding. If this did not work, he applied a hook to the bleeding artery and twisted it. This technique is occasionally still in use. If necessary, he also used ligatures to tie bleeding vessels. The material he used was silk which is probably the first time this is mentioned in the European literature (Majno 1965a). Celsus had used flax or linen. Galen did not use a tourniquet.

For wounds where there was tissue loss, he stated:

> "The cavity, then, is filled by the regenerated flesh, which has its origin from the blood" (Galen 2011c).

He discussed various ointments which could facilitate healing. He was concerned that the humours be brought into balance. In the ideal situation where everything is in balance the wound should be allowed to heal without the assistance of medication. However, in reality, excesses occur. These excesses are called ichor if thin and filth if thick. These will require drying and purifying medications, respectively. He did not support the notion of 'laudable pus' during wound healing (Freiburg 2017).

Thus, Galen advocated the resolution of infection with purifying medications, and the requirement in keeping with Hippocrates' advice, that wounds should be kept dry. He distinguished between the repair of tissue loss as noted in the previous passage with repair of skin, where he contended skin cannot regenerate and the wound is thus covered over not by a tissue like skin, but something which is called a scar (Galen 2011c). In the event of the development of proud flesh, desiccating medicines should be chosen and attempts should be made to choose a medicine and dose which was minimally uncomfortable.

Paul Ægineta (ca.625–ca.690)

Paul gives an account of the management of wound healing (Adams 1846). It contrasts with the writings of Galen by being clear and concise. For a simple wound, the edges should be brought together by bandages. If that did not work sutures should also be used. Agglutinants should be used to accelerate the bonding of the wound edges. These agglutinants included oak leaves, papyrus soaked in wine and wound around, cheese, myrrh, frankincense, and others. There are various sections concerning simple ulcers, agglutinants, painful and inflammatory sores, unconcocted ulcers and such as have not suppurated, hollow ulcers and medicines for cleaning foul ulcers. Yet again this author distinguishes between simple wounds which may be treated by apposition of the margins and wounds where there is tissue damage or tissue loss. In this latter situation healing by second intention is advised and Paul went into greater detail than previous authors on the medications which might be applied to a wound to facilitate healing.

Albucasis (936 – 1013)

It has been suggested that Arabian culture was passive and fatalistic. It proscribed touching dead bodies which effectively prevented anatomical study. There is also an impression that the culture was timid about haemorrhage (Zimmerman and Veith 1967a). Albucasis, while Arabic was actually born in Spain where he spent most of his life. He lived in the

western Ummayad Caliphate of Cordova. Much of what he wrote emphasized the need for great skill with which he of course believed himself to be endowed. In his book he regretted a development which had occurred during the centuries when medical learning was mainly in the hands of Arab scholars. He wrote an encyclopaedia of medicine and surgery (Campbell 1926). Albucasis' text is concerned solely with the practicalities of management. Thus, he describes different kinds and conditions of wounds in terms of healthy or inflamed and instructs the correct management. He maintained wounds varied with the causative agent and the location in the body. Where the skin was attached to the surroundings by just a small strip it should be excised, and the wound should be dressed with medicaments which would produce firm flesh to replace the skin. He did not mention the source of this flesh. (Albucasis 1973).

He was concerned over the changes air can produce in a wound. If there were inflammation one should use cotton wool soaked in oil of roses and wine. If there were no inflammatory changes a powder consisting of Frankincense, Dragon's Blood and Quicklime should be applied. If on the other hand the air had changed a wound, an ointment to cause pus discharge should be applied and the wound should be bound. Such an ointment consisted of gruel of barley-meal mixed with water and honey. He advised haemostasis either with ligature or cautery.

The book was very influential because it was the first text devoted solely to surgery and its instructions are simple and easy to follow. The principle source for the author was the books of Paul Ægineta. The book had an original organisation with topics being arranged anatomically from above downwards. It is worth noting that again the treatment of clean incised wounds involved healing by first intention using bandages or sutures. In contaminated wounds, healing was by second intention.

Roger Frugard of Parma (1140 – 1195)

The Practica Chirurgiae (The Practice of Surgery) of Roger Frugard appeared in 1170. There have been queries about where Roger acquired his surgical knowledge and expertise. It has become known that a series of manuscripts which were never published were available in Salerno. These were found in the Royal Library in Bamberg in north east Germany. They are thus referred to as the 'Bamberg Surgery'. These haphazardly organised texts reveal the sources from which they were taken including Paul Ægineta and Albucasis. The Practica Churgiae is unique among surgical texts in that it was not written by its author but by his students. On the other hand, some

believe he approved the writing (Rosenman 2007). The book soon became the accepted standard text on surgery, in use for three centuries. It is sophisticated and well-ordered using the same system as Albucasis from head to foot.

As previously mentioned, wounds were a much larger part of surgery in the Middle Ages than is the case today. Roger relates wound management with specific details applicable to specific locations. Nowhere in the manuscript is the division into simple and compound wound clearly stated but examination of the text shows that the principles of this classification were respected. In chapter six, entitled 'Head Wounds without Cranial Fractures', his advice was to bring the edges of the wound together with a cloth dressing soaked in egg white and then wrung out until almost dry. Thereafter various plasters are suggested. These differed for the different seasons of summer and winter. It is not necessary to repeat the details of the plasters, but they had various purposes. The first sort of plaster was designed to induce maturation (suppuration). When pus appears use dry packs until the wound dries. From the time of first suppuration until the wound became dry use only the Black Ointment. It will be applied to the material of the dressings with a view to induce healthy granulation tissue and scar. There is no mention of sutures or of a wound healing without suppuration. Here is the real beginning of the notion of laudable pus (Frugard 2002d).

Book two chapter one has the title 'Wounds of the Neck'. Here the treatment is to clean the wound removing foreign objects and then suture it. When bleeding prevented the desired débridement the wound was sutured with gaps between the sutures to permit cleansing later. Then closure is completed. Pus is not mentioned in this context. However, for arrow wounds, a strip of bacon was inserted into the channel of the wound until it suppurates when it is replaced by a cloth strip. He then proposed the promotion of suppuration using methods described elsewhere. He calls this pus 'good pus' and the process 'good suppuration' (Frugard 2002g).

It should however be noted that this is treatment advised for cranial wounds. It is also worth noting that in Book one, chapters two and four débridement is advised (Frugard 2002c, 2002b). In Book one chapter thirteen about facial wounds, it is advised that these be closed with sutures (Frugard 2002f). A gap is left at the lowest part of the wound to permit the drainage of pus but there is no effort to stimulate suppuration. Moreover, in chapter fourteen there is the phrase "*If you want to induce suppuration*" (Frugard 2002a). This clearly suggests that not inducing suppuration was a possibility. For wounds of the neck the advice is débridement followed by

sutures if the wound is caused by a sharp object such as a sword. An opening is left at the lower end of the sutured wound to enable drainage of any pus which may form. There is again no suggestion that suppuration should be induced.

In another part of the text Frugard describes the treatment of abscesses. He applied a plaster to the swelling in an effort to help the contents melt away and avoiding their liquefication into pus (Frugard 2002e).

Thus, it would seem that Roger Frugard was one of the first surgeons to state in writing that débridement was advantageous. It would also seem that he was not an adherent to the use of 'good pus' in all cases. Rather he recommended simple suturing for simple wounds made by a sharp object. He reserved the induction of suppuration as part of the treatment of potentially contaminated wounds where simple closure was either impractical or impossible. It is relevant to mention that away from the head, Roger advocated suturing with a drain opening for fresh wounds caused by sharp instruments in the region of the scapula. Thus, he advocated healing by primary intention for incised wounds and by secondary intention for contaminated wounds, just like everyone else. It is implicit in the text that in certain cases suppuration is unavoidable and that it would be best to facilitate this. However, this is nowhere clearly stated. This may be the reason why later writers could select portions of his text to suggest that he always favoured the stimulation of suppuration as a means of healing rather than accepting that suppuration in such patients was unavoidable.

Bruno da Longoburgo (ca 1200 – 1286)

Bruno is brief but is passionate about surgery being performed by properly educated professionals. The available English translation varies somewhat between longer text and shorter comment. Nonetheless, his first chapter starts with:

> "I state that interruption of continuity, a common defect, is of two sorts, simple and complex" (Tabanelli 2003a).

Simple interruption is where there is no loss of substance. Simple wounds are treated with apposition of the margins and suturing. If there were loss of substance it must be replaced. Simple wounds should heal by first intention and complex wounds by second intention. Wounds with contusion are liable to infection and this was painful. The stimulation of suppuration reduced the pain from inflammation and facilitated healing (Tabanelli 2003b).

This is the first text which specifically classifies wounds using the terms simple and complex. Yet again simple wounds are to heal by first intention and complex wounds by second intention.

Theodoric Borgognoni (1205 - 1298)

Theodoric Borgognoni was probably the son of a surgeon Hugh of Luca, the founder of the Bologna School of Medicine, whom he quotes extensively in his writings (Zimmerman and Veith 1967c). His family moved to Bologna, a leading medical school at the time, when he was nine years old. His ordained status in no way hindered him in the practice of surgery. Despite becoming a friar and eventually the bishop of Cervia, he spent most of his life in Bologna. His Chirugia (Surgery) was released in 1266. It is based mostly on his personal experience and is not organised from head to toe.

His book differs in two vital respects from that of Roger Frugard. The first section concerns different types of wounds and the types of tissues involved. The second book recounts the management of wounds in different locations from head to toe. He classifies wounds as simple and compound where a simple wound is defined as follows.

> "A simple solution of continuity is one in which there is no loss of substance or flesh…therefore in the cure of this there is only one objective, that is: the joining of the severed parts" (Theodoric 1955a).

He describes how treatment of a simple wound may be achieved.

> "In fresh wounds which are full of blood, where exposure to the air has not changed, and in which neither any amount of flesh nor skin has been lost, nothing else is necessary except that their edges should be joined to one another, just as they had been naturally, and the compresses being soaked in hot wine, let a bandage be skilfully bound around if the flesh bulges; then may you place upon it a strong medicine which is necessarily warm and dry." (Theodoric 1955c).

He also advocated débridement prior to apposition of wound edges.

Thus, he advocated healing by first intention in simple wounds. However, there is more to his suggestions than that. Firstly, he informs the reader there are three things of prime importance to be attended to.

> "The first of these is the restriction of blood, if there should be a superfluity, as will be stated below, and in order that a hot abscess may be prevented".

> The second is that medicines may be administered which make pus appear, especially in wounds which the effect of the air has already changed. … In the same manner may generatives of pus be administered in wounds which occur from a contusion, because of which these wounds are painful and abscessive, and their abscesses necessarily produce bloody matter.
>
> The third is that the bloody fluid which has been generated is to be dried up" (Theodoric 1955d)

Thus, Theodoric advocated simple closure for simple wounds and the facilitation of pus production for contaminated or contused wounds. It is hard to see how this differs from the advice of Roger Frugard; it is simply more clearly stated. However, Theodoric was not only a surgeon but also a bishop and he would seem to have felt himself superior to other colleagues as judged by the following passage.

> "For it is not necessary, as stupid men do, to place a wick at the end of a suture line; nor under such conditions, as was said in the first book is it necessary to generate bloody matter in the wound, as Roger and Roland and many of their disciples teach, and as almost all modern surgeons continue to do. For there is no error greater than this, and nothing else which impedes nature so much and prolongs the sickness, prevents uniting and consolidating of a wound, deforms the part and impedes cicatrisation. And what is more deleterious, with their treatments the unskilled make wounds quite eroded and develop sinuses, things which rarely can occur except from lack of care and stem from the great inexperience of the physician. And anyone who reads carefully that book which I entitled 'Daughter of the Prince' will be able, by following the authority of the ancients, and the clearest reasoning, and the present doctrine, to refute a large measure of those things which have been written in the surgical texts of the moderns. But still I fear that we are ploughing in the sands, because, with all this, they will not withdraw from errors; but for it is difficult to relinquish the things to which one is accustomed; and perhaps it is better to let those who are in error continue to err in their own stupidity". (Theodoric 1955e).

This passage has caught the attention of numerous historians who have accepted it as stating the truth. However, examination of Roger's text will show that the wick on which Theodoric pours scorn, was to permit the egress of any pus which might form. It was not present to generate pus. Moreover, Roger was interested in healing by second intention in compound wounds, which was also Theodoric's method of treatment for such lesions. It is unfortunate that this passage has been taken to be an honest and accurate expression of the facts which it is not.

Finally, it may be mentioned that Theodoric actually uses a word translated as 'laudable' with regard to the 'sanies' draining from a fistula. He makes the point as follows:

> "And laudable sanies, just as Hippocrates says in the Prognostica, and as I have already stated in the First Book is white, smooth and even-textured throughout, and has no bad odor" (Theodoric 1955b).

Theodoric was familiar with pus in wounds and is merely a repeating Hippocrates distinction between the different kinds of pus. He is not commenting on the stimulation of pus during wound healing.

William of Saliceto (1210 – 1277)

William was five years younger than Theodoric but contemporary with him at Bologna. He was born in Piacenza, about forty-five miles south east of Milan. He gained a reputation as a leading surgeon of his generation. He again advised suture for simple wounds. The majority of the text is given over to describing what substances may be applied to wounds and in what form. There is no clear statement in William's text that healing by first intention is right and healing by second attention should be avoided. On the other hand, he repeatedly, for different bodily regions advises cleansing the wound followed by suturing leaving an opening at the lowest part of the wound which can permit the drainage of any pus which occurs and also can permit the application of medications. However, unfortunately nowhere does he specify the difference between simple and complex wounds (Saliceto 2002).

Lanfranc (ca 1250–1306)

It might on the face of it seem a puzzle that surgical knowledge was limited to the single country of Italy. However, the time concerned is prior to the invention of printing with moveable type. All books were manuscripts and some of them were expensively illustrated with gold leaf letters and coloured paintings. They were jealously guarded and very expensive (Malgaigne 1965). Lanfranc was born in Pisa in the middle of the thirteenth century (Vico 2007). He was a student of William of Saliceto, and he became the master surgeon in his home city of Milan. He was unfortunate to take the wrong side in one of the many civil disturbances, so characteristic of the thirteenth century and he escaped from Italy to France, bringing with him the new revolutionary Italian surgery, including his books and his teaching. He was accepted by his surgical colleagues in Paris where his travels finally led him. He was invited to lecture and to demonstrate

operations, but because he was not a celibate priest, he could not become a member of the Faculty. This form of teaching was revolutionary at the time (Zimmerman and Veith 1967b).

Regarding the management of wounds, writings about Lanfranc provide a clear example of the persistence of the myth about the necessity of pus generation. A distinguished review states:

> "His wound treatment was predicated upon suppuration being essential to healing" (Zimmerman and Veith 1967b).

In reality, he used perhaps the clearest classification of anyone. He wrote:

> "A simple wound has lost no tissue and is free of complications – no associated illness – no infection. A compound wound is the opposite" (Lanfranc 2003).

For simple wounds he advised healing by first intention with closure with bandages if the wound was small and with sutures if it were large and/or irregular. If the wound was compound with either contusion, tissue loss or inflammation he encouraged treatment by second intention. This clearly illustrates the distance between reviewer and the original author. Yet again, sutures were used for a clean wound where the edges came together; healing by first intention. Contaminated wounds produce a discharge of pus; healing by second intention.

Henri de Mondeville (ca 1260 – 1316)

Henri was an outspoken person. His classification of wounds is clear. Simple wounds are uncomplicated. Compound wounds include wounds with tissue loss and/or contusion. Sutures were used for a clean wound where the edges came together; healing by first intention. Contaminated wounds promoted pus discharge; healing by second intention. He frequently quoted Theodoric. He is renowned for his opposition to pus in a wound. In fact, while it requires an effort to wade through his verbosity, his views were rather more subtle. He also had a love of listing when clarifying his views.

He went to considerable lengths to describe and justify his approach to wound healing. He describes eight measures necessary for it to be successful. They are as follows:

1. Remove foreign material.
2. Control haemorrhage.

3. Select correct topical medicaments.
4. Bandage or suture as appropriate.
5. Perform phlebotomy.
6. Design an appropriate diet.
7. Avoid complications including dyscrasias and infections.
8. Obtain lovely scars and control proud flesh (De Mondeville 2003b).

Any or all of these measures may be required. In the event of a complication, such as an infection the surgeon should stop treating the wound and treat the complication and then return to the wound treatment. This is an excellent principle more clearly stated than by his predecessors.

Where Henri is clearest is in his attitude to pus. He states that in contrast with many colleagues, pus is NOT a natural consequence of a wound but a complication. He vigorously opposed any use of measures to promote suppuration. When pus arose, it was a complication to be removed by the application of suitable medicaments and by drainage.

Where he is more disingenuous is in his account of what other colleagues have done. He divides the 'modern' surgeons into three groups.

Roger, Roland, and others from Salerno.

a. Criticised for same diet to all patients which had no meat nor wine.
b. Enlarged all wounds.
c. Filled all wounds with drains.
d. Provoked infections in all cases.

How does this compare with the realities of Roger's text? Firstly, there is nothing about diet in respect of any wound. He did unquestionably advise stimulating suppuration in compound wounds. He enlarged some wounds to better gauge the extent of the trauma. He used cruciate incisions which are easier to close. He used drains in many cases but by no means all. There is no evidence that all cases became infected because there is little information about the results of the treatments used. Moreover, inducing suppuration was not used in every wound as noted above.

William of Saliceto and Lanfranc (Henri's teacher)

a. Were better allowing wine and meat.
b. Enlarged certain wounds but not all.
c. Sometimes used drains.
d. Forcibly removed bone fragments from head wounds but not others.

William of Saliceto specified care in removing fragments 'avoiding violence'. Otherwise, he insisted that the vitality of the patient should be considered, and the operative removal of bone fragments should be proportionally gentler in weak individuals. Lanfranc specifies simple sharp wounds to the cranium should be sutured. He also taught that bone fragments should be removed with delicacy and not forcibly. Once again there is a gap between Henri's claims and the text to which he referred.

Hugo of Lucca and Theodoric

a. Gave a nice diet including meat and wine.
b. Never enlarged wounds.
c. Never used drains.
d. Never forcibly extracted bone fragments in head wounds except when there was shattering and crushing.

Hugo left no writings. Theodoric did encourage a nice diet including poultry and the best available wine. However, he did enlarge wounds and did use drains and did remove bone fragments. However here de Mondeville is quoting correctly since Theodoric wrote "There is no necessity to remove any bone except what is loose".

Henri's criticisms are riddled with inaccuracies. He was passionate about avoiding pus. He had this in common with Theodoric. The other thing he had in common with his predecessor was an apparent pleasure in criticising colleagues inaccurately. (De Mondeville 2003a)

Jehan Yperman (1260 – 1331)

Born in Ypres, Yperman wrote his surgery textbook in his native language and not Latin, apparently for the easier understanding of his sons who did not know Latin. He was well educated and quoted Galen, Avicenna, Roger, Roland, Bruno, Theodoric, William of Saliceto and especially Lanfranc whose lectures he attended. He seems to have been modest yet opinionated with a chapter on the qualities of a good surgeon which contains sixteen paragraphs and exhorts the practitioner to self-control and sobriety. Yperman advised suturing simple wounds. Otherwise, he instructed the use of Theodoric's methods of cleaning pus from wounds with appropriate ointments. He also advised suturing should be full thickness to avoid superficial closure over a cavity in which pus could accumulate (Yperman 2002b). He did not however, classify wounds into simple and compound.

His treatment of wounds with tissue loss was to apply ointment and keep it in contact with underlying tissue with a pad (Yperman 2002c).

More than any of the other surgeons he quoted the advice of his predecessors. This includes an account of how Theodoric managed purulent cranial wounds. Perhaps the most informative passage comes from his presentation of a gloss by the four masters whose work has never been translated into English. They, like Roland had written commentaries on the work of Roger Frugard. The passage occurs in a chapter entitled 'The Methods of the Four Salernian Masters and of Roland and Others'. It concerns the management of a depressed fracture where a fragment has slipped under intact bone. The initial advice is incorrect in that it advises perforating the fragment and not the surrounding bone. However, the text continues:

> "Furthermore, they observed that when a surgeon knows that he must operate on the head, he should abstain from sexual activity during the night before, that he should avoid any contact with menstruating women, and that, during the entire preceding day he should not eat garlic, onions and spicy sauces. And he should take care to wash his hands before the operation." (Yperman 2002a).

While hygienic precautions prior to surgery may or may not have been commonplace, this is possibly the first specific mention of washing hands prior to surgery.

Guy de Chauliac (1300 – 1368)

Guy de Chauliac distinguished between wounds and ulcers at the beginning of his text on wounds. He states:

> "My own definition of a wound, that it is recent, bloody and not yet corrupted, will define the difference from an ulcer, which is a corrupted lesion" (de Chauliac 2007b).

He specifies healing by first and second intention. The first involved approximation of wound edges using bandages or sutures. He suggested using ointments which will minimise pus formation and accelerate desiccation, production of granulation tissue and healing. He preferred the teachings of Galen to any more modern writer. He also referred to Avicenna extensively.

His advice for a small, incised wound without loss of tissue was:

"close a wound with a single suture".

For a larger superficial wound, he states:

> "Here a single suture will not suffice. Therefore, Galen used the method of suturing by equal spacing". (de Chauliac 2007a)

Various powders or ointments could be applied to the wound, but these should not get under the skin, but remain on the surface. This was healing by first intention.

He specifically defined first and second intention healing. First intention was:

> "the union of the disrupted wound's surfaces without intermediate non-local tissues". (de Chauliac 2007b)

Second intention was:

> "the union is bridged by different tissues" (de Chauliac 2007b).

For wounds with loss of tissue he wrote:

> "The usual methods for treating these wounds – after arresting haemorrhage and mitigating pain and its attraction of the matter that can form aposthems – is to irrigate the wound with warm mildly astringent wine." (de Chauliac 2007b)

This was followed by ointments or powders and a plaster containing substances which would stimulate the generation of proud flesh. The wound would be dressed twice a day in summer and once in winter. In other words, it was cleaned, pus removed and in general healed by second intention.

After Guy, a century would pass before there would be new contributions to surgical writing. However, further comments on wound healing would not be written until the writings of Ambroise Paré roughly two hundred years after Guy's death.

Ambroise Paré (1510 – 1590)

While the medieval surgeons mentioned above may not be familiar to modern colleagues the name of Paré is familiar to most if not all of us. He was of humble origins and qualified eventually as a Master Barber-Surgeon. Nonetheless, during his education he spent some time in the famous Hôtel Dieu hospital in Paris. Despite his humble origins he ended up as surgeon

to four successive French kings. His gentleness and clinical skill were greatly regarded (O'Neill 2007).

His remarks on the nature of wounds and the approach to healing them remain the same as those of his predecessors. He introduced his chapter on wounds with two tables. In Johnson's English translation of his work wounds are defined as follows.

A wound was simple:

> "when there is no complication of any other disease or symptoms besides".

It was compound:

> "when there is a complication of some one or more diseases, which unlesse they be taken away, wee must not hope for cure to the wound" (Johnston 1649).

His treatment of the two kinds of wound was as follows. For a simple wound, all foreign materials in the wound must be removed including coagulated blood. The edges must be brought together and kept together by bandage or suture. For wounds with contusions, he advised the application of ointments to the wound and the encouragement of pus which must then be cleaned. This is in keeping with the teaching of others that secondary problems must be dealt with and wound healing must wait upon the successful management of the complications, as taught by Henri de Mondeville (Johnston 1649).

Peter Lowe (1550 – 1610)

A younger contemporary of Paré was Peter Lowe of Scotland who was educated in Paris and ended up as surgeon to Henry IV of France, the successor to the last of the four French kings whom Paré had served. He wrote a text entitled 'The Whole Course of Chirurgerie' which was published in London in 1597. The sixth treatise in this book, consisting of sixty pages is devoted to a discussion on the nature and treatment of wounds. A wound is defined as:

> "a dissolution of the continuity, recent, bloudie, without putrefaction in the soft, hard, or organic partes" (Lowe 1612).

He divided wounds into simple and 'composed' instead of compound. Simple wounds had no loss of tissue and were treated thus.

> "the simple wound of the flesh, healeth by ioyning the lippes of it together and the help of nature." (Lowe 1612)

In addition:

> "If the wound be great that it ioyneth not by the simple ligature we use a suture." (Lowe 1612)

On the other hand:

> "The composed wound is when there is loss of substance to wit skyn, flesh and bones, for the cure we use two intentions, that is reparation of the substance lost, and induction of the cicatrize". (Lowe 1612)

Yet again healing for simple wounds is by first intention and for compound wounds by second intention.

Richard Wiseman (1621 – 1676)

Richard Wiseman was deeply involved in the British Civil war as a royalist and suffered repeated imprisonment. Eventually his loyalty was rewarded, and he ended up Sergeant Surgeon to Charles II, a position equivalent to Surgeon General elsewhere. In his extensive text on surgery the fifth book is entitled 'A Treatise of Wounds'. His definition is:

> "A wound is a Solution of Continuity in any Part of the Body suddenly made, defined. by any Thing that cuts or tears, with a Division of the Skin. This Definition differs much from what is usually deliver'd by Authors; and it is fit it should. For they generally defining a Wound by a Solution in parte molii, do thereby exclude a Cut made into a Bone, as that into the Cranium by a PoleAxe, &c. which why it should not be called a Wound I know not. I say, it is made by any Thing that Cuts and tears." (Wiseman 1734).

This is the writing of a man who has clearly given the topic much thought. His comments on the care of wounds are amongst the clearest of all writers.

> "In Simple Wounds the Chirurgeon is to afford his Assistance five manner of Ways; the omitting of any of which will render him negligent or ignorant in his Trade.
>
> The first is, in careful and diligent taking away all such extraneous Bodies as by their Interposition may hinder the true Agglutination of the disjoined Parts, whether they be concrete Blood, Hair, Sand, Dust, Pieces of Bones, Cartilages, or pieces of the Weapons, Rags, etc.

The second is, in bringing the Lips of the Wound even together, which were separated.

The third is, in retaining the Lips so brought together, that they may by consolidation be restored to their former Figure.

The fourth is, in conserving the Temperament and natural Heat of the Part, in order to Unition.

The fifth is, in preventing ill Accidents, and correcting such as have already seized on the Part" (Wiseman 1734).

For compound wounds he is equally lucid.

"Thus, much is required if the Wound be only Simple; but if it be a Compound Wound, with Loss of Substance, or Contusion; then he hath somewhat more do. As where there is Loss of Substance, there he must assist Nature with his Sarcoticks, for regaining what is lost; and where there is Contusion, there he must endeavour the turning what is contused into Pus, or Matter, which must be perform'd before there can possibly be any Reunion" (Wiseman 1734).

Once again simple wounds heal by first intention and compound wounds by second intention.

Daniel Turner 1667-1741

Daniel Turner was the son of London merchant whose business was candles and oil. First, he became a barber surgeon and then retired from surgery having qualified as a physician. There is a fair amount of evidence that he aspired to a higher station in life. Nonetheless, he was a respected surgeon in his day and wrote a book on surgery. Turner wrote about simple wounds.

"As to the general Cure of Wounds, we are principally to regard these following Intentions, viz. The Řemoval of extraneous Bodies, restraining the Hæmorrhage, or Flux of Blood, conjoining the divided Lips of the Wound, keeping them so conjoin'd, promoting their Agglutination, and obviating the Symptoms. These I say are primary Intentions in simple wounds." (Turner 1736)

For compound wounds he writes:

"but in those complicate with Contusion, Fracture, Loss of Substance, or the like; there are moreover other Requisites, as Reposition of the fractured

> Bones, Digestion of the Wound, Detersion or Mundification, Incarnation and Cicatrisation" (Turner 1736).

Once again there is the distinction between simple and compound wounds with the same variations in management.

Samuel Sharp Circa 1700-1779

Sharp's father was a worker in brass or 'brazier'. Little if anything is known of his childhood. However, he was lucky in his education being the pupil of the great surgeon William Cheselden. He opens his book on surgery with a section on wounds. It begins with an account of a large wound made by a sharp object. In the introduction to this book, he describes the natural history of wounds; specifically, incised clean wounds.

> "To conceive rightly of the Nature and Treatment of Wounds, under the variety of Disorders they are subject to, it will be proper first: to learn, what are the Appearances in the Progress of Healing a large Wound, when it is made with a sharp Instrument, and the Constitution is pure".
>
> In this Circumstance the Blood-Vessels, immediately upon their Division, bleed freely; and continue bleeding till they are either stopp'd by Art, or at length contracting and with drawing themselves into the Wound, their Extremities are shut up by the coagulated Blood. The Hæmorrhage being stopp'd, the next Occurrence, in about twenty-four Hours is a thin serous Discharge, and a Day or two after an Increase of it, tho' somewhat thickened, and stinking. In this State it continues two or three Days without any great Alteration, and from that time the Matter grows thicker and less offensive, and when the Bottom of the Wound fills up with little Granulations of Flesh, it diminishes in its Quantity, and continues doing so till the Wound is quite skinn'd over".
>
> "The first Stage of Healing, or the Discharge of Matter, is by Surgeons call'd Digestion; the Second, or the filling-up with Flesh, Incarnation; and the last, or skinning-over, Cicatrization. These are the Technical Terms chiefly in use, and are fully sufficient to describe the State of Wounds without the farther Subdivisions usually found in Books" (Sharp 1739a)

His recommended treatment for such a wound was to allow granulation tissue to develop and cover the wound with dry lint. Finally, it will fill with granulations which will be covered over by tissue derived from the skin. It is important to note that the instructions above apply to an incised wound characterised as large. The first impression is that he does not have a special treatment for incised clean wounds as all his predecessors do. However, this

would be wrong. The above description comes from a section on wounds. The treatment of simple wounds is to be found in the section on sutures:

> "When a Wound is recent, and the Parts of it are divided by a sharp Instrument without any farther violence, and in such manner that they may be made to approach each other, by being returned with the Hands, they will, if held in close contact for some time, reunite by Inosculation, and cement like one branch of a Tree ingrafted on another. To maintain them in this situation, several sorts of Sutures have been invented, and formerly practis'd, but the number of them has of late been very much reduced……."From the Description I have given of the state of a Wound proper to be sew'd up, it may be readily conceived, that Wounds are not fit subjects for Suture when there is either a Contusion, Laceration, loss of Substance, great Inflammation, difficulty of bringing the Lips into apposition, or some extraneous Body insinuated into them; though sometimes a lacerated Wound may be assisted with one or two Stitches." (Sharp 1739b).

Thus, while Sharp's account differs slightly in sequence and emphasis, his advice is similar to all his predecessors. Simple clean wounds may be sutured and heal by first intention. Compound wounds require cleansing and drainage and heal by second intention.

Benjamin Bell 1749-1806

Benjamin Bell from Dumfries started training in surgery at the age of fifteen years with James Hill, the distinguished Dumfries surgeon. Two years later he continued his education at the Edinburgh medical school. He was one of the most successful surgeons of his day. He became a fellow of the Royal College of Surgeons in Edinburgh in 1770 at the age of 21. He further studied surgery in London and Paris. In 1772 at the age of 23 he was appointed surgeon to the Royal Infirmary in Edinburgh. It may be fairly said that his subsequent career lived up to his early promise and his "System of Surgery" ran to seven editions and was translated into Italian, French, Spanish, and German.

It is from this book that his notions about wounds may be obtained. He begins by criticising certain contemporary definitions of wounds. Bell's writing is rather verbose, but it should be remembered he was in part a contemporary of Sir Walter Scott, a celebrated author most certainly, but not one noted for succinctness of expression. In brief, his management of clean incised wounds included haemostasis and débridement. There is much discussion of the methods. When bleeding has stopped, and foreign materials removed, the margins of the wound should be kept in close contact with either plasters, bandages or sutures (Bell 1801b).

Contused or lacerated wounds were managed differently. The primary principle is stated as the avoidance of the development of gangrene. Fomentations and ointments are used with a view to accelerate the formation of pus. Bell's reasoning is as follows.

> "We commonly find, when sores of this description become covered with good pus, that the pain and tension abate; and such of the parts as have been much lacerated and contused, and which hitherto have been sloughy or perhaps black with mortification, begin now to separate from those beneath; and this being accomplished they may in general be cured in the same manner with wounds of any other kind" (Bell 1801a).

Yet again the treatment is simple wounds heal by first intention while compound wounds heal by second intention.

Theodor Billroth (1829 - 1894)

Billroth was a pioneer of abdominal surgery leaving after him two major eponymous operations for peptic ulcers. He was also a friend of the composer Brahms and they shared membership of musical groups. Concerning clean incised wounds, he wrote as follows:

> "At first we shall consider only those incised wounds where there has been no loss of substance, but only a simple division of the soft parts. For such a wound to heal quickly, it is desirable that the two edges should be brought exactly together, as they were before the injury; to accomplish this, we make use of strips of adhesive plaster or of sutures." (Billroth 1871b).

He practised during the nineteenth century when scientific medicine was making breakthrough after breakthrough. His textbook for students was published in 1871 so that he would have had access to anaesthesia if not to antisepsis. His description of wound treatment is similar to what has gone before but is illuminated by diagrams of the cell reactions during healing. Its content is virtually indistinguishable from teaching today. About complex wounds he wrote:

> "It now remains for us to inquire what becomes of the wound, if, under the above circumstances, it does not heal by first intention Then, as the flaps gape, we have an open wound before us; and the circumstances are the same as if the gaping wound had not been closed, or as if a piece had been cut out, as in a wound with loss of substance".

A little further on he writes:

> "If you examine carefully with a lens, even the third day, you will see numerous red nodules, scarcely as large as a millet-seed, projecting from the

> tissue —small granules, granulations, fleshy warts. By the fourth or sixth day these have greatly developed, and gradually join into a fine, granular, bright-red surface—the granulating surface; at the same time, the fluid flowing from this surface becomes thicker, pure yellow, and of creamy consistence; this fluid is pus, and, when of the quality here described, it is good pus, pus bonum et laudabile of old authors". (Billroth 1871a)

Finally, it is definitively stated that pale thick pus in complex wounds is not a substance which promotes healing but as a necessary consequence of the process of healing by second intention.

In Summary

In the above text, statements are included from twenty surgeons spanning the period from Hippocrates to the early nineteenth century. That is over two thousand years. It is suggested that the quoted texts confirm the suggestion that all the involved surgeons were agreed on certain aspects of management. These are firstly direct closure and margin apposition with healing by first intention for simple, clean incised wounds. Secondly, wounds with contusion or tissue loss must heal by second intention with the production of pus as a part of the process.

Nowhere in all the writings is it suggested that pus in any form is beneficial per se. Hippocrates description of white thick odourless pus and thin colourless stinking pus indicates that the former is to be preferred as it is associated with a better outcome. There is no suggestion that it is the cause of such an outcome. There is no evidence at all that Galen introduced the term 'laudable pus' as a recent paper on the subject pointed out (Freiburg 2017).

The debate on laudable pus often refers to the roles of Theodoric, Henri de Mondeville and Guy de Chauliac. Theodoric made statements about the use of pus in wound healing in the hands of Roger of Parma which are simply not true. There never was management based on the notion that pus promoted healing. It was only an unavoidable component of healing by second intention in complex wounds.

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CHAPTER 7

SURGICAL INFECTION

Introduction

Despite the risks of surgery associated infection prior to the introduction of antisepsis by Lister in 1867, earlier surgical operations could be survived. There are case reports from as long ago as Galen who reported amongst others the following case.

> "Anyway, I know of one occasion when the frontal bone was shattered. The bone next to this is the one called temporal in which the squamous suture happens to be. That bone, which had a very large fracture extending to the greatest extent, I did not touch at all, and cutting away the frontal bone only, I cured the man so that now after many years he is still alive." (Galen 2011).

Even earlier there is more than adequate evidence of surgical survival in the form of trephined skulls, where the margins of the opening are smooth indicating post-operative healing.

Accurate interpretation of the significance of these diverse observations is impossible since medical statistics beyond tabulating mortality, did not become a feature of medical reporting until the nineteenth century. Not only that, but while some early publications on cranial trauma mentioned individual patients they did not begin to present case series until the eighteenth century. Thus, there is no way of assessing the risks to patients from cranial surgery related infections, which could be acquired in the hospital ward or operating theatre. Much of the writing on the topic has been anecdotal with plenty of opinions. Dramatic stories of unwashed surgeons plying their trade in locations which also serve as mortuaries have great impact and are therefore memorable. However, while statistical analysis of historical series is unavailable, it is possible to tabulate treatment results registering simple parameters. Such tabulation does not provide a basis for statistical analysis, but it does provide a basis for a more nuanced assessment of the material being observed (Ganz 2017; Ganz 2013; Ganz and Arndt 2014; Ganz 2014).

One of the fascinations of any historical research are materials which contain apparent contradictions. A good example of this in the current context is a remark of one Simon Arborsellus, Doctor of Medicine, vice rector (1540) and rector (1541) of the faculty of arts and medicine in Padua (O'Malley 1955). In 1541 this gentleman signed the certificate of matriculation for John Gaius who would subsequently become co-founder of Gonville and Gaius college in Cambridge; a college particularly dedicated to the study of medicine. Gaius for some months during his stay in Padua actually shared a flat with Vesalius. Very little is known of Arborsellus except for a short passage in a small book where he raises doubts about the usefulness of the medical profession. At the end of this short passage is the following remark.

> "Why is it that those who receive a head injury in Verona, no matter how slight cannot be cured, and the unfortunate patient, forsaken by his physicians, dies miserably, but, as I have often seen, he is cured in Padua and Venice?" (C.D. O'Malley 1964).

Interestingly, this remark has been quoted both in a textbook on head injury (Kellett 1964) and a major text on the history of neurosurgery (Dagi 1997). It has clearly captured the profession's imagination. In a sense the curiosity stems from a principle elegantly summarized by Sylvester O'Halloran, albeit in a different context where he asks the question of a particular phenomenon:

> "why is it not constant and uniform, as we know Nature's laws invariably are?" (O'Halloran 1793b)

The dangers of infection for cranial surgery were well appreciated in the nineteenth as mentioned by Quesnay (Quesnay 1848) and Desault (Bichat 1814) in France. Quesnay quotes the view of a surgeon called Mr. Boudon writing:

> "Mr. Boudon however would not upon these conjectures...hazard the trepan, which seldom succeeded at the hospital, on account of the unwholesome state of the air" (Quesnay 1848).

Since variations in surgical infection rates could undoubtedly affect the results of surgery, the view that the dirt in an eighteenth-century or earlier hospital was the cause of surgical infection has persisted to the present day (Dagi 1997; Gross 2009, 2005). However, a semi-quantitative analysis of surgical series written in the eighteenth century would suggest that this was not the case and that other external factors also played a part (Ganz 2014). In addition to hospital cleanliness and hygiene there seems to be a deal of

misapprehension about the history of hygiene in the general population (Smith 2008a). There are simplistic views that filth and infection was everywhere. There are any number of historical TV dramas and movies where the characters are depicted as living in squalid conditions and having poor personal hygiene illustrated not least by dirty fingernails. While such conditions must have existed, this picture is a misleading oversimplification. In view of this, an outline of the evolution of events in the history of hygiene from classical times to the present is relevant.

Personal Hygiene in Ancient Times

In chapter two it was mentioned that Hippocrates required surgeons to be clean. Later, cleanliness was a crucial component of life in Ancient Rome, where sanitation was important. The main sewer, the Cloaca Maxima which dates back to between 400 and 500 BC is still in use today. Fourteen aqueducts supplied that city with over 1.3 billion litres of drinkable water daily (Singer and Underwood 1963), which was necessary given the Roman people's well-known preference for public baths in their cities. A law was passed in 450 BC in the early days of the Roman Republic that forbad burials within the city walls. The law also instructed officials to keep the streets clean and distribute water (Singer and Underwood 1963). Somewhat later, Plutarch recorded that Alexander the Great took frequent baths (Plutarch 2012). In De Medicina, Celsus repeats many times the benefits of bathing.

Mediaeval Hygiene in Europe

Abú Bakr Muhammed ibn Zakariyýa (860 – 932), better known as Rhazes was sufficiently aware of the necessity of hygiene that when he was planning the site of a new hospital in Baghdad, he placed chunks of meat around the city (Guthrie 1960a). The site was chosen where the putrefaction of the meat was longest delayed. There is much information in the bible about hygiene amongst Jews of the Old Testament era (Guthrie 1960b). The laws demanded that no well should be dug near a burial or waste ground. Water should be boiled before drinking and that waste should be burned or buried (Porter 1997). These miscellaneous details from four cultures from the ancient world and Middle Ages can leave little doubt that people of that time, at least educated people were well aware of the association between health and cleanliness, and of the dangers of putrefaction: even if they had no idea about the underlying mechanisms. It is perhaps reasonable to note that infectious processes are often accompanied by an aroma offensive to

the human nose predisposing to regard such processes as something to be avoided.

It has been suggested that people in times past did little to keep themselves clean. This would appear to be a misrepresentation (Anon. 2014; Smith 2008a). During the period 800 AD to 1500 AD The monasteries had latrines and washing facilities as did palaces. In more modern respectable homes, there would be a chamber pot under the bed and a can of water standing next to a washbasin. The water would be fetched from a communal well or pump (Williams 2009). The household might well also possess a bathtub which could be filled from an external water supply. For the less well-off there were communal baths where mixed sexes and nudity were commonplace (Smith 2008b) (see figure 7.1). The church worried about the morality of these activities but appeared to have limited influence (Anon. 2014; Smith 2008b).

Figure 7.1
Outdoors mediaeval bath with nudity of both sexes. Some are amorous one lady is reading a book by Hans Bock d.A. Das Bad zu Leuk, 1597

Renaissance Hygiene in Europe

There were however changes on the way. Firstly, the urban population was rising and much of written UK history concerns London which increased from a population of around 60,000 to 70,000 in 1500 to 250,000 by 1600 (Lambert 2020). This huge increase must have put a great strain on the limited facilities for water supply, domestic hygiene, and waste disposal.

There is subsequent evidence from the nineteenth century which suggests this must have been the case. This will be mentioned later.

It is possible that the supply of fuel was also a problem. Gradually concerns of morality did come to be an issue since Henry VIII closed the 'Stews' in south London and Chester in the 1540s. The word 'stews' here means brothel, giving a vivid image of the use to which, the communal baths were being put. However, Henry's closure of a few baths here and there and the gradual deteriorating quality of personal hygiene associated with urban overcrowding would not have explained what was about to happen. It would seem that the communal baths closed quite suddenly all over Europe in the earlier part of the sixteenth century. The reason is given by so distinguished a thinker as Erasmus who stated.

> "Twenty-five years ago, nothing was more fashionable in Brabant than the public baths. Today there are none, the new plague has taught us to avoid them" (Smith 2008c).

The plague concerned was syphilis. It started shortly after 1490. There is debate whether it was truly brought back from America by Columbus' sailors but there is a good chance that it was. At all events, it provides one of the most dramatic stories in the history of medicine. There are various summaries of the tale but the one which is both dramatically detailed and which also includes a contemporary citation is that by Glasscheib (Glasscheib 1963). It was thus. The French king Charles VIII (1470 – 1498) laid claim to the kingdoms of Sicily and Naples, a claim with some justice. He assembled an army of 18,000 horse and 20,000 foot-soldiers and marched south through Italy meeting little opposition. The army arrived at Naples where all except one citadel surrendered. It was besieged. Ferdinand II of Castile (1452 – 1516) who also had a justifiable claim to the throne of Naples sent Spanish soldiers to assist the Neapolitans. Amongst these were some of Columbus' sailors. They were already suffering from a new disease which became called the great pox to distinguish it from smallpox. The story of the siege was related by the anatomist Gabriele Fallopio (1523 – 1562) whose father was present and wrote the following about the defenders.

> "Since they were but a small band, vastly outnumbered by the French, they stole out of the fortress, leaving behind an adequate garrison and poisoned the wells. Not satisfied with this, they bribed the Italian millers who delivered corn to the enemy, to mix plaster in the meal, and finally under the pretext that food was short, they expelled from the fortress the whores and the women, especially the attractive ones whom they knew had been infected

with the disease. The French, seized with compassion for the woman and attracted by their beauty, gave them asylum." (Glasscheib 1963)

A variety of neutrality agreements which protected Charles on his march south were now flouted and several allies combined against him. His retreat was cut off. His forces fought their way home with heavy losses, but they had become infected with what became known as Morbus Gallicus or the French Pox (Arrizabalaga 1993), though not of course in France.

The impact of syphilis came from the aggression and unpleasantness of its manifestations, quite unlike those which we see today. To give some idea on just how dramatic the sickness was, here is a contemporary quotation, by Ulrich von Hutten (1488 – 1523) who suffered from syphilis and wrote that physicians (See figure 7.2).

Figure 7.2
Ulrich von Hutten, (1488 – 1523) a victim of syphilis.

> "cared not even to behold it; so much less at the first to touch the infected; for truly when it first begun, it was so horrible to behold. They had boils that stood out like acorns, from whence issued filthy stinking matter, that whosoever came within the scent, believed himself affected. The colour of these was a dark green, and the very aspect was as shocking as the pain itself, which yet was as if the sick had lain upon a fire" (Wear 2009).

This passage speaks to the dramatic nature of this new affliction. Even when after twenty years or so the disease lost its initial ferocious virulence, it still remained a horror. In succeeding centuries, it persisted with putrid discoloured skin ulcers which when on the head caused the hair to fall out. It is suggested that this stimulated the use of wigs to cover the baldness, a piece of lace or cambric neckwear called a jabot which hid sores on the neck. Gloves became de rigueur. The whole body was covered in clothing and the face was covered with powder and paint. Bath houses fell out of use and indeed were closed. This had the unplanned consequence that the prostitutes were dispersed into the community and their work became more secretive. In consequence the persistence of syphilis and the need to hide its effects persisted for a good while (Glasscheib 1963).

Eighteenth Century Hygiene

As related above, the drama of syphilis led to the closing of public baths and easy access to bathing for the general population with concomitant disastrous effects on personal hygiene. Other factors contributed to exacerbation of bad habits and poor sanitation. The persistence and more widespread activities of prostitutes as just mentioned was one. Another was the increasing size of the cities with increasing overcrowding in the absence of a supply of clean domestic water or a hygienic way of removing waste. This was true of London but also of amongst other places such as Edinburgh and Dublin (Ganz 2014).

There seems to be an assumption that this behaviour remained unchanged until the nineteenth century and for nigh on three hundred years the population at least of Great Britain stank and lived in filth. It is not however by any means certain that this view represents the truth. To begin with humans do not like bad smells, so while there were means to reduce their impact it would be natural for efforts to be made to avoid them. Recent books on eighteenth century London do not specifically address the behaviour of surgeons but do specify that personal cleanliness was a virtue to be attempted. Dr. Johnson's lack of personal cleanliness was the cause of unfavourable comment (White 2017). The streets were filthy, the prisons were filthy, but this is not the basis for concluding everywhere was filthy. Lord Chesterfield in 1750 advised his son:

> "In your person you must be accurately clean; and your teeth, hands and nails should be superlatively so" (Smith 2008d).

In 1714 in the newly started newspaper, the Spectator the virtues of cleanliness were extolled. The upper and professional classes would have expected to be clean (Smith 2008d). There were trends to improve the supply of water to their new premises. The poor however could not be clean, until the latter half of the nineteenth century. The mechanisms whereby this came about are outlined by Alfred Russel Wallace (1823 – 1913), the co-discoverer of evolution along with Charles Darwin. He recalled the elements which caused a reduction in mortality in London. These included the following:

1. Improved sanitation and supply of clean water.
2. Widening of the roads.
3. Reduced overcrowding moving people out to the suburbs.
4. Improved diet (Wallace 1898).

Over and above community hygiene there was the matter of hospital cleanliness. A celebrated or notorious account of nineteenth century resistance to hygiene precautions concerns Ignac Semmelweis (1818 – 1865). As most physicians know, he observed that puerperal sepsis was much less common in wards which only used midwives, and which were closed to students. He worked out that dirt on the hands of the students coming from the mortuary was the agent at fault and insisted on their washing their hands in a solution of chloride of lime. This immediately had a dramatic effect on the puerperal sepsis rate which fell to one percent (Guthrie 1960c; Putnam 2007). This was however in a single clinic and the results were not published until 1861, many years after the study was undertaken (Ellis 2009).

Semmelweis' work indicates research moving in the right direction but there remain distressing circumstantial accounts of surgeons' behaviour. This is demonstrated by dramatic anecdotes, which nonetheless need to be assessed with care and not taken to necessarily typical of practice. Let us consider some of them. In a history of hospitals, it is stated of a surgeon at St. Thomas' Hospital in London:

> "Sydney Jones, a senior surgeon at St. Thomas's during the latter half of the 19th century, would turn up the collar of his old frock coat, pick up a knife which he had dropped on the floor and…." (Carruthers and Carruthers 2005).

In the same passage is another distressing quotation. It reads:

> "From earliest days surgery was a theatrical performance, with the leading surgeons amongst the stars of their day. A surgeon would invite his colleagues, students and even the public to watch his weekly operating session. The usual pattern was for him to enter the adjacent operating theatre from the dissecting room, where he had been demonstrating at the head of his students, and don his old frock coat, kept hanging on the back of the door especially for the use at operations and matted with blood and filth from previous use" (Carruthers and Carruthers 2005).

In another quotation from a well-reviewed biography of John Hunter

> "Covering his normal day clothes with an apron, probably stiff with the dried blood of past patients, he would have worn neither gloves nor mask. With no understanding of how infection transferred from surgeon's begrimed fingers to patient's open wounds - this was almost a century before Joseph Lister pioneered antiseptics - Hunter would have had no cause to wash his hands or sterilize his instruments. Quite likely they were encrusted blood, pus and tissue of previous operations." (Moore 2006)

Let us look at this passage a bit more closely, because it is presented without any citation, which would be reasonable to require for such a damning statement. The matter of clothes is not an issue. Even Lister did not change his clothes prior to surgery. The matter of not wearing gloves is also not an issue because even in Berlin, in Bergman's department which pioneered asepsis no gloves or masks were worn although they did wear proper surgical gowns (Schlich 2011). The issue concerns the impression that surgeons would have been slovenly concerning their personal cleanliness and that of their instruments. This is not in keeping with the advice of eighteenth-century surgeons and physicians. William Buchan in his celebrated book 'Domestic Medicine' wrote

> "Were every person, for example, after visiting the sick, handling a dead body, or touching any thing that might convey infection, to wash before he went into company, or sat down to meat, he would run less hazard either of catching the infection himself, or of communicating it to others." (Buchan 1791).

That was written 1791 at a time when the author was in his sixties. There is another much earlier text written by James Woodall (1570 to 1643) and was concerned with the conditions of surgeons in the navy. It is fair to consider that in those days, conditions for surgeons on board ship were amongst the worst to which any member of the profession was exposed. Woodall's important book, 'The Surgion's Mate', published in 1617 documented just how appalling the conditions were. Woodall was passionate about cleanliness judging from statements in his book. He makes the following statements in respect of scalpels.

> "Only in conclusion note, that it is very fit and needfull for the Surgion to have at the least two incision knives, one greater, one lesse, and that he keepe them sharpe and cleane; but let them not be so thinne grownde in the edge as the Rasor, for then they will deceive the workeman , when hee hath most use of them." (Woodall 1617)

He further states the following concerning trepans.

> "First be sure the instrument of it selfe be good, and of the best making, and that it be cleane from rust, and perfect without faults; for those Trapans which are brought from Germany are not to be used, nor yet to be tolerated." (Woodall 1617)

How interesting to learn that metal engineering in Germany was regarded as inferior. Thus, serious seventeenth- and eighteenth-century writers were at pains to emphasise the need for clean instruments and hands.

So, while not denying the account of Sydney Jones, there is no evidence to suggest his slovenliness was a universal characteristic of behaviour prior to Lister.

Apart from the surgeons and their instruments there was the matter of the wards. The need to improve the wards was apparent and was the concern of the prison and hospital reformer John Howard, High Sheriff of Bedford (1726 – 1790). He compared the lower mortality with compound fractures in the well-ventilated wards in Leeds with the overcrowded London equivalents. Sir George Blake at St Thomas' in London noted that improving ventilation and reducing bed numbers in a ward materially reduced mortality (Carruthers and Carruthers 2005).

Eighteenth Century Understanding

At the beginning of the 18th century there was considerable awareness of the processes now known to be due to infection which are both local and systemic. The local components were inflammation and pus. The components of inflammation, rubor, tumor, dolor and calor had been known since Celsus described them (Celsus 1938). This was understood in the same way then as now when applied to tissues which could be seen or touched. However, in 18th century texts the term inflammation needs to be interpreted with caution when used about invisible tissues such as the brain. A good example is provided by Sylvester O'Halloran who mentions that:

> "Now every one knows, that inebriety, which is a kind of temporary inflammation of the brain, is most sensibly relieved by strong tea or coffee; and is it not surprizing, that such obvious effects are not applied to practical cases" (O'Halloran 1793a).

This is obviously not current usage.

Sepsis and 18th Century Cranial Trauma

In a recent paper on head injury surgery and infection, mentioned earlier in this chapter it could be proposed that there was no clear-cut evidence that an eighteenth-century hospital admission for a head injury was associated with an increased risk of wound infection (Ganz 2014). This observation was based on a detailed analysis of case histories and the timing of infections in relation to injury. Moreover, the mortality from infections was much lower in two series based on the treatment of mainly rural patients. It was proposed that the filthy insanitary living conditions of big cities

presented a greater risk of infection to patients than admission to a hospital. The basis for these comments can be seen in table 7.1. There were seven cases series of patients with cranial injuries, published in the eighteenth century. It may be emphasised that we have no knowledge of the personal hygiene and the cleanliness of instruments in these series, but it seems more than possible they were following the advice of Buchan and Woodall rather than behaving in the infamous way outlined in the anecdotes mentioned above.

Author	No.	TD	OM	ID	IM
Le Dran (Le Dran 1740)	14	8	(57.1%)	5	(35.7%)
Quesnay (Quesnay 1848)	36	11	(30.5%)	8	(22.2%)
Pott (Pott 1768)	43	22	(51.1%)	15	(34.9%)
Hill (Hill 1772)	18	3	**(16.7%)**	1	**(5.6%)**
O'Halloran (O'Halloran 1793c)	71	21	**(29.5%)**	8	**(11.3%)**
Dease (Dease 1776)	24	13	(54.1%)	13	(54.1%)
Abernethy (Abernethy 1810)	20	8	(40.0%)	5	(25%)

Table 7.1
No. = Number of Cases. TD = Total Deaths. OM = Overall Mortality. ID = Deaths due to Infection
IM = Mortality due to Infection
The table illustrates that the dangers of infection were considerably less in the series of O'Halloran and Hill and the only special difference between these two series and the rest is that the patients lived in the country and not the towns.

Evolution of Modern Management of Surgical Infection

Until the nineteenth century, surgery of any kind was plagued by the agony of a procedure performed on a conscious person and by the risk of infection following the operation. The introduction of anaesthesia in the 1840s solved the first of these problems. The work of Joseph Lord Lister (1827 – 1912) went a long way to solving the other. He became aware from the findings of Louis Pasteur (1822 – 1895) that microscopic organisms were responsible for putrefaction. Being convinced that the cause of surgical infection was bacteria in the air Lister introduced a system of 'antisepsis' in which the bactericidal material carbolic acid (phenol) was infused into a wound and applied to the surrounding skin. While it was markedly successful it was not without its problems. Firstly, phenol irritates the skin not only of the patients but also of the medical attendants. It was this irritation and not protection from bacteria on their hands which first led surgeons and nurses to wear gloves in theatre. The first gloves were manufactured by the Goodyear rubber company, famous today for tyres for motor vehicles. This change in technique had been introduced by William

Halsted (1852 – 1922) under pressure from his operating room nurse who shortly afterwards became his wife. Halsted was also the chief of the neurosurgical pioneer Harvey Cushing's (1869 – 1939). Interestingly in this context there is a film of Cushing performing his 2000th tumour operation in 1931 and he was wearing rather thick coarse rubber gloves, very different from the thin latex items in use today.

While Lister had correctly identified bacteria as the cause of wound infection, he mistakenly considered them to be only in the atmosphere and it took time for him to accept that they could be in other locations such as the skin of both the patient and his/her medical attendants. Several other surgeons were trying other chemicals and they opposed phenol in preference for their own procedures. Thus, from 1867 when Lister first published his paper on antisepsis to the end of the nineteenth century, a series of papers were written refining and adapting the method. Lawson Tait (1845 – 1899) used milder agents with improved results. Lister's operation technique apart from his use of bactericidal chemicals was still very old-fashioned. He wore no special clothing, even keeping on his coat and merely rolling up his collar and cuffs. His hands and the patient were thoroughly soaked in a one in twenty carbolic solution. Instruments and sponges were steeped in the same fluid (Ellis 2009).

The introduction of true asepsis is credited to Ernst Bergmann (1856 – 1907) of Berlin. He introduced heat sterilised instruments and insisted on the obsessional washing of the patient and the hands and arms of the surgeon, his assistants, and nurses (Schlich 2011). Much the same procedure was undertaken by William MacEwan (1848 – 1924) of Glasgow, a pupil of Lister who also steam sterilised the instruments and introduced surgeon's gowns which could be sterilised. He was also one of the fathers of neurosurgery (Ellis 2009). Lister had no notion of the specific bacteria involved. The identification of individual bacteria for individual diseases followed on the work of the German bacteriologist Robert Koch (1843 – 1910), who devised a set of rules known as Koch's postulates which needed fulfilment if a specific germ was to be identified as the cause of a specific disease (Long 1965). The most frequent causes of wound infection were identified later when Ogston identified both staphylococci and streptococci in 1881/2 (Wilson 1987).

In Summary

The history of wound infections goes back over two and a half millennia. Yet understanding of the underlying processes began only in the nineteenth century. Books written in the twentieth century about occurrences at earlier times have a duty to quote evidence for the opinions presented. There seems little doubt that for most of history, people have attempted to keep themselves clean. The main limitations being absence of available infrastructure and poverty. There was a remarkable period from the beginning of sixteenth century lasting into the seventeenth produced by the horrors of syphilis. Since there was reason to believe syphilis acquired in public baths could in some way be related to the process of bathing is easy to understand. The extent and depth of the problem is difficult to determine. Nonetheless, it would seem that wound infection was not as automatic as some authors have assumed and that it could be more than previously accepted related to the external milieu and not the hospital bed or operating room.

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CHAPTER 8

TWO STRANGE ANOMALIES

Introduction

This chapter is concerned with two failures of observation. The first concerns cerebrospinal fluid (CSF). The other failure relates to the lateralisation of a neurological deficit following cranial trauma. This was not finally appreciated until the eighteenth century and not unequivocally documented until the nineteenth century.

CSF

Anyone who has assisted a cranial or spinal operation is immediately aware of the presence of CSF. This is a colourless liquid of unsurpassed transparency and clarity. Its examination by lumbar puncture, in the diagnosis of a variety of diseases began towards the very end of the nineteenth century. Its hydrodynamics, chemical and cellular composition constitute an important part of neurological diagnosis and to some extent treatment. However, this obvious and constant component of the central nervous system (CNS) was not properly identified before the eighteenth century.

First Mention

In Case 6 of the Edwin Smith papyrus the initial description of the injury per se is not relevant in the current context. However, there are two glosses. Gloss A mentions

> "Smashing his skull, rending open the brain of the skull" (it means) the smash is large, opening to the interior of the skull, (to) the membranes enveloping the brain, so that it breaks open his fluid in the interior of his head' (Breasted 1930)

An updated translation of the relevant passages states the following.

> As for "smashing in of his braincase and exposing/breaking open the skull" the large smash fracture is open to the inside of his braincase and the dura mater/membrane that envelops the brain has to have ruptured, its fluid being inside the head" (Sanchez and Meltzer 2012)

A third translation reads as follows.

> As for "which has fractured the skull and exposed the brain of his skull" it is a big fracture, which is open to the inside of his skull and the membrane which covers his brain; it has to fracture so that it gushes from inside his head. (Allen 2005)

The three translations are mentioned because their differences indicate that it is not wise to be dogmatic about interpreting these statements. They differ in content and elegance. However, it does seem reasonable to consider that CSF and dura were both observed. If that is correct, this case involves the first ever description of the brain, dura, and CSF. It also makes it the more surprising that CSF was not again identified for over three and a half millennia.

Subsequent Millennia

As indicated in chapter three, Egyptian surgical knowledge would not become available until the discovery of the Edwin Smith papyrus at the end of the nineteenth century and its subsequent translation in the twentieth. Thus, the observations in the papyrus consistent with the understanding that there was a fluid within the head was lost.

The next major contribution was from Hippocrates. He is credited with being aware of the presence of fluid within the cranium, but the documentation is imprecise (Lifshutz and Johnson 2001; Woollam 1957). Galen was aware of the cerebral ventricles and described the anatomy with some accuracy including the anterior (our lateral) the third and the fourth ventricles. He also described the calamus scriptorius in the floor of that ventricle. He believed that the psychic pneuma generated in the rete mirabilis was stored in the ventricles. In neither the work of Hippocrates nor that of Galen is one left with the impression that the ventricles were filled with a fluid.

Paul Ægineta devotes a chapter to hydrocephalus. His description is as follows.

> "The hydrocephalic affection is so named from the peculiarity of the fluid, it being of a watery consistence. It occurs in infants, owing to their heads

> being improperly squeezed by midwives during parturition, or from some other obscure cause; or from the rupture of a vessel or vessels, and the extravasated blood being converted into an inert fluid; or from rarefaction, the matter exuding and lodging between the skin and the pericranium. For the fluid is formed either between the pericranium and the skin, or between the pericranium and the bone, or between the bone and the meninx." (Æginata 1834).

Adams in his commentaries, states that modern views (early nineteenth century) are sceptical to the existence of the 'hydrocephalus externa' described above. At all events, the word as used by Paul has nothing to do with the familiar dilated cerebral ventricles which characterise hydrocephalus in the twenty first century.

After Galen, systematic legal dissection of any kind was not undertaken until the development of the medical school in Bologna, where it became legal in 1405 AD (see chapter 3). Even so there was no serious mention of the existence of CSF. Vesalius described the smooth lining of the ventricles and stated that they were filled with a watery humour (Woollam 1957); whatever that might mean. According to Woollam it was a Variolo from Padua who, in 1573 first maintained the ventricles contained a fluid. The generally accepted first description of CSF was made in 1764 in a monograph on sciatica by a Neapolitan physician called Domenico Cotugno. (McHenry 1969)

Cerebral Lateralisation

Classical Times

Hippocrates, in his text on head injury mentioned the occurrence of convulsions on the opposite side from an injury (Hippocrates 1928). He did not however note that paralyses were likewise contralateral. Galen made no contribution on this point. On the other hand - Aretaeus the Cappadocian made the following precise statement

> "But if the head be primarily affected on the right side, the left side of the body will be paralyzed: and the right if on the left side." (Aretaeus 1856).

This remarkable finding was forgotten maybe in part because like Celsus, Aretaeus' writings were lost; in this case until 1552. Be that as it may, it remains amazing that so few surgeons commented on the presence of post traumatic paralyses and their lateralisation. However, there were a few exceptions.

Medieval to Renaissance

William of Saliceto

William of Saliceto in 1275 wrote

> "Take note of this: If the head was struck by a sword, cudgel, batton, rock etc., and the blow was strong enough to strike down the victim and cause him to lose his powers right then or afterwards, the paralysis, if any, will be on the side opposite the injured side of the head. Avicenna discussed that in Book II, in the chapter on head injuries" (Saliceto 2002).

The reader should note the reference to Avicenna who had become such an authority to medieval European surgeons. These comments on contralateral paralysis were ignored by later surgeons.

In 1518, again prior to the rediscovery of the writings of Aretaeus, Berengario da Carpi wrote a monograph on cranial fractures. In this as in much else he was more observant than his predecessors, contemporaries, and successors. He wrote:

> "Note that Avicenna, Canon 1,3, says that paralysis occurs on the side of the wound and spasm on the side opposite to it as in many cases. Nevertheless I say that the reverse situation can happen, that is, in the injured part spasm can occur while paralysis occurs in the part opposite. Likewise, it is possible that only one of these afflictions may occur or neither. But the reason why spasm occurs in the opposite part and paralysis in the injured side is because the part near the wound is weaker. (Carpi 1990)

The observations are perhaps the most accurate so far even if the explanation is not so good. Even so, like Aretaeus the teachings were ignored. Paré also noted that a convulsion or a paresis could occur either on the injured side or the opposite side. He stated:

> "the wounded part is seized by a Convulsion and the sound by a Palsie; otherwhiles both of them by a convulsion or Palsie and somewhiles the one of them by a convulsion or Palsie, the other being free from both affects". To this he added "the causes of all which belong not to this place to explain" (Johnston 1649).

His younger contemporary Peter Lowe also noted convulsions on the opposite side and sometimes apoplexy without noting the side.

Seventeenth to Eighteenth Century

It should be noted that while the brain was so far not regarded as the structure responsible for post-traumatic dysfunction, observation of the side of the paralysis does not depend upon this understanding. Having said that, the next step in the dawning understanding came from the Académy Français in Paris. While this centre was directed by James Louis Pétit, the earlier publications from the centre was produced by his assistant Henri-François Le Dran. Moreover, his mastery of English was welcome and he achieved eminence across the English Chanel. Thus, his writings were the first to provide evidence for the brain as the source of clinical disturbance after head injury. Even so he did not comment on the side of any paralyses (Le Dran 1740).

James Hill of Dumfries (1703 – 1776)

The first person to use contralateral neurological deficit as a component of his surgical planning was James Hill of Dumfries. He mentioned the relationship of side and deficit in two of his cases.

The first was a patient who had been beaten up. The text reads as follows:

> "February 27. 1751. John Rogerson, when about thirty years of age, received a blow or two on the head with a loaded whip-handle and as many with a crab-stick.
>
> Next morning he was in a profound apoplectic-like lethargy, and his whole right side was paralytic though there was neither fracture nor depression.
>
> The symptoms showed the necessity of opening both sides of the head. But the impressions of the staff being strongest on the right side, it was opened first, though the symptoms indicate the contrary." (Hill 1772a)

In other words, the symptoms or paralysis on the right side suggested a left sided lesion but this was given a lower priority because of the serious external injuries on the right side.

The second case was a young lady with a cerebral abscess. The case notes read as follows:

> "Elizabeth Walker, a robust country girl about nineteen years of age, felt a numbness in her left hand on the 6th of February 1761, which gradually rose up the arm, and was attended with constant vomiting, and such a violent headache, that her friends were obliged to hold her head between their hands

> for two months; at the end of which her whole left side and arm became paralytic.
>
> Blistering, and other nervous medicines had been used without any advantage. Application was made to me for spirits, or warm oils, as they termed it to anoint her; which I refused and told her friends 'That as the distemper lay in the right side of her head, everything was useless till that was removed, and that I would willingly open it, if there were any symptoms showing where the operation ought to be performed.
>
> About the beginning of May, a small tumour, about the size of a pea, appeared on the right side of the bregma." (Hill 1772b).

This text indicates a clear-cut awareness that a left sided paralysis came from a right sided lesion but with no external location for surgery it could not be attempted. Subsequent appearance of a right sided swelling indicated the location and subsequently an abscess would be found and operated. Unfortunately, the patient's friends preferred her to be cared for by an Irish woman who was employed for seven months. In consequence, Hill was asked to operate too late and all he could do was reduce her suffering during her subsequent deterioration to death.

The Final Step

In 1867 Sir Jonathan Hutchinson insisted that localization of an epidural haematoma could be achieved by noting that a hemiparesis would be contralateral, while a fixed dilated pupil would be ipsilateral. (Hutchinson 1867).

In Summary

It is not possible to explain the absence of an event. However, it is tempting to believe that it took such a long time to observe CSF because of a well-accepted physiological system approved by the authorities, not least the church authorities with their influence on the fate of a person's soul. The system of humours and pneumas was not likely to promote anatomic and physiological clarity. This is another example of the previously mentioned principle formulated by Claude Bernard., that observation as an active process. Observers would not be looking for CSF and its existence was contrary to humoral doctrine, not least because mental characteristics had come to be placed in the ventricles under the auspices of the church. The tendency for people to accept the authority of their elders and betters would potentiate attitudes of keeping to the status quo. As Bernard stated:

"Man is by nature metaphysical and proud" (Bernard 1957).

In the case of cerebral lateralisation, it is easy to believe that this was not an issue of great importance except insofar as with which arm a person wrote or wielded a sword. It was only with the realisation that the brain was the source of symptoms after cranial trauma that the specifics of loss of function became more of a matter of interest. It is still however strange that a number of observers noted the relationship between injury and neurological deficit, but their findings did not stimulate further interest and acceptance.

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CHAPTER 9

CRANIAL FISSURES

Introduction

For the past fifty years the finding of a cranial fissure has not required any special management, though to a certain extent its presence indicates a more severe injury. Moreover, in the days before CT, skull x-rays showing a fissure were much prized in the law courts. The introduction of the CT and the development of the modern speedy spiral CT, the details of skull injury have become much better demonstrated and the information is available very quickly. While the modern neurosurgeon addresses his attention to the underlying brain, this is a relatively modern approach. For the majority of the last two and a half millennia, attention has centred on the cranial fractures. It is the development of their management which is the subject of this chapter. The practice of a series of important surgeons is reviewed with consideration both of access to a fissure and actions on identifying it. It is largely and sadly an account of an unnecessary procedure based on a no doubt well intentioned error of Hippocrates.

Ancient World to Early Middle Ages

Hippocrates (ca. 460 BC – ca. 370 BC)

Fractures had been managed for well on two millennia according to principles laid down initially by Hippocrates. In the absence of diagnostic images only clinical information and observation could detect a fracture. Hippocrates lived at a time when there were a great number of wars in his native land providing many patients with cranial injuries. Based on his broad experience he wrote a monograph on cranial injury which described amongst other things the way to manage cranial fractures.

In order to diagnose a fracture, in the absence of X-rays the damaged bone required direct observation. With the frequent number of wounds inflicted by sharp instruments, in many cases there would be an associated laceration through which the skull could be seen and indeed touched.

Nonetheless, not every laceration would be adequate in size or location and a judgement had to be made to decide which patients should be subjected to a search for a fracture. First, a probe should be used to assess the state of the cranium. Irregularities might indicate a fracture, but Hippocrates warned against confusing sutures with fissures. In addition, Hippocrates would question extensively about the source of the injury, the nature of the agent striking the head and the force and direction of the blow. He stated:

> "One should incise wounds occurring in the head and forehead where the bone is laid bare and seems to be in some way injured by the weapon, while wounds are not long and broad enough for inspection of the bone, to see whether it has suffered any harm from the weapon, the nature of the injury and the extent of the contusion of the flesh and any lesion of the bone, or, on the other hand, whether the bone is uninjured by the weapon and has suffered no harm; also as regards treatment to see what the wound requires, both as regards the flesh and the bone lesion." (Hippocrates 1928a).

Hippocrates classified fractures as fissure, hedra, contusion, depressed fracture and contre coup fracture. What he meant by bone contusion is unclear, though he insisted they were variable. He specified the following characteristics:

> "There are many forms of contusion; for the bone is more contused or less, to a greater depth, going right through, or less deeply, not going through the bone, and to a greater or smaller extent in length and breadth. Now none of these forms can be distinguished by the eye as to the precise shape and size, for it is not even clear to the eye immediately after the injury whether contusion has taken place even if the parts are contused and the damage done..." (Hippocrates 1928b).

These remarks suggest that contusions of bone were more assumptions than actual detectable clinical pathology. The nature of a hedra has been discussed but most recent works seem to consider it is a focal dent of the outer table produced by a sharp weapon (Panourias et al. 2005; Chang 2007). Hippocrates specified it may also be complicated by an adjacent fracture (Hippocrates 1928c). If no fracture were visible but he felt the injury was sufficiently severe or was associated with serious clinical findings such as:

> "vertigo, and loss of sight, was stunned and fell down" (Hippocrates 1928d)

then he applied jet black ointment, kept in place with a linen rag smeared with oil. When the rag was removed the following day a hair line fracture would be revealed by the black colour. This technique was to be adopted by most who followed him.

The surgical instruments available to Hippocrates included scrapers and trephines. While trephination had been known since as early as 10000 BC (Rose 2003), it was Hippocrates who provided the first detailed advice on the correct way in which to perform the operation. He was also most concerned that cranial injuries should be kept as dry as possible. He noted that putrefying soft tissues could in turn damage the bone so that such tissues should be removed.

When it comes to surgery, his indications for operating differed from what would seem rational to us. Thus, he recommended trepanation for contusions, for fissures, and for hedra with a fracture or hedra with a contusion and no fracture. This cannot have been easy to assess, given that contusions could be invisible. Depressed fractures and hedra without fracture or contusion did not require trepanation. The description of fractures given the label depressed sounds much closer to what we would call comminuted so that it would indeed have been wise to avoid operating.

What is of concern in the current context is Hippocrates' advice for the treatment of fissures. He mentioned they can be varied in both extent and severity differing from obvious to so fine that they defy detection by the naked eye; requiring the use of the black dye mentioned above. Once demonstrated, a fracture was scraped with a special instrument designed for the purpose called a raspatory. If the fracture disappeared during scraping, there was no cause for concern. That was a partial thickness fissure (see figure 9.1). To a modern surgeon, a partial thickness skull fracture is an unfamiliar concept. In a comprehensive book on the radiology of the skull there is no mention of them (du Boulay 1980). In MEDLINE there are only three papers which mention partial thickness fractures. Two of these concern paleontological studies (Tappen 1979; Riccomi et al. 2017). The third is a Japanese case with insufficient information in the English abstract to analyse its significance (Miyaki, Yamamura, and Abe 2016). There is one other contemporary mention of a partial thickness fracture in Leestma's book on forensic neuropathology. The comment is as follows.

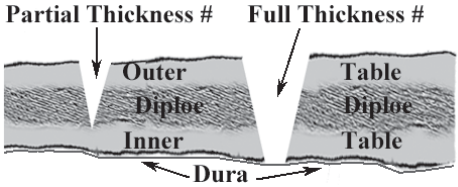

Figure 9.1
The two kinds of fissure. Both would be scraped until they disappeared. If this was in the diploe nothing further need be done. If the fissure extended to the dura, trepanation to permit any underlying haematoma to be removed, thus preventing suppuration and death.

"Simple linear fractures, especially if they do not fully involve the inner and outer tables of the skull, may be difficult to observe at autopsy" (Leestma 1988).

Thus, all the available evidence indicates that partial thickness fractures are not common well recognised entities in modern practice. Yet they were a major concern from the time of Hippocrates right up to the beginning of the eighteenth century; a period of well over two millennia. Too many distinguished surgeons mentioned these partial thickness injuries for their existence to be ignored. Several authors have noted that they were inflicted by implements no longer in common use. These would be sharp-edged weapons, such as swords. The injuries inflicted were mentioned and given a name (absolute avulsion) by Albucasis over a thousand years ago. He wrote:

> "Or the sword may cut through part of the bone, only slicing through the surface and not reaching the depth; this kind is called an absolute avulsion." (Albucasis 1973).

This mechanism of injury was further mentioned by Berengario da Carpi (Carpi 1990b) and Richard Wiseman (Wiseman 1734).

If a fissure did not disappear after the bone containing the fissure had been scraped all the way through, then it was a full thickness injury, and the trephine would be required; but why? Nowhere is a clear-cut reason given in Hippocrates' monograph on head injuries for this indication. On the other hand, concern for suppuration is clearly expressed but not as an indication for trepanning, rather as a risk associated with crushed, damaged soft tissue. However, elsewhere there is a principle amongst Hippocrates' teachings which runs as follows in translation.

> '…for lesions become inflamed when they are about to suppurate and they suppurate when the blood in them is altered and heated until it putrefies and becomes pus' (Hippocrates 1995).

Celsus (ca. 25 BC – ca. 50 AD)

Celsus would not be relevant until the fifteenth century because his manuscripts were lost. It has moreover been suggested that they were of lesser interest because they were written in Latin and not Greek, the preferred language of Academia at that time. Nonetheless, he would achieve great influence when his works were recovered. His De Medicina was the first medical work to take advantage of the newly invented printing press. It is convenient therefore to look at his practice now even if its influence had to wait a millennium and a half to be appreciated.

Celsus' classification is simpler than that of Hippocrates. This is not because he was unfamiliar with the master's work. He demonstrated great

respect because Hippocrates stated that he sometimes made mistakes in distinguishing between a cranial suture and a fissure. Celsus thought that only a great man would admit error in this way. Celsus mentioned just fissures and depressed fractures (Celsus 1938). He described the symptoms which arise from a cranial fracture which are bilious vomiting, obscurity of vision, speechlessness, bleeding from the nose or ears, falling to the ground, senseless as if asleep. He suggested that:

> "If in addition there is also stupor, if the mind wanders, if either paralysis or spasm has followed, it is probable that the cerebral membrane has also been lacerated". (Celsus 1938)

For fissures, Celsus favoured dressings soaked in vinegar and bandages. This is not following the dry treatment of Hippocrates, but vinegar is a powerful antiseptic (Majno 1965). He wrote that the treatment should be followed by healing of soft tissues and bone. If this failed and instead the patient suffered headaches, fever, loss of appetite, discharge and swollen glands in the neck, bone needed to be removed. In other words, Celsus did not advise prophylactic trepanation but restricted the indications for an operation to those patients who had developed an infection.

Galen (ca 130 – ca 210)

Galen's contribution to diagnosis was to change the classification. He started by specifying full thickness and partial thickness fractures. He thereafter specified fissures, comminuted and depressed fractures. There was no mention of hedra (Galen 2011). Galen made no comments on diagnosis, merely mentioning Hippocrates monograph as a source and claiming his only function was to clarify portions that were vague. There is nothing on diagnosis or on the use of black dye to find hairline fractures. He began with the classification mentioned above. He went into some detail on the use of raspatories and introduced new instruments including cyclisci and the lenticular knife. He recommended the application of topical drying medicines so that the bones are kept clean and dry. For full thickness fractures he emphasised that crushed bone fragments must be removed and outlined the different instruments employed for that purpose. He thought trephines were too dangerous and cyclisci (chisels with a curved cross section) shook the head too much. He preferred the lentiform knife as the safest tool for cutting away bits of bone remarking that the dura could not be injured even if the operator were 'half asleep'. He recommended the use of trephines if the bone was thick. He did NOT recommend prophylactic trepanation by the side of fissures. He also emphasised that fissures heal by callus formation.

Paul Ægineta (ca.625 – ca.690)

Paul Ægineta sorted out concepts which had been less clearly expressed by previously more creative persons than himself. He wrote about fractures:

> "It is also discovered by its appearances to the senses; for if there be a considerable division of the skin we ascertain the occurrence readily thereby; but if there be no division, or a very narrow one, and we suspect a fracture, we make an incision in the skin and ascertain it by the sight, or by probing it with an instrument." (Adams 1846b).

This established a principle that incision, examination and observation would be the appropriate technique to examine skull fractures until something better came along. It could hardly be more clearly and concisely expressed.

Paul classified fractures as follows: fissures, incisions, expressions, depressions, arched fractures, and dents arising in infants. A fissure was defined as by other authors and he specified the risk of hairline fractures and the need to use ink to identify them if there were reason to suspect a fracture which could not otherwise be seen. The symptoms suggesting the presence of a fracture were:

> "…vertigo, loss of speech, and sudden prostration...owing to the compression of the brain" (Adams 1846b).

His attributing the symptoms to compression of the brain was a new idea. It was an insight which would be largely ignored during subsequent centuries. His concern was also greater if the fracture were depressed, comminuted, arched or if contusion were present. He did not explain how he decided if contusion were present. He also went into some detail to deny the existence of contre-coup fractures.

Paul's treatment of fissures was similar to that of Hippocrates with one vital difference. Hippocrates advocated trepanation when scraping had revealed a full thickness fissure. Paul only advocated this after a fissure had been scraped through and there was evidence of dural separation. Without it he advocated the same treatment as for partial thickness fissures. On the other hand, if the dura were separated, Paul advised trepanation. His reason for removing fractured bone in the presence of dural separation was to avoid the development of inflammation and what he calls unconcocted pus with other dangerous symptoms such as changes of intellect, bilious vomiting, high fever, and convulsions may thereby be avoided. If these symptoms developed Paul advised that surgery was contraindicated.

Paul did not review the treatment of each kind of fracture systematically. He had an excellent account of his technique for opening the skull by the side of a fissure which he ended by stating the same technique is appropriate for other kinds of fracture. He specified the removal of spicules and residual small bone fragments. He recalled the instruments used by Galen and in cases other than a fissure he described how much needs to be removed quoting the master.

> "But regarding the amount of bones requiring extraction Galen informs us, writing thus plainly: 'What parts of a fractured bone are to be removed I will now explain to you in order. When it is greatly bruised it is to be taken out entire, but if certain fissures extend from it farther, as sometimes they appear to do, we must not pursue them to their termination, well knowing that no harm will result from them if everything else be properly done'" (Æginata 1834).

Middle Ages to Eighteenth Century

Scalp Incisions

Today, diagnostic imaging provides information on which to base management. Right up to the time of Wilhelm Röntgen, in the absence of a laceration, the surgeon would have to make a skin incision if he wanted to examine the skull. Surgeons distinguished between the type of incision required for diagnosis and the kind required for therapy. Celsus introduced the notion of a cruciate incision which facilitated closure as shown in figure 9.2, although his advice would be unavailable until his book was rediscovered during the Renaissance. However, Paul Ægineta also recommended the use of a cruciate incision to examine the underlying cranium and most of his successors employed the same technique for both investigation and therapy. There were a few who worried about the trepan damaging the skin and thereby preferred removing a disk of skin; a process known as scalping. However, most were happy with either a cruciate incision or a triangular opening which could easily be sutured and thereby cover the underlying cranium.

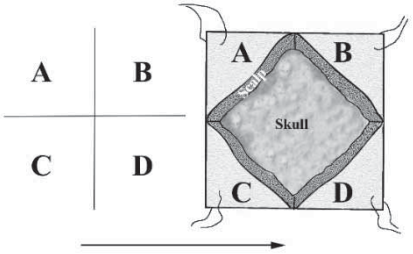

Figure 9.2
In a cruciate incision two cuts are made to from a cross. This creates four triangular flaps which are bent outwards. When the procedure is complete the triangles can be sutured together very simply.

Finding Fissures

Having identified a fissure, the next stage was how to cope with it. They were treated as described by Hippocrates (Hippocrates 1928e), Galen (Galen 2011), and Paul Ægineta (Adams 1846). Emphasis was directed at determining if fissures were full thickness. Up to the time of Roger Frugard of Salerno (1140 – 1195), the depth of a fissure could only be assessed with scraping which stopped when it was demonstrated that the defect did not go all the way through the bone. Subsequent treatment involved ointments and dressings. Roger demonstrated that once a fissure was exposed, if a Val Salva manoeuvre were performed, in full thickness fissures fluid would emerge through the fissure. This would not happen with a partial thickness lesion. Patients could thereby be spared a scraping procedure (Frugard 2002). Nonetheless, scraping is mentioned, and the Val Salva manoeuvre is not mentioned by Bruno da Longoburgo (Longoburgo 2003), William of Saliceto (Saliceto 2002), Berengario da Carpi (Carpi 1990a) and Richard Wiseman (Wiseman 1734). On the other hand, Theodoric (Theodoric 1955), Guy de Chauliac (de Chauliac 2007), Jehan Yperman (Yperman 2002), and Robert Lowe (Lowe 1612) all mention the use of the Val Salva manoeuvre. Lanfranc disliked the Val Salva Manoeuvre without explaining why. He would make a plaster of mastic (an aromatic gum) and egg-white and apply it to the injury with a cloth for twenty-four hours. When removed he claimed if the paste on the cloth was drier where it had lain over the fracture then the fracture was full thickness (Lanfranc 2003). Henri de Mondeville shared Lanfranc's dislike of the Val Salva test considering it induced harmful brain motions. He supported Lanfranc's method (De Mondeville 2003a). De Mondeville also approved tapping the head with a twig and detecting a different note from that heard in a healthy head. In addition, he claimed that plucking a string held between the teeth would produce pain at the fracture site (De Mondeville 2003b). Three distinguished later surgeons, Berengario da Carpi (Carpi 1990b), Ambroise Paré (Johnston 1649a) and Richard Wiseman (Wiseman 1734) insisted these tests were worthless.

Cranial Fissures – Indications for Trepanation

Pus between the cranium and the dura would be lethal so, if a fissure were full thickness, it was necessary to ensure that no blood had accumulated beneath it, hence the need for trepanation. The need to drain such accumulations permeated the writings of most subsequent surgeons though their indications varied. Some, Paul Æginata, Frugard, Bruno da Longoburgo, Theodoric, Peter Lowe, and Richard Wiseman were prepared to trepan prophylactically if a fissure was full thickness (Frugard 2002;

Longoburgo 2003; Theodoric 1955; Saliceto 2002; Lowe 1612; Wiseman 1734; Æginata 1834). Theodoric also made extensive use of potions and superficial applications of oils and ointments (Theodoric 1955). Jehan Yperman explained how to scrape a full thickness fissure without being totally clear as to the indication. Guy de Chauliac favoured opening a fissure if there was drainage of fluid through the fissure quoting Galen as his authority. He favoured the elevation of depressed fragments. He required a large enough space must be made for drainage either by adjacent bone or by widening the fissure (de Chauliac 2007). Lanfranc was sceptical of the need to make an opening prophylactically to permit the drainage of the expected accumulation of pus and blood. He believed such accumulations could resolve spontaneously and he considered trepanning dangerous. He reserved its use for two indications. The first was depressed fractures with a bone fragment impacted under the normal bone at the edge of the fracture. The second was a fragment which had penetrated the dura and caused great pain (Lanfranc 2003). Henri de Mondeville, at great length preferred to treat without operating. However, he advised bone removal if pus was leaking through the fissure. His motive was therapeutic not prophylactic (De Mondeville 2003c).

In addition to the details mentioned in the previous paragraph, the indications for the trepanation of cranial fractures were fairly consistent from ancient times up to the eighteenth century. In the presence of a full thickness fissure, the operation was performed either prophylactically to prevent the formation of pus or therapeutically in the presence of pus leaking through the fracture fissure. There were however some variations in the details of indications. The first to modify that policy was Lorenz Heister (1683 – 1758) who considered but it was essential to trephine if there were bad symptoms, including stupor, vomiting, vertigo, speech loss or bleeding from nose or ears. What Heister did not do was to speculate on the origin of these symptoms. Nonetheless, for the first time he seemed to have awareness that they come from the brain in that he wrote:

> "T'is well known, that the Bones of the Cranium are often fissured, and the adjacent Blood-vessels lacerated by external Injuries, without any apparent Fracture or Depressure of them; so that if the extravasated Blood be not removed by the Trepan, by pressing on the Brain, it will greatly injure, if not totally destroy its several Functions; and the consequences of neglecting this Instrument in such cases will be Restlessness, Delirium, Convulsions, Vertigo, Apoplexies, Stupidity, with a loss of the Senses Speech, and voluntary Motion, and at last Death itself." (Heister 1743)

A Misunderstanding

Raised intracranial pressure is a modern concept and its relief played no part in the management of cranial fissures through the centuries after Hippocrates. Nonetheless, there has been a persisting error in reporting on the indication for trepanation for fissures in the past. It goes back to the Frances Adams 1849 translation of Hippocrates' Head Injury monograph. The translation is preceded by an 'Argument'. In this Adams correctly characterises this treatment as prophylactic. On the other hand he commits the error of suggesting it is done to make space and compensate for pressure. He wrote:

> "Believing, then, that, in contusions, the internal structure of the brain is extensively injured, and that irritation, with hypertrophy, are the consequences, he advocated instrumental interference, in order as I have stated, to give more room to the brain, and relieve it from its state of compression! This, no doubt, was the rationale of his practice also in simple fractures, not attended with depression, that is to say, his object in perforating the skull was to remove tension, and furnish an outlet to the collection within, whether of a liquid or a gaseous nature." (Adams 1849a)

He quotes a number of contemporary surgeons to support this view, which was completely valid in the 19th century but not earlier.

Trepanation Technique – A Detail

Today any medically qualified person knows that if you block your ears, a sound applied to the bone of the cranium, be it a tuning fork or a tap, becomes louder. The awareness of hearing by bone conduction was first reported by Phillipus Ingrassia (1510 – 1580). The work was published in 1603 and noted that sound could be heard through the teeth. The underlying mechanism of bone conduction was experimentally demonstrated as late as 1684 (Kelley 1937). The relevance of this information is demonstrated in table 9.1. Strange to say none of the surgeons concerned observed that this procedure actually would make the noise worse.

Surgeon	Material in Ears
Paul Ægineta (ca.625–ca.690) (Adams 1846a)	Wool
Bruno da Longoburgo (ca 1200 – 1286)	Not stated
Theodoric Borgognoni (1205 - 1298) (Theodoric 1955)	Cotton
William of Saliceto (1210 – 1277) (Saliceto 2002)	Silk/Cloth
Lanfranc of Milan (ca 1250–1306)	Not stated
Henri de Mondeville (ca 1260 – 1316) (De Mondeville 2003)	Cotton
Jan Yperman (1260 – 1322) (Yperman 2003b)	Cotton
Guy de Chauliac (1300 – 1368) (de Chauliac 2007)	Cotton
Berengario Da Carpi (1460 – 1530) (Carpi 1990c)	Cotton or wool
Ambroise Paré (1510 – 1590) (Johnston 1649b)	Cotton wool
Richard Wiseman (1621 – 1676) (Wiseman 1734)	Lint

Table 9.1
The above surgeons filled the external auditory meati of their patients during trepanation in the well-meaning but incorrect belief that this would reduce the noise to which patients were being subjected.

Correction of Error

This error of believing hematomas turned to pus inside the body influenced every surgeon down to Richard Wiseman in the seventeenth century. It came to an end following the writings of Sir Percival Pott, in his text ‘Observations on the Nature and Consequences of those Injuries to which the Head is liable from External Violence’, published in 1758. He noted in respect of epidural pus which he found several days after cranial trauma in a number of cases.

> ”I am very sensible that it is a generally received opinion, that blood shed from its vessels, and remaining confined in one place, will become pus; and that the matter found on the surface of the dura mater, toward the end of these cases, was originally extravasated blood. But I apprehend both these positions to be false.” (Pott 1768).

This writing marked the beginning of the end of an erroneous notion introduced by Hippocrates, and which had endured for over two thousand years.

In Summary

Hippocrates believed that extravascular collections of blood would turn to pus. In consequence from his time onward the management of fissures was fairly standardised, involving scraping followed by trepanation if the fissure was full thickness, to enable any collections of matter to be evacuated. Paul of Ægineta tended to a more conservative use of the trephine and so did Lanfranc and de Mondeville, but the majority stuck to the methods of their fathers. Yet again we meet the preference for authority over observation and personal experience. Thus, countless people were subjected to an unnecessary painful procedure. Roger Frugard introduced the use of the Val Salva manoeuvre to determine if a fracture was full thickness. This permitted a more gentle investigation by those who took up the method but not everyone did.

In the eighteenth century a number of advances in knowledge resulted in gradually changing patterns of practice. The Paris Academy and Percival Pott in London finally insisted that brain injury was the source of symptoms following cranial trauma. This finally eradicated the belief, the origin of which lay with Celsus that these symptoms were due to injury of the bone and the meninges. In addition, an increasing awareness of the role of increased intracranial pressure directed attention away from the external cranium towards the soft tissues which it contains.

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CHAPTER 10

CONCLUSION

It has been fascinating to study the material which forms the basis for this book. We live during the early part of the twenty-first century where the power of belief is all around us, illustrated by the consequences of different religious faiths and forms of government. The practice of cranial surgery has similarly been much influenced by the power of belief. The totally irrational procedures of bloodletting and trepanation for skull fissures were both based on seemingly rational notions.

After the fall of Rome, Europe descended into a dark era. While Christianity was and is a religion of hope, and kindness its worldly institutions, in particular the Roman Catholic Church evolved into authoritarian even tyrannical bureaucracies. Education was to be in the hands of the literate Latin speaking priesthood. Yet it is encouraging that the spark of curiosity which is so essential to all learning could not be completely extinguished, so that gradually studies permitting the acquisition of new knowledge emerged from under the yoke of Papal authority.

What is cause for concern is our persisting willingness to cling to irrational, incorrect notions blessed by authority at the expense of personal observation and experience. The trouble is that the accepted feels safe and resisting it leads not only to uncertainty but also to the often, powerful opposition of others, who wish to retain their attachment to what is accepted. Over time new techniques of observation and analysis could demonstrate that certain beliefs were irrational even though they might well persist for a while because they were accepted.

It is not however technology which is the most important requirement for introducing new ideas. That requirement is the mind and attitudes of the observer. An excellent example is the discovery of the circulation of the blood by William Harvey. This did not involve the use of materials or equipment which were newly invented and hence unavailable to predecessors. Harvey's experiments could just as well have been carried out in Galen's Rome as in Harvey's London. What was different was that

Harvey lived at a time when it had become increasingly customary to query accepted ideas. Nonetheless, even in his time he was aware of the risks of new ideas and the initial publication of ‘du moto cordis’ was in Frankfurt. It was of poor quality with 126 errors (Wright 2013). Even today when scientific advances are discovered with increasing speed it should not be thought that refusal to accept new ideas and the desire to cling to accepted truth have disappeared. As recently as 1982 there was a splendid example when Robin Warren and Barry Marshall identified helicobacter pylori as the cause of peptic ulcers. Their discovery was not greeted overnight with approbation (Marshall and Warren 1984).

This attitude of adhering to accepted notions has meant that the possibility of progress failed to develop. One of the side effects of such acceptance is a lack of interest in observations which do not seem relevant to the observer. As mentioned repeatedly throughout the book, as taught by Claude Bernard, observation is an active process. Thus, Galen, and Paul Ægineta and several others noted that the normal brain pulsates, but this was not considered in any serious way until towards the end of the eighteenth century. Aretaeus noted that paralyses following cranial trauma were contralateral. This must have been glaringly obvious to anyone looking for it. Avicenna, William of Saliceto and Berengario Da Carpi all commented on the contralateral side of the paralysis but there was no sign that they considered it was important. This may well be because none of these authors considered the brain was the source of the deficit. One of the most surprising failures of observation was the persistent inability to observe CSF even though it is more than possible that it had been noted by the Ancient Egyptians.

Another aspect of modern science is the intensive use of statistics to test biological and therapeutic endeavour. Nonetheless, the actual discovery of new ideas still depends on the talents and efforts of individuals. Examples one could quote are the discovery of the structure of DNA by Watson and Crick or the invention of the world wide web by Tim Berners-Lee. Of course, statistics become invaluable in the processes involving the application and control of the consequences of the above advances.

In conclusion, while we live in a time of unsurpassed technology which has been shown to increase not only the quality but the length of our lives, we remain human and retain the ability to err. It is hoped that this book has illustrated some of the processes by which error arises and persists. It is also hoped that it can be accepted that the lessons it contains will remain relevant

even if our ability to acquire and organise data is vastly improved. No matter how expert our knowledge becomes, it can never be perfect.

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