The Evolution of Surgical Instruments

FRONTISPIECE

Amputation below the knee in the men's operating theater at St. Thomas's Hospital, London, late eighteenth/early nineteenth century (artist unknown). A Petit's screw tourniquet is in use, and the patient is held on a firm table in a semi-seated position by assistants, perhaps to promote fainting more readily. The surgeon adopts a tour de maître approach, reaching underneath the leg and holding the point toward himself before sweeping the concave blade from the outer to the upper, inner, and finally lower surface, performing a rapid circular amputation. Note two knives, a saw, a bonecutter forceps, a bowl of dressings, and a bowl on the floor to catch blood; no heated cauteries are seen. If ligatures were applied, these would possibly be in the dressing bowl.

The Evolution of Surgical Instruments

An Illustrated History from Ancient Times to the Twentieth Century

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The prolonged gestation of this treatise
is dedicated to Pierrette,
my supportive and tolerant wife.

Contents

Preface

Instruments of iron; some are to cut as shears, razors and lancets . . . And some to draw out diverse things, as tongs and pincers. And some to know the deepness of sores, as spatulas and searchers; And some be to sew as needles and pipes.

Thomas Morstede, *Fair Book of Surgery,* 1446[1]

My fundamental interest is the history of surgery, in its broadest sense, and the following study of surgical instrumentation is but a particular method of investigating this history. As the reader will discover, the evolution of instrumentation is not isolated from aspects of the biological sciences, clinical acumen, operative practices including those of nonindustrialized societies, and the technical skills of instrument manufacture. In addition, any comprehensive assessment of surgical progress must address the points of view of patients, of society, and of surgeons; however, while patients and society are not neglected here, space dictates that surgical input predominate, augmented by vital contributions from instrument makers and by crucial observations of archeologists, scientists, historians, and museum curators.

The dramatic ascent of safe operative surgery since the mid nineteenth century, inseparable from the discoveries of anesthesia, antisepsis, asepsis, bacteriology, x-rays, transfusion, and antibiotics, cannot be divorced from a long, preceding period of slow endeavor during which many fundamental concepts related to surgical anatomy, diagnosis, and instrumentation were resolved. This book intends to demonstrate that the basic surgical armamentarium was already in place and able to adapt quickly to the innovative techniques of predictable safe surgery through numerous material and structural modifications. As the twenty-first century begins, we can surmise that proliferation of two-dimensional techniques and computerization may alter the armamentarium radically and lead to the eventual demise of conventional scalpels, forceps, and other familiar objects. Hence, from a historical perspective, it is appropriate to review the evolution of surgical instruments thus far, and especially to relate them to earlier manual skills, before the memories of an older generation of surgeons fail.

Clearly, trained expertise is important to apply instruments safely and beneficially to patients. Indeed, surgical knowledge and experience are almost always essential to make a relevant diagnosis; to determine if, when, and how to operate; and, occasionally, to undertake procedures without specific instruments if these are not immediately at hand. As a recent airline passenger with acute lung collapse due to tension pneumothorax discovered, in an emergency, an instructed surgeon lacking dedicated instruments is not totally incapacitated: The passenger recovered following the intelligent application of a urinary catheter, a wire coathanger, and five-star brandy[2] (see figure 10). Similarly, a writer deprived of pen and paper can continue to inscribe ideas in sand or mud with a forefinger or a stick. Yet in both instances, specific "tools of the trade" are preferred for rapid and accurate handiwork; today, this may mean control of computerized equipment.

Unlike surgery itself, the history of the surgical armamentarium has received only piecemeal attention. Hence we find detailed studies of specific instruments, for example, obstetric forceps, and of particular groups of instruments, such as Greco-Roman items, leaving the broader field of instrument development and relationships virtually unexplored. Undeniably, surgical historians frequently refer to lan-

cets, skull trephines, amputation saws, and other equipment of the past, just as modern surgeons acknowledge the instruments of their specialty. Despite this, the historical context of their long evolution and continuing modification in relation to surgical and technological change is widely overlooked. Moreover, the expertise and manual skill necessary for their manufacture secure little attention, for, sadly, few surgical practitioners of my acquaintance have visited an instrument factory, and many remain unaware of the individual craftsmanship invested in all sophisticated or high-quality instruments. In response to this hiatus, to recent major changes in surgical practice, to a growing interest in surgical history including the establishment of new museums exhibiting instruments, and to personal requests to identify items, I believe a review of instrument origins, their structural evolution, and their application is timely.

Instruments become historical objects every day as techniques and equipment are constantly replaced in response to new surgical ideas, advancing technology, and a growing disposable armamentarium. In consequence, it would be a huge task to catalogue every innovative modification of the past; such a work demands the labors of a research team and would require many volumes, even if limited to the British context. My more modest objectives have been to analyze the long evolution of operative instrumentation, originally often derived from human hands and teeth, and to classify instruments in such a way that their structure, composition, and function can be followed in a logical fashion. This involves investigation of archeological evidence, of surgery in nonindustrial communities, of each instrument's mechanical construction, and of the many materials of manufacture, as well as a study of successive technological achievements. Though all these investigations are interrelated to the history and progress of surgery in general, recent and rapid subspecialization has rendered interpretation more difficult, and apologies are tendered to specialists who find errors within their field.

Some will ask, does it matter how and why surgical instrumentation reached its current sophistication? Indeed many a surgeon may consider this subject of minimal interest, especially if immersed in the struggle to come to terms with recent technical changes related to advancing endoscopic methods; in any event not everyone reacts favorably to historical perspectives. Yet, as has been said repeatedly, we stand on the shoulders of our forebears, and appreciation of this heritage is perhaps more necessary than ever as innovation rapidly succeeds innovation. Furthermore, surgeons need to be aware of previous work in order not to overlook fresh opportunities in certain fields, for long-discarded ideas can be revived by new concepts and technology.

My experience as a curator of surgical instruments has revealed many errors of description or total lack of identification in publications, in museum displays, among antiquarian dealers, at auctions, and in personal collections. Undoubtedly, many items never appeared in manufacturers' catalogues, or the relevant catalogues have not survived; in some instances, instruments were made by short-lived companies who never produced a catalogue. Others are isolated or "one-off" productions for trial or experimental purposes, used by a single surgeon or a single hospital and hence never publicized or manufactured on a large scale. In the absence of written information and the manufacturer's name or mark, analyses of structure and material composition often provide sufficient evidence to date and identify an instrument. For example, structural analysis indicates that scissors of about 10 to 11 centimeters in length are for ocular use, scissors of 13 centimeters are standard for general dressing purposes, and those of 30 centimeters are used for intrapelvic or thoracic surgery. Observations on material composition indicate that before heat sterilization replaced antiseptic techniques (between 1883 and 1893), many instruments had ebony, ivory, or tortoiseshell handles. These were then rapidly replaced by nickel-plated steel until this was displaced more gradually by stainless steel after 1920. By employing such information, many items can be identified fully or, at least, categorized functionally, even if complete details remain uncertain.

This approach to identification and classification is, I believe, an important by-product of the analyses of

instrument origins, materials, structure, and modifications recorded in my text, which for some readers may justify publication of the book. Research began in 1980 with a series of articles concentrating on the eight fundamental shapes of instruments derived from a common cylindrical metal bar. These were published at intervals in the *Annals of the Royal College of Surgeons of England*,[3] often concurrently with an exhibition in the College based on the Historical Instrument Collection. I soon discovered through my work on this series that the recognition and appreciation of instrument materials were vital to a fuller understanding of the armamentarium's history. In addition, I realized that a close relationship existed between instrument shapes and the unaided hand, so often instruments' direct precursor. Later, I explored in detail the question of origins and the impact of materials and presented my findings as a thesis in which I analyzed the composition of some 8,000 instruments.[4] This thesis has been incorporated into the text along with many other personal communications studying the influence of instruments on surgical practice. Several exhibitions arranged for the Royal College of Surgeons and the British Orthopaedic Association have included historical instruments and implants. A recent display at the College stresses Joseph Lister's contributions to safe surgery by exploiting his extensive collection of archives, equipment, and personally invented or modified instruments. Earlier displays feature a pocket case of instruments used by the explorer Mungo Park in West Africa during 1795–1796, instruments of unsophisticated construction used by Shawiya Berber surgeons in Algeria as late as 1922, instruments employed by fellows of the College when working as missionaries in China a century ago, traditional instruments used by Fijians in the 1870s, instruments made for Japanese surgeons in the early twentieth century, and fracture plates and screws employed by William Macewen before 1920.

This gradual and incomplete accumulation of information and evidence within this field reflects, in part at least, a paucity of comprehensive reference publications for consultation. Nevertheless, without the detailed studies of Milne,[5] Künzl,[6] and Jackson[7] on Greco-Roman instrumentation; of Das and Hibbard[8] on obstetric instruments; of Moller-Christensen[9] on the spring forceps; of Davis and Appel[10] on bleeding lancets; of Hilton-Simpson[11] on Arabic surgery; and of Spink and Lewis[12] on the instruments of Albucasis, progress would have been impaired. Additionally, the illustrated manufacturers' catalogues, available from the early nineteenth century onward, provide accurate descriptions to reinforce analyses of material and structure.

As Charles Bell, both a surgeon and an artist, emphasized in 1821, "[W]here the demonstration is presented to the eye . . . knowledge is most easily conveyed."[13] Indeed, comprehensive illustrations convey vital information, not readily available otherwise, especially in line drawings. Fortunately, manufacturers' catalogues and surgical works are often illustrated in this way, and these have been reproduced in significant numbers. Certain instruments, particularly of the forceps type, have closed or static positions as well as open or dynamic functional positions; neither these positions nor the disjointing mechanisms of certain forceps are clearly illustrated in standard surgical catalogues and texts. For this reason, new drawings were commissioned to delineate these finer points.

Finally, it is my hope this book will appeal not only to physicians, surgeons, and operating-room personnel, but also to historians of medicine, technology, and materials science; to instrument manufacturers and museum curators; to collectors of surgical instrumentation; and, perhaps, to a wider audience of readers, including general historians, ethnologists, archeologists, and members of the public at large, particularly those with scientific and biological interests.

John Kirkup
Weston Hill, Bath, United Kingdom.
October 2004

NOTES

1. Morstede, Thomas, *A Chirurgicall Treatise,* also known as the *Fair Book of Surgery,* a manuscript compiled in 1446 (British Museum Harl. 1736 PL. XLVI.B). The quotation is modernized from

the fifteenth-century English transcript in Beck, R. T., *The Cutting Edge* (London: Lund Humphries, 1974), 108.

2. Wallace, W. Angus, "Managing In-Flight Emergencies," *British Medical Journal* 311 (1995): 374–376. Faced by a passenger who was deteriorating due to a tension pneumothorax, and having only a scalpel, scissors, urinary catheter, and local anesthetic at hand, Professor Wallace, with the assistance of Dr. T. Wong, fashioned a trocar for the catheter from a wire coat hanger, an underwater seal drain from a bottle of Evian water, and a length of oxygen tubing, and used five-star brandy as a disinfectant. (Successful decompression was reversed temporarily when the patient elevated the bottle above the chest while sitting on the toilet. Putting the bottle back on the floor saved the patient's life a second time.) See also Bill Holmes, "Is There a Doctor on the Plane?" *Respiratory Disease in Practice* (Spring 1998): 16–17.
3. Kirkup, J. R., "The History and Evolution of Surgical Instruments" (12-part series), *Annals of the Royal College of Surgeons of England* 63 (1981): 279–285; 64 (1982): 125–132; 65 (1983): 269–273; 67 (1985): 56–60; 68 (1986): 29–33; 77 (1995): 380–388; 78 (1996): 544–552; 80 (1998): 81–90; 80 (1998): 422–432; 81 (1999): 420–428; 84 (2002): 149–155; 86 (2004): 202-205.
4. Kirkup, J. R., "A Historical Study of the Surgical Armamentarium: Origins and Materials," MD thesis, Cambridge University, 1994.
5. Milne, J. S., *Surgical Instruments in Greek and Roman Times* (London: Clarendon Press, 1907).
6. Künzl, E., *Medizinische Instrumente aus Sepulkralfunden Romischen Kaiserzeit* (Cologne: Rheinland Verlag, 1982).
7. Jackson, Ralph, "Roman Doctors and Their Instruments: Recent Research into Ancient Practice," *Journal of Roman Archaeology* 3 (1990): 5–27.
8. Das, K., *Obstetric Forceps: Its History and Evolution* (Calcutta: Art Press, 1929); Hibbard, B., *The Obstetrician's Armamentarium* (San Anselmo: Norman Publishing, 2000).
9. Moller-Christensen, V., *The History of the Forceps* (Copenhagen: Levin and Munksgaard, 1938).
10. Davis, Audrey, and Toby Appel, *Bloodletting Instruments in the National Museum of History and Technology* (Washington, D.C.: Smithsonian Institute, 1979).
11. Hilton-Simpson, H. M., *Arab Medicine and Surgery: A Study of the Healing Arts in Algeria* (London: Oxford University Press, 1922).
12. Spink, M. S., and G. L. Lewis, *Albucasis on Surgery and Instruments* (London: Wellcome Institute, 1973).
13. Bell, Charles, *Illustrations of the Great Operations of Surgery* (London: Longman, 1821), preface.

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At the Royal College of Surgeons of England, London, I thank several presidents and their councils for permission to reproduce photographs of items in the Historical Instrument Collection and for the assistance of Stella Mason, Keeper of the Collections; Caroline Grigson; Elizabeth Allen; Professor John Turk; Simon Chaplin; Christine Taylor; and Sarah Pearson of the Museums' Service. In the College Library, the ever-willing support of Ian Lyle, Thalia Knight, Tina Craig, Matthew Derrick, and their assistants has been exemplary in tracing obscure sources. And I especially value the dedication and material support of Martyn Cooke and his team of the Conservation Unit in arranging numerous instrument exhibitions. Latterly, I have been joined by Mick Crumplin, FRCS, as my deputy to the Historical Instrument Collection and acknowledge a growing obligation to his knowledge and enthusiasm.

I owe a considerable debt for illustrative material to the College of Surgeons Photographic Unit; to the Medical Illustration Department of the Royal United Hospital, Bath; to Frances Lambert for line drawings of unusual instruments; to Dr. Norval Taylor for

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Not the least important was the patience of my neighbor, Julian Burridge, who introduced me to the basic mysteries of desktop computers. For many chapter transcripts, by word processor and computer, I am indebted to my former secretary, Colette Clarke. And I remain especially grateful to Andrée and Michel Nogué for many, many hours of quiet repose to write at their villa in Cap Ferret and their house in Bordeaux.

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Foreword

This is a study a long time in the making and well worth the wait. I first became aware of John Kirkup's research on instrumentation through a series of articles in the *Annals of the Royal College of Surgeons* in the 1980s. In those articles, John traced the evolution of specific instrument forms (such as probes and forceps) from neolithic origins to contemporary incarnations. His enthusiasm and passion for his subject were to a degree subordinated to his endeavor to approach the topic in a systematic, scientific way. I can attest to the liveliness of his interest, which I experienced some years ago in his company on the streets of London, visiting historic medicochirurgical haunts and scrutinizing intriguing objects along the way. From the vaunted halls of the Royal College of Surgeons in Lincoln's Inn Fields to the remarkably preserved Old Operating Theatre of St. Thomas's Hospital, we strode and all the while "talked instruments." John and I had both been researching the impact of anti- and asepsis upon instruments and had simultaneously but separately published our findings, his documenting the British and Continental experience, while my work focused upon American developments. A friendship and collegial bond formed then that endures still, and it is therefore a great pleasure and honor to offer this foreword to his work, *The Evolution of Surgical Instruments: An Illustrated History from Ancient Times to the Twentieth Century.*

The *Evolution of Surgical Instruments* fills a distinct void in the literature on instrumentation. Others, notably Elisabeth Bennion's *Antique Medical Instruments* (1979), have approached the topic by treating the artifact as an *objet d'art* and concentrating chiefly upon the aesthetic aspects of instruments. Diagnostic instruments have been the subject of outstanding interpretive histories, including Stanley J. Reiser's *Medicine and the Reign of Technology* (1978) and Audrey Davis's *Medicine and Its Technology : An Introduction to the History of Medical Instrumentation* (1981). No one has to date tackled therapeutic instrumentation in so comprehensive or successful a manner, however, although efforts such as C. J. S. Thompson's *The History and Evolution of Surgical Instruments* (1942) and J. S. Milne's *Surgical Instruments in Greek and Roman Times* (1907) offered important early contributions in this direction. Instead, study has generally been focused upon specific instrumentation for particular medical and surgical specialties (obstetrics and gynecology, ophthalmology, and otolaryngology), or particular forms of treatment (bloodletting) and diagnosis (auscultation and sphygmomanometry). Even though instruments have been the topic of all the above-mentioned studies, few relied directly upon the instruments as primary sources. John's work, in contrast, does just this to great effect.

Perhaps John's most useful and welcome contribution in the present work lies in his logical approach to the subject of surgical instrumentation. I can distinctly recall being completely overwhelmed with a sense of chaos in my first days as curator of an instrument collection. There seemed to be literally thousands and thousands of different instrument forms, a fact confirmed by a quick glance at an instrument trade catalogue of 1900. Few guides existed to categorize and study this welter of instrumentation, and most of them, composed by instrument makers, were exceedingly rare.* The reader will find that John brings to this inquiry the special insights that a practitioner can offer, and this firsthand experience is sprinkled

through the text in wry, often self-deprecating asides. Another welcome contribution found in these pages is the clarification of confusing terms, usually grounded in misinterpretation or poor translation of Latin source words (for instance, *cannula)*.

As honorary curator of the surgical instrument collections of the Royal College of Surgeons, John confronted a broad and comprehensive array of instruments. Making sense of them necessitated that he cast his net more broadly, to encompass all forms and manner of instrument and to derive a better sense of how each originated and developed over time. Investigation involved examination, testing, and measurement (not just dimensions but pressure required for activation/operation) of instruments, chiefly in the extensive collections at the Royal College of Surgeons and at the Science Museum. He traces eight primary structural forms and their changes and evolution over time. Particularly interesting evolutions of specific instrument forms include dissection forceps (chapter 15) and scissors (chapter 17). Although he is inclined to adopt an evolutionary approach, his study reveals that development does not follow in a unilinear or evidently logical manner; instead of a tree, we have something more akin to a multibranched bush. Dead ends abound in instrument development as fledgling designs were discarded for new approaches, while conversely some instrument forms, notably the ubiquitous thumb lancet, persisted despite evident poor design. All this is grist for John's historic mill and makes for a fascinating read.

Although instrument form comprised the chief focus of John's work, the development of instrument materials became an equally important interest over the course of this study. As he reveals, the symbiosis between medicine and technology took different forms. On the one hand, advances in technology spawned opportunities for medicine and surgery; new and different materials opened broader vistas to instrument design, as demonstrated by the advent of cast steel in the eighteenth century, hard rubber or ebonite in the mid nineteenth century, and the introduction of stainless-steel alloys around 1912. On the other hand, technical developments outside medicine proper called forth new forms of instrumentation and medical technology in unexpected ways. Advances in weaponry, for example, gave rise to elective amputation and related instrumentation, while industrial accidents promoted the spread of blood transfusion and improved hemostasis.

Collectors of surgical instruments and curators of such collections will undoubtedly be interested in John's analysis of the composition of instrument materials over time. This analysis is based upon his thesis in medical history. Rather than rely solely upon impressionistic generalizations, he devised a quantitative means to analyze instrument materials in different eras. He devised a point system and uses it to assess the composition and distribution of materials in " collections." This methodology is applied to artifact collections that he has studied in Britain, on the Continent, and in the United States, and also used to analyze instruments appearing in early surgical treatises and in trade catalogues and other ephemeral literature.

A final word of thanks goes to both John and to historyofscience.com for the inclusion of so many images to illustrate and explain the instrumentation. Many surgical treatises of the past were almost devoid of illustration, which always seemed to me most peculiar and incongruous. Here, happily, the reader will benefit from profuse and useful illustration.

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July 2003

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* Such esoteric guides include Robert Froriep, *Chirurgische Kupfertafeln. Eine kleine Sammlung der nöthigsten Abbildungen von anatomischen Präparaten und chirurgischen Instrumenten und Bandagen, zum Gebrauche für praktische Chirurgen* (1820–1847); Henri C. Landrin, *Manuel du coutelier; ou, Traité théorique et pratique de l'art de faire tous les ouvrages de coutellerie (1835) and Nouveau manuel complet du fabricant d'instruments de chirurgie* (1860); Gustave Gaujot and E. Spillmann, *Arsenal de la chirurgie contemporaine: description, mode d'emploi, et appréciation des appareils et instruments en usage* (1867–1872); and Charles Truax, *The Mechanics of Surgery* (1899).