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The Surgery of Celsus' *De Medicina*

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Abstract: Celsus' *De Medicina* (first century CE) is the first comprehensive treatise on medicine and surgery to survive from antiquity. Bridging the gap between the Hippocratic Corpus and the works of Galen, it documents the important advances in anatomy and surgery of the Alexandrian school during the Hellenistic era. *De Medicina* contains an anatomically based system of surgery and strikingly modern concepts of wound management, as well as the first accounts of hemostasis by ligature, per primam healing of wounds, amputation, and complex, elective operations, including lithotomy and inguinal herniotomy. The possibility (and desirability) of per primam healing, thereby permitting elective surgical procedures, was ignored until rediscovered in the 19th century; its recognition by Celsus prompts a re-evaluation of the excellence of ancient surgery.

Ave Caesar, Morituri Te Salutant (Hail Caesar, Those Who Are About Die Salute You, Fig. 1) was exhibited by the French Salon painter, Jean Gérôme, in 1859. Although considered the apotheosis of dry academism by the Impressionists, Gérôme's reconstructions of events in Imperial Rome were, in the words of Goodrich, "impeccable in the accuracy of their exotic and historical details, their truth of character... and the perfection of their craftsmanship."[1(p23)] The cruel barbarisms of the gladiatorial combats depicted in Gérôme's painting provided ample material for Roman surgeons,[2,3] but contrast sharply with the accomplished and humanistic system of surgery contained in Celsus' treatise on medicine and surgery, *De Medicina*, one of the most important medical works of antiquity. It constitutes the first comprehensive view of medicine and fills the lacuna between the fragmentary Hippocratic Corpus (ca. 460 BCE) and the voluminous works of Galen (second century CE), which held sway until finally challenged in the Renaissance. Celsus' treatise was little regarded in its own time, because it was written in the vernacular Latin, rather than the Greek expected of scholarly medical works. Lost and forgotten by scholars during the Middle Ages, 2 manuscript copies of *De Medicina* were discovered in the 15th century. In 1478, *De Medicina* became, by order of the Pope, the first medical book to be printed using the newly invented movable type (Fig. 2). *De Medicina* thus became a canon of Renaissance medicine, although never achieving the influence or authority of Galen's works.

The 8 books of *De Medicina* are seminal works for the surgical historian. Celsus documents highly significant advances in surgical principles and practice over those recorded in the Hippocratic Corpus, incorporating the discoveries of the Alexandrian school. Here, one finds a practical system of surgery largely unfettered by speculative theory, based on an accurate knowledge of anatomy and rational wound management. It contains the first accounts of hemostasis by ligature, amputation, per primam healing of wounds, and, as a consequence of the latter, ambitious elective surgical procedures, including lithotomy and herniotomy.

Although it is impossible in a short study to review comprehensively the entire scope of surgical procedures described in *De Medicina*, a selective consideration of Celsus' basic surgical principles and operations will serve to demonstrate the following points: first, Celsus' surgery was a judicious mix of the best of the various schools of medicine then extant; second, his advances in surgery were a direct result of the anatomic and physiologic research carried out at Alexandria during the third century BCE; and third, the sophistication and range of elective surgical procedures made possible by the expected per primam healing of wounds were, in many respects, not duplicated until the advent of antiseptic surgery in the latter half of the 19th century.

AULUS CORNELIUS CELSUS

Aulus Cornelius Celsus (Fig. 3) lived in Rome during the rule of Tiberius, which extended from 14 to 37 CE. Very little else is known of his life other than that he was of high birth.[4] There is no disputing that Celsus was a great Latin stylist, but it has been variously argued that he was a mere compiler or encyclopedist in the manner of Pliny the Elder; the translator, or worse, the plagiarist of a then extant Greek work; and a practicing physician and surgeon. While this issue has been the subject of an "almost disproportionately great, scholarly quarrel,"[5(p174)] perhaps the most satisfactory explanation is that of Meinecke: Celsus was not a *medicus*, a physician who treated patients for a fee,[6] but an *artifex medicinae*, a Roman patrician, and a "scholarly scientist who especially devoted himself to the study and pursuit of... medicine."[4(p297)] Celsus' medicine is truly eclectic, yet characterized by such coherence and evidence of critical thought as to render the notion that he was a mere compiler completely untenable.[7,8]

SCHOOLS OF MEDICINE INFLUENCING CELSUS

It is useful to consider upon what medical traditions Celsus drew in synthesizing his system of medicine. The variously authored and fragmentary Hippocratic Corpus dates from the fourth and fifth centuries BCE. The Hippocratic school developed a scientific medicine, free from magical and superstitious practices, based on the humoral theory of disease (wherein disease resulted from an imbalance or disharmony of the 4 cardinal humors: blood, phlegm, yellow bile, and black bile).[9] Early

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FIGURE 1. Jean-Leon Gérôme: *Ave Caesar, Morituri Te Salutant*, 1859. Oil on canvas. Yale University Art Gallery, Gift of C. Ruxton Love, Jr., B. A. 1925.

in the third century BCE, the center of medical learning shifted from Greece to Alexandria, where the Dogmatists, Herophilus and Erasistratus, developed the study of human anatomy by dissection and established a great school of anatomy and physiology.[10,11] They conceived of disease thus in terms of the dysfunction of solid organs, while the humoral pathology receded in significance.[12]

With the decline of the Hellenistic world, Rome became pre-eminent in medicine, which nevertheless remained Greek in character. In Celsus' time, there were 3 principal schools of medicine, the tenets of which he summarizes in the Prooemium of *De Medicina*: the Dogmatists, the Empirics, and the Methodists. The Dogmatists professed a reasoned theory of medicine, based on a knowledge of hidden causes, evident causes, natural actions, and internal parts (which correspond, roughly, to our modern concepts of pathogenesis, etiology, physiology, and anatomy, respectively). The Empirics contended that inquiry about obscure causes was superfluous because nature is not to be comprehended; knowledge of medicine comes only through experience. They held, "[I]t is not... by eloquence but by remedies that diseases are treated."[13(p21)] The Methodists were reductionists who, in the words of Celsus, "dissent from... [the Dogmatists] because they are unwilling that the Art should consist in conjecture about hidden things, and from... [the Empirics] because they think that in the observation of experience there is little of an Art of Medicine.... [T]hey hold that it is sufficient to observe certain general characteristics of diseases; that of these there are three classes, one a constriction, another a flux, the third a mixture."[13(p31)]

Perhaps characteristic of Roman practicality, Celsus maintains an eclectic stance. He states, "[N]othing adds more to a really rational treatment than experience…, [but theorizing is] yet helpful by stimulating the minds of those who practice…. [I]t is probable that Hippocrates, Erasistratus and certain others… to some extent searched into the nature of things, [and] did not by this become practitioners, but by this became better practiononers."[13(p27)] Thus Celsus seems closest to the Dogmatists, accepting their rationalism, which he believes equally as important as experience or empiricism. He rejects the reductionism of the Methodists. Celsus is discriminating, selecting what, from a modern point of view at least, was the best of the various medical traditions of the time.

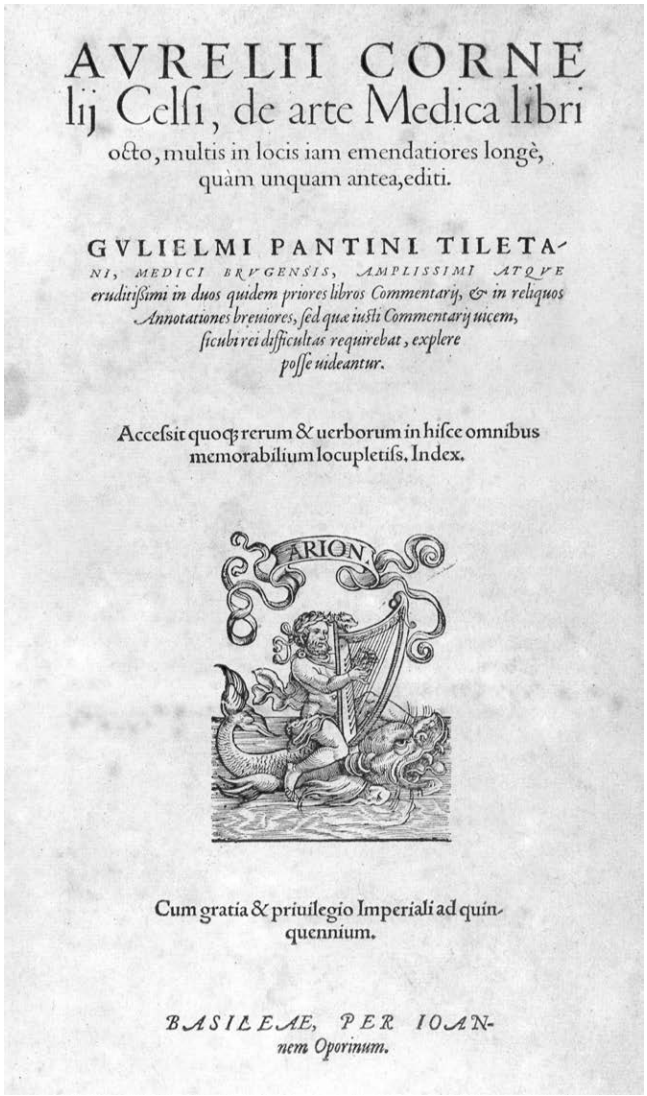
CELSUS AND ANATOMY

Anatomy is the sine qua non of surgery, and one may therefore presume that the great advances in human anatomy made by the Alexandrians, Herophilus and Erasistratus, account for the concomitant, impressive advances in surgery reflected in *De Medicina*. Celsus acknowledges the primacy of anatomy in medicine and surgery as set forth by the Dogmatists:

> [P]ains, and also various kinds of diseases, arise in the more internal parts... [and] no one can apply remedies for these who is ignorant about the parts themselves; hence it becomes necessary to lay open the bodies of the dead and to scrutinize their viscera and intestines…. For when pain occurs internally, neither is it possible for one to learn what hurts the patient, unless he has acquainted himself with the position of each organ or intestine; nor can a diseased portion of the body be treated by one who does not know what that portion is. When a man's viscera are exposed in a wound, he who is ignorant of the colour of a part in health may be unable to recognize which part is intact, and which part damaged.[13(pp13–15)]

Celsus then accepts the necessity of human dissection but decries human vivisection (a practice attributed, not without controversy, to Herophilus and Erasistratus[11,12]): "[T]o lay open the bodies of men whilst still alive is as cruel as it is needless; that of the dead is a necessity for learners, who should know positions and relations, which the dead body exhibits better than does a living and wounded man."[13(p41)] However, the anatomical dissection of human cadavers began and ended in Alexandria: therefore, Celsus is expressing his approbation of a practice that was no longer available to him in Rome[12] and one not truly resurrected until the time of Mundinus in the 14th century. The loss of human dissection had, by the time of Galen, resulted in a swing away from the anatomic concept of disease (organ dysfunction) back to the humoral pathology, which "makes it unnecessary to take the internal organs or their form or character into account."[12(p266)]

From Celsus' brief, four and one-half page account of internal anatomy[13(pp355–363)] and only somewhat more detailed osteology,[14(pp475–493)] one would not presuppose any great knowledge of anatomy. Much more revealing is the manner in which he prefaces descriptions of surgical procedures with lucid anatomical descriptions of the often complex anatomy involved, an arrangement that similarly appears in present-day surgical texts. Celsus' cogent anatomical descriptions, such as that of the inguinal region, are indicative of a degree of familiarity which,


AVRELII CORNE
lij Celſi, de arte Medica libri
octo, multis in locis iam emendatiores longè,
quàm unquam antea, editi.

GVLIELMI PANTINI TILETA-
NI, MEDICI BRVGENSIS, AMPLISSIMI ATQVE
eruditiſſimi in duos quidem priores libros Commentarij, & in reliquos
Annotationes breuiores, ſed quæ iuſti Commentarij uicem,
ſicubi rei difficultas requirebat, explere
poſſe uideantur.

Acceſsit quoq; rerum & uerborum in hiſce omnibus
memorabilium locupletiſs. Index.

ARION.

Cum gratia & priuilegio Imperiali ad quin-
quennium.

BASILEAE, PER IOAN-
nem Oporinum.

FIGURE 2. Title page of an early printed edition of *De Medicina* (1552) published by Joannes Oporinus of Basel, who also published Vesalius' magnificent *Fabrica* in 1543. Beinecke Rare Book and Manuscript Library, Yale University.

FIGURE 3. Portrait of Celsus from an 18th century edition of *De Medicina*. Medical Historical Library, Harvey Cushing/John Hay Whitney Medical Library, Yale University.

if not acquired through dissection, must necessarily have come about through clinical demonstration and *vulneraria speculatio* (observation through chance encounters of the wounded), methods of instruction which he endorses: "[A]ctual practice will demonstrate it [i.e., anatomy] in the course of treating the wounded in a somewhat slower yet much milder way [than vivisection]."[13(p41)]

ADVANCES IN SURGERY

De Medicina documents a number of important advances in surgery that had taken place since the Hippocratic era, including per primam healing of wounds, development of sophisticated surgical instruments, and ligature for the control of hemorrhage. There is no reason to assume that Celsus was himself responsible for any of these innovations, nor does he make any such claim. His matter of fact accounts of ligature of vessels and of amputation suggest that, in his time, these were well-established practices. To which school, then, can such advances be traced? The obvious source is Alexandria, where Herophilus and Erasistratus cultivated the study of anatomy and physiology. The ligation of arteries and veins by the Dogmatists for physiological demonstrations is well-documented, and it is therefore reasonable to postulate that ligation of vessels for hemostasis, certainly absent from the Hippocratic Corpus, had its origin at Alexandria as well. A direct consequence of this innovation is the appearance in *De Medicina* of amputation for gangrene and for trauma. Control of bleeding with the ligature is more precise than with the cautery, and, combined with the recognition of the possibility of per primam healing of wounds, allows for an extensive spectrum of procedures that would be considered elective, such as plastic operations and inguinal herniotomy. The inclusion of the elective (nonemergent) cases is of particular significance: it is one of the theses of Wangensteen and Wangensteen's *The Rise of Surgery* that elective procedures developed only after antisepsis and per primam healing became available.[15]

The profusion of specialized surgical instruments described by, and inferentially available to, Celsus[16] as well likely had their origin in Alexandria, which was famous for its mechanical innovations.[17(pp313–338)] The procedure for couching the cataract, plastic procedures involving advancement flaps, and the treatment of snakebite are probably the result of an Indian influence.[17(pp261–312)]

Thus, although it is impossible to trace with certainty the origin of many of the surgical advances, it is reasonable to conclude that

they are principally the result of anatomical investigations, as well as the development of ligature and surgical instrumentation; all were known to have been available in Ptolemaic Alexandria.

CELSIAN SURGERY

The accurate knowledge of human anatomy permitted the wide scope of operations contained in *De Medicina*. In addition to an essentially Hippocratic management of injuries, luxations, fractures, and operation for empyema thoracis, Celsus describes resections of tumors, paracentesis abdominis, amputation, inguinal herniotomy, hydrocelectomy, lithotomy, proctological surgery, vascular surgery, ophthalmological surgery, and plastic surgery. Since space precludes even brief analysis of this encyclopedic array of procedures, we shall first discuss Celsus' general principles of surgery and wound management and then treat in some detail 3 operative procedures that illustrate these principles and the important advances in surgery considered above.

In defining surgery as a branch of medicine, Celsus pinpoints its essential appeal:

> The third part of the Art of Medicine is that which cures by the hand.... It does not omit medicaments and regulated diets, but does most by hand. The effects of this treatment are more obvious than any other kind.... It is obvious that all improvement comes chiefly from this, even if it be assisted somewhat in other ways. This branch, although very ancient, was more practiced by Hippocrates... than by his forerunners. Later it was separated from the rest of medicine, and began to have its own professors.[14(p295)]

No such separation is apparent in *De Medicina*. As for Celsus' view concerning this separation, he states, "I for my part deem one and the same man able to undertake all of these; and when divisions are made, I praise him who has undertaken the most."[14(p297)] The surgeon:

> [S]hould 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.[14(p297)]

WOUND MANAGEMENT

Concerning traumatic wounds, Celsus states:

> [A] practitioner should know above all which wounds are *incurable*, which may be *cured with difficulty*, and which *more readily* [emphasis added]. For it is the part of a prudent man first not to touch a case he cannot save, and not to risk the appearance of having killed one whose lot is but to die.... But... it is like a mountebank to exaggerate a small matter in order to enhance his own achievement.[18(pp67–69)]

Compare Celsus' pronouncements to the 3 verdicts of the surgeon of the Edwin Smith Papyrus (ca. 1600 BCE) listed by Breasted: "An ailment not to be treated [cannot treat]," "An ailment with which I will contend [can treat and try to cure]," and "An ailment which I will treat [can treat and cure]."[19(p46)]

Celsus draws an extremely important distinction between clean and infected wounds: "From wounds, then, there comes out blood, or sanies [serosanguinous fluid], or pus.... Now blood comes out from a fresh wound or from one which is already healing, sanies between these two periods, pus from an ulceration [infected wound]."[18(p77)] Whereas the Hippocratic physicians, and 19th century surgeons along with them, believed that the formation of pus was a necessary step in the healing process, and, in fact, induced such laudable pus if it did not form of its own accord, Celsus stresses healing by what we would now call *per primam intentionem*: "[B]y far the best thing is for the wound to become agglutinated [or healed, as opposed to suppurated]. But this is possible for a wound in the skin, or even in the flesh [muscle], if nothing else has occurred to do it harm."[18(p83)] That Celsus regarded infection as pernicious is clear: "[W]hen a man has been wounded... there are in the first place two things to be kept in mind: that he should not die from hemorrhage or inflammation."[18(p81)] Earlier Greek physicians relied heavily on the body's own inflammatory response, the product of which is pus, to effect debridement of wounds. Celsus tries to avoid this reaction by using surgical debridement, careful cleansing of the wound, and the avoidance of blood clot in the wound (which provides a medium for bacterial proliferation): "But then there is an underlying fear of another kind, that if too much diseased matter is forcibly retained in the wound it will afterwards cause great inflammation."[18(p81)] Neither sutures nor fibulae "should be inserted until the interior of the wound has been cleansed, lest some blood-clot be left in it. For blood clot turns into pus, and excites inflammation, and prevents agglutination of the wound."[18(p85)]

Celsus' description of inflammation is classic, not improved upon in almost 2000 years: "Now the signs of inflammation are four*: rubor et tumor cum calore et dolore*."[13(pp272–273)] Redness and swelling with heat and pain are the 4 cardinal signs of inflammation, which may be found in any modern text. Celsus knew well, too, the signs of systemic infection: "[I]f the patient retains his senses, if no fever follows, we may recognize that the wound will soon heal.... That fever is harmful which either supervenes upon a slight wound, or lasts beyond the inflammatory period, or excites delirium; or which does not put an end to the rigor or spasm of the sinews."[18(p91)]

Celsus' principles for wound management include meticulous debridement with irrigation of the wound to remove any blood. Various dressings can be applied, but Celsus remarks: "[A] wound can be treated without foreign and far-fetched and complicated medicaments."[18(p87)] Wounds that are healing by first intention without suppuration need only be cleaned with warm water. "[I]t is not inappropriate to make use of such things as butter with rose-oil and a little honey.... More beneficial, however, is an occasional bath… [and] a nourishing diet."[18(p97)] It should be noted that honey and rose oil indeed possess antiseptic properties and may well have been beneficial.[17]

"Such is the procedure of a successful treatment," writes Celsus, but "dangerous complications... are wont to occur."[18(p99)] He goes on to describe chronically festering wounds, spreading cellulitis, gangrene, and erysipelas. Chronic wounds should be radically debrided: "Now a wound when of long standing should be cut with a scalpel, its margins excised, and incisions made at the same time into any livid area surrounding the margins…. Then when the blood has been let out and the wound made like a new one, the same treatment is to be adopted as that described for recent wounds."[18(pp101–103)] For gangrene, first corrosives (potential, or chemical, cautery) are to be tried; if ineffective, the actual cautery must be used: "[T]he place should be burnt by a cautery until no more humor escapes from it; for sound flesh is dry when it is burnt."[18(p105)] For spreading gangrene, Celsus can offer only venesection, cautery, and finally, amputation. "In such circumstances there is one sad but solitary remedy to secure the safety of the rest of the body, that is to cut away the limb which is gradually dying."[18(p107)]

Overall, Celsus' wound management is strikingly rational and well-considered; he has, for the most part, done away with the damnable greasy wool dressings of his predecessors. His goal is clearly healing by first intention, with stress on the important principle of debridement. Except for the addition of asepsis and antibiotics, the modern surgeon could add little more.

HEMOSTASIS

One of the greatest advances described in *De Medicina* is the use of ligature for the control of bleeding vessels, a technique probably developed in Alexandria.[20] The use of ligature for hemostasis was lost after the classical era and became supplanted by the

use of the brutal cautery until the ligature was reintroduced by the great military surgeon, Ambroise Paré, in the 16th century. In his *Apologie and Treatise* (1585), Paré cites the authority of Celsus, writing, "Celsus... chargeth expressely, to tye the vessells in a fluxe of blood happening to wounds, as a remedy most easie and most sure."[21(p5)] Celsus notes:

> [W]ounds are dangerous wherever the blood-vessels are larger, because they may exhaust the patient by profuse bleeding…. If we are afraid of haemorrhage which can be judged both from the position and size of the wound and from the force of the flowing blood, the wound is to be filled with dry lint, and over that a sponge applied, squeezed out of cold water, and pressed down by the hand. If the bleeding is not checked thus, the lint... is to be soaked in vinegar. Vinegar is powerful in suppressing a flow of blood.[18(pp69,81)]

Condemning the use of the potential cautery (chemical styptics), he continues:

> [T]here is an underlying fear of another kind, that if too much diseased matter is forcibly retained in the wound it will afterwards cause great inflammation. It is on this account that no use is made, either of corrosives or of caustics, owing to the crust they induce.... But if even these are powerless against the profuse bleeding, the *blood-vessels which are pouring out blood are to be seized, and round the wounded spot they are to be tied in two places and cut across between* so that the two ends coalesce each on itself and yet have their orifices closed [emphasis added].[18(p81)]

Here Celsus is describing ligation in continuity with division. Paré's famous "Crowes beake" (Paré, *Apologie and Treatise*[21(p151)]), used to grasp bleeding vessels to facilitate tying with ligature, should be compared to a Roman instrument of remarkably similar construction (Milne, *Surgical Instruments*,[16] plate XLIII); the latter could have been used for a like purpose, although it is not described by Celsus. He concludes: "When circumstances do not even admit of this [i.e., ligation], the blood-vessels can be burnt with a red-hot iron."[18(p81)]

WOUND CLOSURE

Concerning wound closure, Celsus writes:

> [If] the wound is in a soft part, it should be stitched up, and particularly when the cut is in the tip of the ear or the point of the nose or forehead or cheek or eyelid or lip or the skin over the throat or abdomen. But if the wound is in the flesh [muscle], and gapes, and its margins are not easily drawn together, then stitching is unsuitable; fibulae… are then to be inserted, which draw together the margins to some extent and so render the subsequent scar less broad.... The suture or fibula[17(fig9.22)] should take up, not only skin but also some of the underlying flesh [i.e., muscle and fascia]... that it may hold more firmly, and not tear through the skin…. [A]nd both should be inserted at intervals not too distant or too close. For if the intervals are too distant, the wound is not held together; if too close, it is very hurtful, for the more often the needle transfixes the tissues, and the more places are wounded by the inserted stitches, the worse is the inflammation set up…. Neither procedure needs any force…. [The wound margins] should not be brought actually into contact throughout the whole length of the wound, in order that there may be an outlet for any humour collecting within.[18(pp83–85)]

The principles of wound closure elaborated by Celsus, namely, hemostasis, proper wound drainage, gentle handling of tissues, and careful approximation of wound edges without tension or strangulation, are the very concepts emphasized by Halsted in his classic papers on surgical technique.[22]

AMPUTATION

Although it is a commonplace in surgical histories to state that, surely, amputations must have been among the earliest operations performed by primitive man, masters of trepanation, the evidence for this is wholly lacking.[23] True amputations are not found even in the Hippocratic Corpus; rather, there are accounts of debridement of necrotic tissue that has already undergone autoamputation. Celsus is the first to describe amputation, for indications of gangrene (discussed above) and trauma. Undoubtedly, the introduction of the ligature played a major role in the development of the technique of amputation during the Hellenistic period. Thereafter, amputation was practiced for centuries, albeit with a dreadful mortality, using the cautery to control hemorrhage, until use of the ligature was reintroduced by Paré. Celsus writes:

> When gangrene has developed between the nails and in the armpits or groins, and if medicaments have failed to cure it, the limb, as I have stated..., must be amputated…. And in the case of [fracture of] the thigh-bone, if the fragments have separated from one another, amputation is generally necessary…. But even that involves very great risk; for patients often die under the operation, either from loss of blood or syncope. It does not matter, however, whether the remedy is safe enough, since it is the only one. Therefore, between the sound and the diseased part, the flesh is to be cut through with a scalpel down to the bone, but this must not be done actually over a joint, and it is better that some of the sound part should be cut away than that any of the diseased part should be left behind. When the bone is reached, the sound flesh is drawn back from the bone and undercut from around it, so that in that part also some bone is bared; the bone is then to be cut through with a small saw as near as possible to the sound flesh which still adheres to it; next the face of the bone... is smoothed down, and the skin drawn over it; this must be sufficiently loosened in an operation of this sort to cover the bone all over as completely as possible.[14(pp469–471, 549)]

Celsus omits the details regarding hemostasis by ligature (described elsewhere in *De Medicina*) as being too obvious. He concludes: "The part where the skin has not been brought over is to be covered with lint; and over that a sponge soaked in vinegar is to be bandaged on."[14(p471)] The Celsian operation does not differ essentially from a circular amputation performed today.

Celsus' technique illustrates several important points that, throughout the history of amputation, have had to be relearned again and again. First, he stresses the necessity of cutting through healthy tissue, avoiding infection of the stump and the need for further debridement. Second, he forbids amputation through a joint space. Third, he emphasizes proper shortening of the bone. Finally, and most importantly, he employs open wound management, thereby avoiding near-certain stump infection, with the attendant danger of secondary hemorrhage. Celsus does not mention delayed primary closure of the amputation stump or use of the tourniquet, important innovations adopted in the 18th to 19th centuries. It is ironic that our terse, first description of amputation is one of the most rational of the centuries preceding the antiseptic era, employing techniques and principles of wound management that remain sound even today.

PERINEAL LITHOTOMY

Now almost unheard of, bladder calculi were once common among adults in Europe and in the United States; they were, in fact, so prevalent in 17th and 18th century France that lithotomists were appointed to the court by kings. According to Wangensteen et al, "For more than two centuries, lithotomy was the most commonly discussed operation in surgical circles…,"[24(p929)] for "[n]o operation of the preantiseptic era tested the surgeon's skill and mastery of wound management as did perineal lithotomy."[24(p932)]

The Hippocratic Oath forbids lithotomy, requiring that it be left to persons skilled in that art. Celsus is the first to give a detailed description of the technique of perineal lithotomy, along with its indications and complications. Celsus' technique of median lithotomy, or "cutting on the gripe," is the oldest and simplest. Subsequent operations were elaborations of the basic

Celsian procedure: for example, the so-called lithotomy of the "small apparatus" (in which a staff or sound is passed through the urethra into the bladder to act as a guide for the incision into the prostate and membranous urethra); and the lithotomy of the "grand apparatus" (in which various dilators, forceps, and scoops are passed into the bladder to aid in the removal of the stone). The latter operation was perhaps unduly complicated and risky.[24]

The goal of perineal lithotomy is to remove the stone or stones by entering the bladder through the prostatic urethra; bleeding, rectal injury, and extravasation with dissection of urine into the surrounding tissues are the complications to be avoided.[24] It is critical that the incision remain within the confines of the prostatic capsule (Pattison or Denonvilliers fascia). An incision placed too far posteriorly results in a rectal injury; straying outside the prostatic capsule permits urine to dissect into the perivesical tissues, and it risks hemorrhage, either through injury to the internal pudendal artery or the periprostatic venous plexus.

Celsus gives the following description of the signs and symptoms of bladder calculi:

> Cases of stone in the bladder are recognized by the following signs: urine is passed with difficulty and slowly, now and again even involuntarily, drop by drop, the urine being sandy; at times blood... is excreted with the urine; this some pass more readily standing, some whilst lying on the back…, some even pass urine bending forwards whilst they relieve the pain by drawing out the penis. There is in that part also a feeling of weight, increased by running, or by any kind of movement.[13(p123)]

The indications for operation follow, with the caveat:

> [I]t is most inadvisable to undertake it [lithotomy] hastily, since it is very dangerous. This operation is not suitable for every season or at any age or for every lesion, but it must be used in the spring alone, in a boy who is not less than nine years of age and not more than fourteen, and if the disease is so bad that it cannot be relieved by medicaments, or endured by the patient without shortly bringing his life to a close.[14(pp427–429)]

The technique of operation is carefully described:

> [The patient should] take walking exercise to encourage the stone to descend to the neck of the bladder.... When that is assured…, 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 boy's legs have been drawn up, the man orders him to put his hands behind his knees, and pull upon them as much as he can.... Hence it results that the hollow between the iliac regions above the pubes is outstretched without any folds, and as the bladder is crammed into a narrow space the calculus can easily be seized hold of.... Then the surgeon... gently introduces two fingers, the index and the middle, first one and then the other, into the anus; next he places the fingers of his right hand upon the hypogastrium, but lightly, lest if the two sets of fingers should press around the calculus with any force, the bladder may be injured. And in this procedure we must not act with haste... [as] safety is the first consideration.... [T]he stone is first sought for about the neck of the bladder..., or if it has slipped backwards, the fingers are placed against the base of the bladder, while the surgeon's right hand too is placed above the stone and gradually follows it downwards. When the stone has been found, and it must fall between his hands, it is guided downwards…. Therefore the right hand of the surgeon is always kept above the stone whilst the fingers of the left press it downwards until it arrives at the neck of the bladder.... [T]hen the skin over the neck of the bladder next the anus should be incised by a semilunar cut, the horns of which point towards the hips; then a little lower down in that part of the incision which is concave, a second cut is to be made under the skin, at a right angle to the first, to open up the neck of the bladder until the urinary passage is opened so that the wound is a little larger than the stone…. Now when the urethra has been laid open, the stone comes into view.... If it is small, it can be pushed outwards with the fingers on one side, and extracted by those on the other. If large, we must put over the upper part of it the scoop[16(plateXLVI,fig2)] made for the purpose…. And if there are several stones they are extracted one by one, but if a very small stone remains over it had better be left…. In such a prolonged search the bladder is injured and fatal inflammations set up…. If, however, at any time the stone appears too large to extract without tearing the neck of the bladder, it is to be split up.[14(pp429–439)]

For hemostasis, Celsus advises:

> But if again the bleeding does not cease of its own accord, it must be stopped lest all his [the patient's] strength be used up…. [S]o much blood may be lost as to prove fatal. To prevent this the patient should be seated in a bath of strong vinegar to which a little salt has been added; under this treatment the bleeding generally stops.[14(p441)]

If this method is unsuccessful, Celsus resorts to cupping (a form of blood-letting). Postoperatively, sitz baths are prescribed to keep the wound clean. Dressings of wool soaked in warm oil can be employed, but Celsus notes, "[N]ot even a bandage is required."[14(p443)]

Celsus recognizes the possible postoperative complications of perineal lithotomy and discusses their management:

> On the next day if there is difficulty in breathing, if urine is not passed, if the region about the pubes swells prematurely it may be recognized that a clot has collected in the bladder; for this the fingers are introduced into the rectum as before and the bladder stroked gently so as to break up clots…. It is not inappropriate to inject vinegar mixed with soda into the bladder through the wound by means of an ear syringe, for in this way also clotted blood is broken up.... [I]f the patient sleeps and breathes regularly and his tongue is moist and there is only moderate thirst and the hypogastrium is flat, if there is not much pain and but moderate fever, we may assume that the treatment is doing well.... During this period, however, when the course of the treatment has not gone well, various dangers arise. These may be expected: if there is persistent insomnia, laboured breathing, a dry tongue, great thirst, a distended hypogastrium..., if there is some livid discharge…, if the patient does not answer or replies slowly; if there are severe pains; if after the fifth day high fever oppresses the patient.... But the worst complication is spasm of the sinews and bilious vomiting before the ninth day.... The nearest danger is canker [gangrene].[14(pp443–447)]

Here, Celsus goes on to describe Fournier gangrene and its spread to the genitals, anus, buttocks, and thighs. Since the only appropriate treatment is radical debridement, such cases necessarily ended fatally, for Celsus is only able to prescribe suppuratives. But the expected postoperative course is as follows:

> Generally all the urine escapes at first through the wound; then in the course of healing it divides, and part begins to pass through the penis until the wound has completely closed; and this occurs at times in the third month, at times not before the sixth month, and occasionally not for a year. And we need not despair of the firm healing of the wound, unless the neck of the bladder has been roughly ruptured, or when owing to gangrene many large portions of flesh have sloughed away.... [T]he greatest care must be taken that no fistula, or only a very small one, is left there…. [S]o it is necessary to keep the wound open..., and only when there is nothing more to come out of the bladder is the wound allowed to heal. If the margins of the wound stick together, before the bladder has been cleaned, and pain and inflammation recur, the wound should be reopened.[14(pp451–453)]

Celsus' clear description of the signs and symptoms of vesical calculus, the indications for operation, and the technique, postoperative management, and complications of perineal lithotomy, all evidence a seasoned familiarity with the disease and its surgical treatment. As Wangensteen et al write, "[A] surgeon is readily persuaded that only someone with a first-hand acquaintance with the procedure could have authored his [Celsus'] description of perineal lithotomy…."[24(p932)] That Celsus prefers to limit the operation to young boys may reflect an unacceptable

morbidity and mortality when applied to older and more debilitated patients, and perhaps greater technical ease in young, less well-developed subjects. Although Celsus recognizes the major pitfalls of perineal lithotomy, the description of the placement of the incision in the prostatic urethra is not sufficiently detailed to suggest that he knew of the existence of the prostatic capsule or of the necessity of remaining within its confines, although this secret may have been learned empirically or taught in the course of the actual performance of the operation. Though Celsus does not use a 2-stage approach, he does suggest forbearance of a prolonged search that contributes to shock and increases the risk of injury. Significantly, Celsus advocates open wound management, rediscovered and popularized by Franco some 1500 years later, which was perhaps the most important development contributing to the truly outstanding results of certain lithotomists in 18th century England and France, that rival even present-day mortalities. Thus, the Celsian operation embraces, or anticipates, the 3 cardinal principles of perineal lithotomy cited by the Wangensteen et al as contributing to its success in the preantiseptic era: a urethrovesical incision confined to the prostatic capsule; a 2-stage approach; and most importantly, open management of the wound.[24]

HERNIA AND HERNIOTOMY

While the problem of inguinal hernia has undoubtedly plagued man since earliest times, the first adequate description of hernia and its surgical treatment is found in *De Medicina*. The technique of herniotomy described by Celsus (isolation and excision of the hernial sac) requires a fairly sophisticated knowledge of inguinal anatomy and of the pathology of hernia; hence, like amputation, herniotomy probably dates from the Hellenistic era and the anatomical research pursued at Alexandria.

Celsus begins his description of the maladies affecting the groin and the genitalia with a description of the anatomy of the region:

> [T]he testicles hang from the groins, each by a cord which the Greeks call the cremaster [i.e., spermatic cord] with each of which descends a pair of veins and a pair of arteries. And these are ensheathed in a tunic, thin, fibrous, bloodless, white, which is called by the Greeks elytroides [tunica vaginalis]. Outside this is a stronger tunic, which at its lowest part is closely adherent to the inner one [i.e., tunica vaginalis]; the Greeks call it dartos [i.e., spermatic sheath, comprised of the cremasteric and external spermatic fascia]. Further, many fine membranes hold together the veins, and the arteries, and the [spermatic] cords aforesaid, and also in between the two tunics there are some fine and very small membranes, descending from the parts above [internal spermatic fascia]…. [N]ext... is the pouch which is now visible to us; the Greeks call it oscheon, we the scrotum.[14(pp391–393)]

The use of the Greek anatomical terms, which have entirely different modern usages,[25] has likely contributed to the confusion and gross inaccuracies concerning the Celsian operation in many modern analyses and histories.[26–28]

Concerning the etiology of hernia, Celsus writes:

> Now, underneath the scrotal coverings many lesions are apt to occur, sometimes after the rupture of the coverings which, as I have said, begin from the groins, sometimes when they are uninjured. Since at times either owing to disease there is first inflammation, then afterwards a rupture from the weight; or after some blow there, there is a direct rupture of the coverings which ought to separate the intestines from the parts below; then either omentum, or it may be intestine, rolls down by its own weight; this having found a way gradually from the groins into the parts below as well, there separates by its pressure the coverings which are fibrous and therefore give way. The Greeks call the condition enterocele [intestinal hernia] and epiplocele [omental hernia], with us the ugly but usual name for it is hernia.[14(p393)]

Andrews[25] has pointed out that it is possible that Celsus believed that the tunica vaginalis was normally patent; this is explicitly stated in parallel passages in later authors. The belief may have derived from dissections of lower animals (human dissection having been lost) and from the surgical treatment of congenital hernias. Consequently, it is reasonably certain that by "the coverings which ought to separate the intestines from the parts below," Celsus is referring to the aponeurotic fasciae of the internal and external rings, and not the peritoneum.

As alluded to above, the Greeks, and Celsus with them, differentiated omental from intestinal hernia, a distinction no longer considered important:

> Now if omentum has come down, the tumour in the scrotum never disappears, either if the patient fasts, or if his body is turned from side to side, or lies in some special position; again, if the breath if held, it does not increase to any extent; to the touch it seems uneven and soft and slippery. But if the intestine has also come down this tumour is without inflammation, sometimes it diminishes, sometime increases, and is generally painless and soft. When the patient is quiescent or lying down, it disappears, at times altogether; sometimes it becomes divided so that very small remnants stay in the scrotum. But after shouting or over-eating, or if the patient has been strained by a weight of any sort, it increases...; and within the scrotum the intestine slips about, when pressed upon it reverts towards the groin, when released it rolls down again with a sort of murmur.[14(pp393–395)]

The statement concerning the irreducibility of omental hernia is certainly incorrect; moreover, either intestinal or omental hernia can become incarcerated. Andrews[25] suggests that this misconception may have derived from 2 factors: first, that omental adhesions are more common than bowel adhesions inside a sac; and second, that since incarceration with strangulation was considered a contraindication to operation (see below), such adhesions were not observed.

The complication of intestinal obstruction and strangulation is clearly described:

> [B]ut at times, when the faeces have been taken in, it [the intestine] swells more largely, it cannot be forced back, and it then brings on pain both in the scrotum and in groins and abdomen. At times the stomach also becomes affected, and there is an issue from the mouth, first of red, then of green, and even in some of black bile.[14(p395)]

Celsus gives a complete differential diagnosis of inguinal hernia. Hydrocele, both communicating and noncommunicating, is considered, along with tests for fluctuation of fluid and transillumination. He describes varicocele and resultant atrophy of the testicle accurately and mentions also lipoma of the cord. He describes orchitis and epididymitis with the occasional spread of inflammation to involve the groin and inguinal lymph nodes.

Celsus advises limiting the operation to young children without incarceration, who have failed conservative treatment with truss. The more extensive hernias of adults (even if reducible) are to be avoided, and obstruction–strangulation is an absolute contraindication to operation, as "it is clearly impossible to employ the knife except harmfully."[14(p409)] For the latter condition, Celsus can recommend only venesection and plasters. Clearly unequipped to handle nonviable bowel, the reluctance to operate on strangulated hernia was understandable, although it consigned to the patient to near-certain death. It was not until 1556 that Franco attacked the problem and fully described his operative technique; moreover, as Wangensteen and Wangensteen have emphasized, only in the latter half of the 20th century had the success rate in operation for strangulated hernia significantly bettered those of Astley Cooper in the early 19th century (42% mortality).[15] That Celsus limited operation to boys was likely because his operation (see below) consisted of herniotomy and not true herniorrhaphy and would be doomed to failure in extensive or long-standing cases. Herniotomy (removal of the sac) alone suffices for the cure of many cases of congenital hernia, although the internal ring is usually tightened in current practice.

In describing the technique of herniotomy, Celsus first gives the general approach to lesions of the inguinal region, and then specifically that of herniotomy:

> [A]fter stretching the scrotum, so that the skin of the groin is rendered tense, the cut is made below the abdominal cavity, where the membranes below are continuous with the abdominal wall. Now the laying open is to be done boldly, until the outer tunic, that of the scrotum itself [scrotal skin and dartos muscle], is cut through, and the middle tunic [spermatic sheath] reached. When an incision has been made, an opening presents leading deeper. Into this the index finger of the left hand is introduced, in order that by the separation of the intervening little membranes the hernial sac may be freed. Next the assistant grasping the scrotum with his left hand should stretch it upwards, and draw it away as far as possible from the groins, at first including the testicle itself until the surgeon cuts away with the scalpel all the fine membranes which are above the middle tunic [spermatic sheath] if he is unable to separate it with his finger; then the testicle is let go in order that it may slip downwards, and show in the wound and then be pushed out by the surgeon's finger, and laid along with its two tunics [i.e., tunica vaginalis and spermatic sheath] upon the abdominal wall. There whatever is diseased is cut round and away, in the course of which many blood vessels are met with; the smaller ones can be summarily divided; but larger ones, to avoid dangerous bleeding, must be first tied with rather long flax thread. If the middle tunic [spermatic sheath] be affected, or if the disease has grown beneath it, it will have to be cut away even as high as the actual groin. Lower down, however, not all is to be removed: for at the base of the testicle there is an intimate connexion with the inner tunic [tunica vaginalis], where excision is not possible without extreme danger; and so there it is to be left.... But the cutting away cannot be done quite completely at the inguinal end of the wound, but only somewhat lower down, lest the abdominal membrane [peritoneum] be injured and set up inflammation. On the other hand too much of its upper part should not be left behind, lest subsequently there forms a pouch which continues to be the seat of the same malady.[14(pp401–403)]

Celsus continues with the details of the operation for intestinal hernia:

> [A]s soon as the incision made in the groin reaches the middle tunic [spermatic sheath and the contained hernia sac] this [the hernia sac] must be seized near the margins by a couple of hooks, when, after drawing down all the fine membranes [of the surrounding cremasteric and internal spermatic fascia] the surgeon sets it free. Nor is there any danger in wounding what has to be cut out [i.e., the hernia sac], since the intestine must lie underneath it. When the middle tunic [spermatic sheath] has been thus drawn down, it is slit open from the groin to the testicle, but so as not to injure the latter; then it is cut away…. The testicle having been thus cleared is to be gently returned through the incision, along with the veins and arteries and its cord.[14(pp403,411)]

Meticulous hemostasis is advised, which "will be accomplished if the surgeon takes the precaution of tying the blood vessels."[14(p403)] Wound closure is effected in such a way as to encourage cicatricial healing about the external ring to help prevent recurrence: "Through the margins of the wound itself two pins [fibulae] are then passed, and over this an agglutinating dressing. But it becomes necessary sometimes to cut away a little from one or other of the edges of the skin incisions in order to make a broader and thicker scar."[14(p403)] It appears unaccountable that, after carefully separating the sac from the cord structures with preservation of the testicle, Celsus failed to ligate the hernial sac prior to its excision at the level of the external ring: for in his description of the treatment of umbilical hernia, he clearly describes ligation of the sac. It is possible that this relates to a deficiency of the text[25] rather than a failure to understand the anatomy of hernia, since Celsus advocates high division of the sac, "lest subsequently there forms a pouch which continues to be the seat of the same malady." Lacking the sophistication necessary to perform a true herniorrhaphy, the Celsian operation relies on scarring at the external ring to prevent recurrence. Celsus avoids adult cases with large hernias in which he admits such a procedure would be doomed to failure. It is worth noting that the Celsian operation remained scarcely improved upon for nearly two millennia, and, in fact, often degenerated into one accompanied by castration. Although modest progress in the treatment of strangulation was made from the 16th century on, it was not until the late 19th century that a truly satisfactory solution to the problem of inguinal hernia was described independently by Bassini[25] and Halsted.[22]

CONCLUSIONS

Although this brief survey of Celsus' operative surgery scarcely does justice to the wide spectrum of surgical diseases and procedures described in *De Medicina,* we have considered in some detail Celsus' concept of wound management and healing, and the techniques and procedures that constitute the most significant advances in surgery since the Hippocratic era. Celsus' *De Medicina* emerges as reflecting a uniformity and striking rationality of thought. His work is not a mere compilation or encyclopedia. Independently of the arguments of classicists or historians, Celsus must be adjudged by surgeons to have been an experienced practitioner, particularly skilled in wound management, and able to perform a wide variety of procedures, both emergent and elective. Unfortunately, *De Medicina* had little influence surgically, despite its wide availability from the late 15th century onwards, apparently being regarded more as a model of classical Latin or as a history of Hellenistic medicine. This neglect may have been because Celsus was widely considered a compiler or even a plagiarist, and was ignored by Galen, whose influence was overwhelming.

The surgical advances documented in *De Medicina* are ascribable not to Celsus himself but to the heritage from the anatomical and physiological school established at Alexandria in the third century BCE. This fundamental importance of anatomical knowledge to surgical science is further emphasized by the stagnation of surgery following the loss of human dissection and the dogmatic adherence to the anatomy of Galen, who dissected various animals, including Barbary apes, but not men. The tying of vessels for hemostasis, a practice derived from the physiological investigations of the Alexandrians, is an early example of how basic research benefits clinical science; and it was, sadly, an advance largely forgotten until rediscovered by Paré.

Celsus' almost modern concepts of wound management and clear recognition of the possibility and superiority of per primam healing differed from those of Galen and subsequent medical writers, who believed more in the Hippocratic notion of healing following suppuration. It is, therefore, ironic that when Galen's anatomy and physiology were finally challenged in the Renaissance by men such as Vesalius and Harvey, and *De Medicina* became widely available, the old Hippocratic and Galenic notions of wound healing failed to be questioned; indeed, they failed to be questioned until the 19th century with the discoveries of Semmelweis and Lister. Until this time, and despite tremendous advances in anatomical knowledge from the 15th century onwards, surgery remained surgery of necessity secondary to the curse of infection. The Celsian concepts of wound management and the elective surgery it engendered, largely unequaled until the advent of antisepsis, and then asepsis in the late 19th century, force us to re-evaluate the excellence and sophistication of ancient surgery developed in the Hellenistic era as epitomized in Celsus' *De Medicina.*

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