COMPLICATIONS IN NEUROSURGERY

Anil Nanda

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Complications in Neurosurgery

"asato mā sadgamaya
tamasomā jyotir gamaya
mrityormāamritam gamaya
"From ignorance, lead me to truth;
From darkness, lead me to light;
From death, lead me to immortality

Brihadaranyaka Upanishad. [700 BC]

To my wife, Laura, my children, Alexander, Christopher and Mary Catherine.
and to my mother, Uma Nanda and late father Dr. K.G.S.Nanda

Complications in Neurosurgery

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Foreword

I am truly honored to be asked by Dr. Nanda to write the foreword for this important comprehensive text on neurosurgical complications. Dr. Nanda is in a particularly advantageous position to edit this book because he is one of the few neurosurgeons of his generation that, while achieving true technical mastership in some of the most difficult neurosurgical specialties such as skull base and neurovascular surgery, continues to accumulate vast experience in practically all areas of neurosurgery. It is also appropriate that he edits and personally writes a good portion of this book because of his well-earned reputation for honest assessment and discussion of his complications. To watch a master surgeon like Anil operating on a difficult petroclival meningioma or basilar aneurysm and to hear of his excellent results leaves us in awe of his virtuosity and with admiration and not infrequently envy of his results. However, to hear an honest and thoughtful discussion of his complications and possible ways to avoid them educates us and makes us better and safer neurosurgeons to the advantage of our future patients.

I am not sure if Dr. Nanda asked me to write this foreword because of the quantity and variety of complications that I have encountered in my career or because he may have heard me say that of the papers and chapters I have written in neurosurgery the ones that have given me the most pride and satisfaction have been those I have written about my own complications. These writings have certainly not been frequently quoted and have not significantly contributed to my "quotation index" but, much more importantly, have not infrequently led to a colleague stopping me in a meeting to thank me for having written about that personal complication and how I could have avoided it. This led him to prevent this complication and result in a good outcome on a patient he recently encountered. I am sure that any of us would rather hear that comment than hear somebody telling us "Wow, I was so impressed by those wonderful results you reported in that recent paper."

I teach my residents that there are three levels where complications should be discussed. The first level is at the time when they occur, which in our case is usually at surgery. When we make the wrong move, which results in massive rupture of the aneurysm, there is no point in telling our assisting resident, hopefully after the situation was controlled, that the rupture resulted from "bad luck" or "abnormal anatomy". Much better is to discuss exactly what was the mistake made and how it could have been avoided; this the resident will not forget. The next level to discuss complications is at morbidity and mortality conference. I have always advocated for a brutally open and honest discussion of complications which has frequently not been popular with my colleagues. By giving our colleagues the opportunity to hear about our complications it offers them the opportunity to learn from them and avoid them in their own future practice. It would be a sad thing if the only complications that we could learn from were our own. Much safer for our patients is that we learn not only from our complications but also from those of others. The third level to discuss complications is to talk about them in formal lectures and write about them in papers, chapters or in a comprehensive text of which I am sure this one will be a model.

This foreword is just that and it is not a book review so I will not make it insufferably long by describing the contents of the book in detail. Suffice it to say that the list of senior authors of each chapter compiled by the editor reads like a "who is who" of American neurosurgery and, for good measure, Dr. Nanda has also included contributions from several international neurosurgical eminences. Of the chapters that Dr. Nanda has contributed himself, I particularly enjoyed reading the proofs of his first chapter "Historical Perspective". In his uniquely elegant and scholarly fashion Anil begins the chapter by telling us that the first punishment for surgical complications was spelled out in the Code of Hammurabi, a Babylonian king of the 17th century BC. Fortunately, the punishment he decreed for surgical complications was not as severe as that for stealing which was death! What a lovely historical pearl!

I know that this book will make us better neurosurgeons. I could not imagine that the library of any conscientious colleague would be complete without it. Congratulations Anil!

Roberto C. Heros

Preface

"This above all: to thine own self be true.
And it must follow, as the night the day,
Thou canst not be false to any man."
William Shakespeare
Hamlet: Act 1, Scene 3

The great Roman, Seneca, has contributed richly to the world's aphorisms. Shakespeare provided an English translation of one of Seneca's most quoted guidelines for professional conduct. This aphorism about not being false to any man extends to our surgical sphere and is the Magna Carta of our art, our profession, and our oath.

I am delighted to welcome you to a book solely focused on complications. One might ask, why? As someone put it best, "Victory has a thousand fathers and defeat is an orphan." Too often in our specialty, we inflate our bravado to talk about triumphs and too little of the klieg light is focused on our failures. I remember as a young attending going to a major meeting where a prominent surgeon said that all his patients went home after an acoustic neuroma on post-op day two. I felt incomplete and inadequate, since most of my patients were still in the ICU. But I think it is important to talk about this. We have taken an entire textbook and devoted it to the different facets of complications.

On a theological note, talking about your worst-case disaster can be almost like a religious experience. In the Jewish faith, they talk about *cheshbon hanefesh*, a personal accounting about what has gone wrong. As my Catholic wife would remind me, *mea maxima culpa* is one of the cornerstones of Catholicism. So, to improve your surgical karma, it is most important to look at complications with complete dispassion and honesty, learn what went wrong, and most importantly, share what happened with others so if they go down that path they are guided and may perhaps find their way out of these dark corners.

Much like Odysseus on his perilous journey home to Ithaca, we take you through a veritable odyssey of complications. We begin with section one, the history of complications, all the way from the Code of Hammurabi almost 4000 years ago, where you would lose your hand if you had a mortality – something most of us would dread since we all confront surgical mortalities – through the Renaissance and Victorian times, where Robert Liston had a 300 percent mortality when the patient, his assistant, and an observer died in the same operation! In the general chapters, we have looked at wrong level disc-surgery, wrong-side craniotomies, post-op hematomas (both in the back and spine), the medical legal aspects, and how, in fact, surgical consent has been framed by certain landmark neurosurgical cases. Section two is mainly cranial complications, which are divided into vascular and endovascular, as well as skull base, primary brain tumors, and functional neurosurgery. Section three is focused on spine and peripheral nerve complications, including adjacent level disc disease, graft related complications, neurological deteriorations, as well as vascular injuries during approaches to the spine. The contributing authors have done a great job providing us with surgical pearls and a neurosurgical "selfie" moment with their worst-case disasters

As a resident and young attending, Dr. Charles Drake's brutal honesty, in terms of complications, was inspirational and the gold standard for all of us. In this generation, I think that mantle has been carried by Dr. Roberto Heros, with his unabashed honesty while talking about his complications with AVMs, aneurysms, and other topics. I feel privileged that he agreed to write the foreword to this book. He has been an incredible mentor and a blessing to so many of us. I am deeply grateful to him.

An offering of this sort is never an individual work, but it has been an amazing team effort. I am deeply indebted to the fellows in my department who have richly contributed to this book, including Dr. Amey Savardekar, Dr. Devi Patra, Dr. Vinayak Narayan, Dr. Bhavani Kura, and Dr. Mohammed Nasser. I am also grateful to my PA, Alice Edwards, and editorial assistant, Cody Hanna, as well as Belinda Kuhn and Trinity Hutton from Elsevier, who were a pleasure to work with. Lastly, I am deeply indebted to my wife, Laura, and my children, Alexander, Christopher, and Mary Catherine, who have always inspired me and reminded me about what is truly important in life. Their love and affection have always sustained me.

In the end, as American poet John Berryman wrote in "Dream Song," "I am obliged to perform in complete darkness operations of great delicacy on myself." This offering is a book about mistakes and how to avoid them, with the hope that it benefits all of us and makes the profession stronger, deeper, and richer.

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1 Historical Perspective

BHAVANI KURA, ANIL NANDA

If a physician make[s] a large incision with the operating knife, and kill[s] him, or open[s] a tumor with the operating knife, and cut[s] out the eye, his hands shall be cut off.[1]

This is one of the 282 laws that constitute the Code of Hammurabi, a Babylonian king who ruled from 1792 to 1750 BC (Fig. 1.1). His decrees were inscribed on a stone pillar after his rule, and several of his rulings pertained to the practice of medicine, including the enacting of a heavy penalty for a surgical complication. It is a wonder that anyone would choose to perform surgery with such a possibility at a time when morbidity and mortality likely were very high. This punishment was still less severe than that of being caught committing theft, for which the penalty was death.[1]

The earliest evidence of surgical procedures is from trephinations performed approximately 12,000 years ago in the Mesolithic era.[2] The actual reason for these surgeries is unknown and may have been for ritualistic purposes, but there have been examples found from ancient civilizations throughout the world (Fig. 1.2). From ancient Egypt, the Edwin Smith papyrus, which dates back to approximately 1700 to 1600 BC, is the oldest known medical text and detailed 48 cases of surgical pathologies and their management, including those of injuries of the cranium and spine. These treatments largely involved stabilization to allow healing with time. The Ebers papyrus (circa 1550 BC) was more encouraging of surgical intervention and included descriptions of procedures for the removal of tumors and abscesses.[3]

The earliest documentation of trephination comes from Greece. Hippocrates (460–370 BC) is known as the "father of medicine" due to his incredible contribution to the advancement, analysis, and documentation of the practice of medicine (Fig. 1.3A). The Hippocratic Corpus, a large collection of medical works attributed to Hippocrates and others in the Hippocratic School, included the book *On Injuries of the Head*, which detailed several types of skull fractures and their recommended management.[4] In the most famous of the writings within the Corpus, the Hippocratic Oath (Fig. 1.3B), the responsibilities of the physician are outlined, including:

> *I will follow that system of regimen which, according to my ability and judgment, I consider for the benefit of my patients, and abstain from whatever is deleterious and mischievous.*[5]

Similarly, in *Of the Epidemics*, the author notes:

> *The physician must … have two special objects in view with regard to disease, namely, to do good or to do no harm.*[5]

As in the texts from ancient Egypt, and unlike the code from ancient Mesopotamia, there is no indication of any penalties for complications, but in *On the Articulations,* Hippocrates does show disdain for those physicians lacking proper "judgment," to whom he attributes certain complications. He describes the inappropriate treatment of a nasal fracture leading to unsatisfactory healing[6]:

> *… those who, without judgment, delight in fine bandagings, do much mischief, most especially in injuries about the nose … those who practice manipulation without judgment are fond of meeting with a case of fractured nose, that they may apply the bandage … the physician glories in his performance … and the physician is satisfied, because he has had an opportunity of showing his skill in applying a complex bandage to the nose. Such a bandaging does everything the very reverse of what is proper … will evidently derive no benefit from bandaging above it, but will rather be injured…*[5]

He also provides advice for the prevention of complications in *On Injuries of the Head.* The readers are advised to avoid incising the brain to prevent convulsions on the contralateral side and to make the operative wounds clean and dry to prevent gangrene.

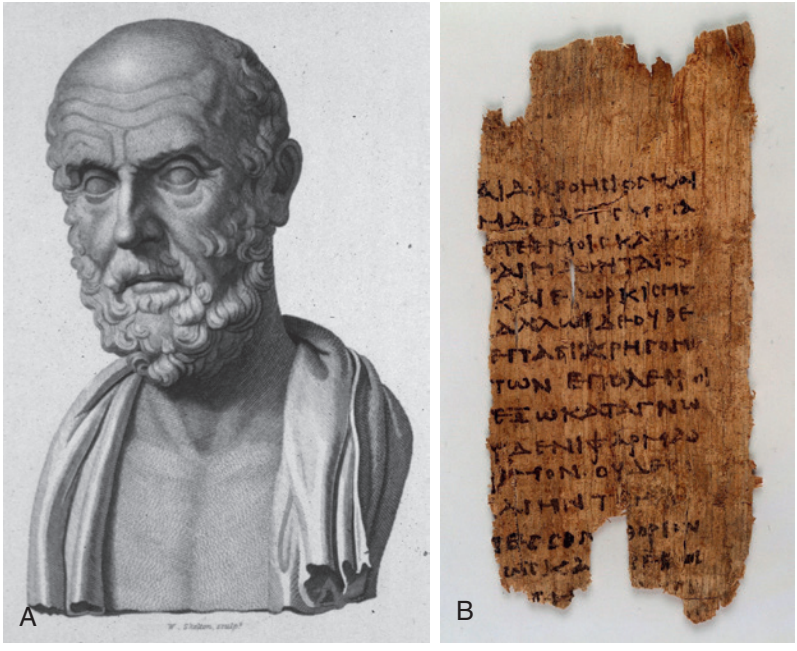
Several centuries later, Galen of Pergamon (129–200 AD) followed and expanded on the teachings of Hippocrates. He used his surgical experiences and anatomic dissections of animals to provide detailed descriptions of anatomy, which remained the standard for a millennia, despite some errors.[7] He emphasized the importance of the knowledge of anatomy in surgery:

> *If a man is ignorant of the position of a vital nerve, muscle, artery or important vein, he is more likely to maim his patients or to destroy rather than save life.*[2]

The first recorded medical malpractice case was *Stratton vs. Swanlond* in 1374 in London. The surgeon had attempted to repair the plaintiff's hand, which had been severely disfigured by trauma. The patient claimed that the surgeon had promised a cure, but her hand remained significantly deformed after the operation, and she filed a lawsuit for breach of contract. Although the case was actually thrown out on a technicality, the judge asserted that a physician would be held liable if harm came to the patient as a result of negligence, but not if he was unable to obtain a cure despite making every effort.[8] This decision became a part of English common law, or judge-made law. It countered people's expectation that only a complete cure could be a good outcome and not a complication. The term "malpractice" came about much later; it was coined from the Latin term *mala praxis* by Sir William

• **Fig. 1.1** The Code of Hammurabi inscribed on a stela. (Photo copyright Wellcome Library, London, supplied by Wellcome Collection, licensed under CC-BY.)

• **Fig. 1.2** A skull that had undergone several trephinations and shows evidence of healing, from 2200 to 2000 BC. (Photo copyright Science Museum, London, supplied by Wellcome Collection, licensed under CC-BY.)



• **Fig. 1.3** (A) A bust of Hippocrates (from the National Library of Medicine). (B) A fragment of the Hippocratic Oath, from the 3rd century BC (from Wellcome Library, London).

Blackstone's *Commentaries on the Laws of England* in 1768. He described malpractice as injuries "by the neglect or unskillful management of his physician … breaks the trust which the party had placed in his physician, and tends to the patient's destruction."[9] The first malpractice case in the United States occurred in 1794, but the overall number of malpractice cases remained low until the mid-1800s.

Infection was a major cause of surgical morbidity and mortality during the long history of surgery before the introduction of antisepsis. Because there was limited understanding of the origin of infections, which were thought to arise by spontaneous generation, hospitals and operating rooms remained decidedly unsterile.[10] Many physicians made varied attempts to improve wound healing. Some physicians, such as Paul of Aegina (625–690 AD), used wine-soaked dressings, unknowingly applying antisepsis, but this was not the norm.[7] The theory of "laudable pus," that inducing pus formation encouraged wound healing, has been attributed to Galen as well as Roger of Salerno (fl. 1170) and remained the guideline for wound care until the 19th century.[4] Theodoric Borgognoni of Cervia (1205–1298 AD), among others, advocated against the idea of laudable pus. He recommended careful hemostasis, debridement of foreign and necrotic tissue, closure of dead space, and wine-soaked dressings, but his ideas were met with skepticism. Others attempted to explain the transmission of infection but were ignored or rebuked by the medical community. In the 19th century, 80% of patients undergoing surgical procedures developed "hospital gangrene," and they carried a 50% mortality rate.[10] The mortality rate of women giving birth actually increased at this time as physicians took over the job of delivering babies from midwives. Ignaz Semmelweis reported in 1847 that handwashing significantly reduced maternal mortality from puerperal fever, but it still took decades for the practice to become routine.[11]

Louis Pasteur's (1822–1895) discovery of the fermentation process supported the germ theory of disease rather than spontaneous generation. Joseph Lister (1827–1912) expanded on these findings to develop the concept of antisepsis, which he delineated in a landmark report in *Lancet* in 1867. He recommended using carbolic acid for sterilization of instruments, washing of hands, and dressing of wounds (Fig. 1.4).[12] Although many physicians were slow to accept Lister's conclusions, the use of antiseptic technique in operating rooms and for wound care reduced the mortality rate after amputations by 30%.[13] Even with the incredible reduction in complications that occurred with the introduction of antisepsis, surgeons continued attempting to reduce their rates of infection. Harvey Cushing, often referred to as the father of neurosurgery, noted:

> *Even to the painstaking final approximation of the scalp wound, every detail of the operation and the local after-treatment must be followed with the greatest care, if one wishes to avoid that most distressing of all complications, a fungus cerebri, which I am happy to say has occurred to me only twice.*[14]

The emergence of anesthesia in the 19th century was a significant breakthrough in the advancement of surgery. Surgeons had previously been limited by patients' tolerance for pain, requiring them to work as rapidly as possible. The British surgeon Robert Liston was known to be a very good, exceedingly fast surgeon and in fact operated with such speed that he reportedly once amputated his assistant's fingers in addition to his patient's leg (Fig. 1.5). Both the patient and assistant subsequently died from sepsis, and an observer died of shock, resulting in "the only operation

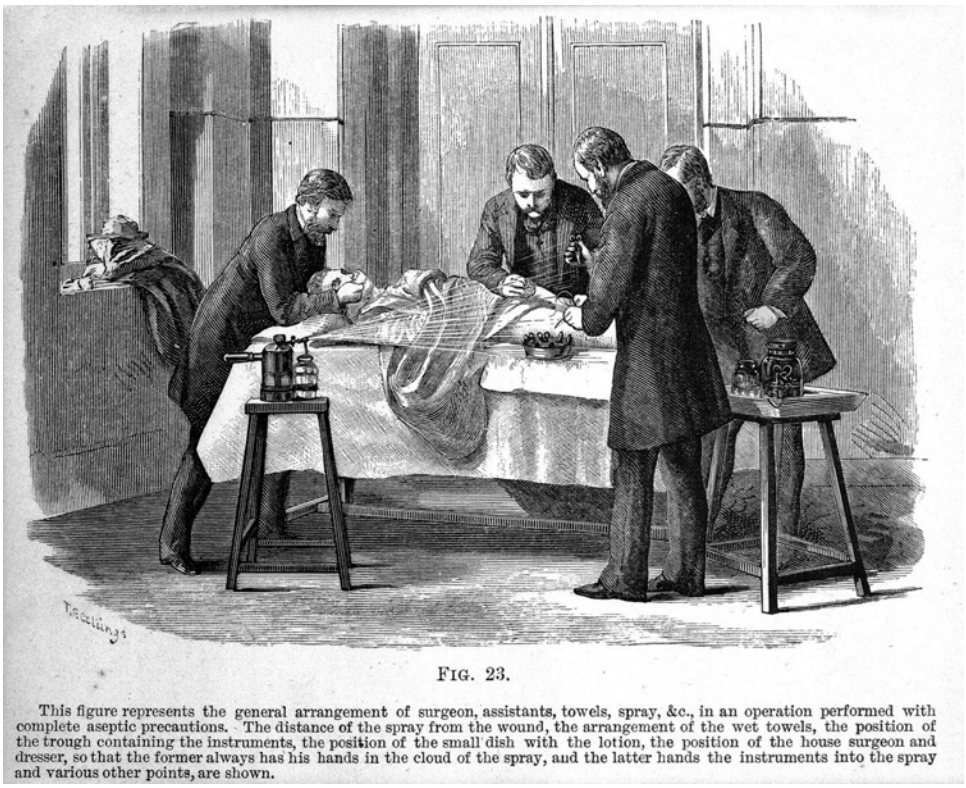


FIG. 23.

This figure represents the general arrangement of surgeon, assistants, towels, spray, &c., in an operation performed with complete aseptic precautions. The distance of the spray from the wound, the arrangement of the wet towels, the position of the trough containing the instruments, the position of the small dish with the lotion, the position of the house surgeon and dresser, so that the former always has his hands in the cloud of the spray, and the latter hands the instruments into the spray and various other points, are shown.

• **Fig. 1.4** Antiseptic surgery with the use of carbolic acid spray. The drawing is from a book by William Watson Cheyne published in 1882. (Photo copyright Wellcome Library, London, supplied by Wellcome Collection, licensed under CC-BY.)