Percutaneous endoscopic gastrostomy tube

The birth of the civilian burn center

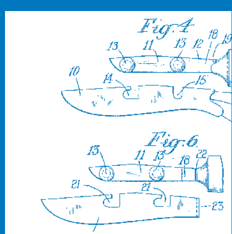
The gentle barber-surgeon

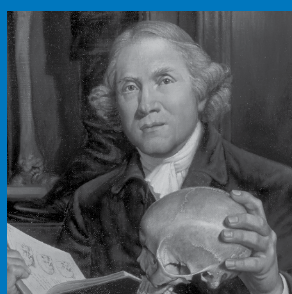
Bulletin of the Surgical History Group

Papers from the 2017 Poster Competition

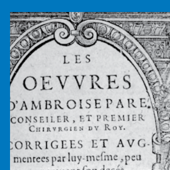
CLINICAL CONGRESS 2017 | SAN DIEGO, CA

The assassination of President James A. Garfield



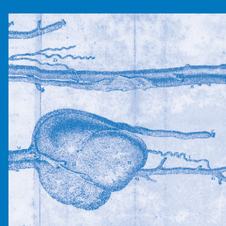


Father of scientific surgery



Origin of wound ballistics

The history of the scalpel



Minimally invasive operations

"A Moses in the profession"

An extraordinary life

SURGICAL
HISTORY GROUP

American College of Surgeons
Inspiring Quality: Highest Standards, Better Outcomes

100+*years*

American College of Surgeons
Inspiring Quality:
Highest Standards, Better Outcomes
100+years

SURGICAL
HISTORY GROUP

Bulletin of the Surgical History Group
Papers from the 2017 Poster Competition

CLINICAL CONGRESS 2017 | SAN DIEGO, CA

Patrick Greiffenstein, MD, FACS
CHAIR, POSTER COMMITTEE
MEMBER, PROGRAM COMMITTEE
NEW ORLEANS, LA

Don Nakayama, MD, FACS
CHAIR, SURGICAL HISTORY GROUP
BULLETIN EDITOR
CHAPEL HILL, NC

Acknowledgements

The activities of the Surgical History Group (SHG) are possible only because of the work of several key persons on staff at the American College of Surgeons (ACS). Meghan Kennedy, ACS Archivist, administers the SHG in addition to her considerable responsibilities caring for archival documents at the College headquarters in Chicago, IL. She ran the poster competition, a complex task of judging more than 100 entries, 20 formal presentations, and shepherding the preparation of articles in the volume you see here. Dolores Barber, Assistant Archivist at the ACS, gives loyal support to the SHG activities and the maintenance of the ACS Archives. Dolores retired this year, and she will be missed.

Basil Pruitt, MD, FACS, chaired the program committee and led a highly successful educational session at this year's Clinical Congress. LaMar McGinnis, MD, FACS, conceived of the SHG and led it through its formative years. He continues to provide welcome advice. Patricia Turner, MD, FACS, Director, ACS Division of Member Services, gives overall leadership and guidance to the SHG. The ACS Division of Integrated Communications produced the present volume.

Special thanks goes to the members of the Poster Competition Committee, and those who spent time as judges at the Clinical Congress. This year's success was the result of their dedication to the program and interest in promoting surgical history.

Table of Contents

Table of Contents

Preface

Dr. Turner

This is the second collection of papers from the annual poster competition of the Surgical History Group of the American College of Surgeons. Held during the annual Clinical Congress of the ACS, the session features the scholarly work of students and residents on a wide range of historical topics. It is the most popular activity sponsored by the SHG.

This year, more than 100 abstracts were submitted for presentation at Clinical Congress 2017, which was held in San Diego, CA, in October. A panel of judges led by Patrick Greiffenstein, MD, FACS, Chair of the Poster Competition Committee, selected 20 abstracts for the program. The judges singled out two for top prizes, a task made difficult by the quality of the presentations.

Participants were invited to submit their work in written form in order to be included in the present collection of articles. It afforded authors a chance to prepare their work for publication, and to give ACS members and those interested in the history of surgery the benefit of their scholarship.

A glance at the titles reveals a wide range of topics certain to interest anyone with a passing curiosity about medical history. We read the history of what is arguably the oldest surgical instrument, the scalpel, as well as the very recent story of the development of the percutaneous endoscopic gastrostomy tube, one of the earliest minimally invasive surgical techniques that has revolutionized surgery. Biographies of figures important in the history of surgery range from Ambroise Paré of the French Renaissance of the 16th century, to Everett Evans, founder of the first modern burn center at the Medical College of Virginia in Richmond, a product of the Atomic Age.

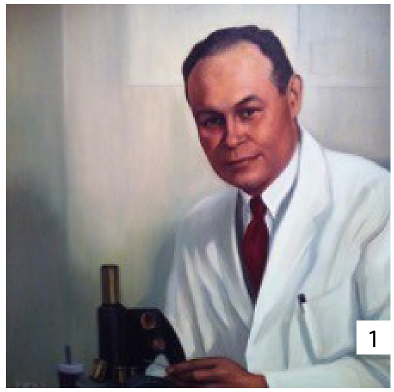
The stories of Charles Drew and Daniel Hale Williams inspire, as we read of their groundbreaking work in surgery and their prominence in black history. The assassination of James Garfield demonstrates the frequent intersection of surgery and current events.

We hope to add contributions from the members of the SHG and the membership of the College in future issues of this publication. This year, Dr. Greiffenstein leads off with a summary of Theodor Kocher's work on wound ballistics. It is far less well known than his Nobel Prize-winning work on the thyroid, but it led to an international agreement that limited the destructiveness of small arms ammunition.

The continued success of the SHG depends on the support of the ACS Division of Member Services and its director, Patricia Turner, MD, FACS. She has been unwavering in her encouragement and financial support. It is appropriate that the present collection is dedicated to Dr. Turner.

This collection will be distributed through the ACS website and through the history of surgery, general surgery, and pediatric surgery online ACS Communities. The articles will reside on the ACS Archives web page, the forum for SHG communications. A limited number of hard copies will be available for purchase through the ACS Archives office.

Don Nakayama, MD, FACS
Chair, Surgical History Group
Bulletin Editor
Chapel Hill, NC



1

Charles Drew: An extraordinary life

American College of Surgeons
Inspiring Quality: Highest Standards, Better Outcomes
100+*years*

AUTHORS
Saptarshi Biswas MD, FRCS, FACS[1]
Dannie Perdomo MS4[2]
[1]Department of Trauma and Acute Care Surgery, Forbes Hospital, Allegheny Health Network, Monroeville, PA
[2]Medical Student, Lake Erie College of Osteopathic Medicine, Erie, PA

CORRESPONDING AUTHOR
Saptarshi Biswas, MD, FRCS, FACS
Department of Trauma and Acute Care Surgery
Forbes Hospital, Allegheny Health Network
Monroeville, PA

Charles Richard Drew (1904–1950), surgeon and researcher, made fundamental contributions to blood preservation and the practice of plasma infusion. He led the first effort at large-scale blood donation and collection, first in New York with the Blood for Britain program of 1940–1941, then on a nationwide scale with the National Research Council and the American Red Cross. As chair of the department of surgery at Howard University, and chief of surgery at the Freedmen's Hospital in Washington, DC, he educated a generation of African American surgeons. The tragic circumstances of his death at age 46 years adds poignancy to his legacy as one of foremost figures in American surgery in the 20th century.

3

Early life and education

Drew was born on June 3, 1904, in Washington, DC, the oldest of five children of an African-American carpet layer and a mother with a teaching degree. Of modest circumstances, his family was well respected in their racially mixed neighborhood. With a mature sense of responsibility at an early age, young Drew, "Charley" to his friends, was only 12 when he managed a crew of six newspaper delivery boys.[1]

While his academic achievements in Washington's Dunbar High School were modest, he lettered all four years in football and track. He was named the school's top athlete in his final two years. He went to Amherst College in 1922, where he lettered as a freshman in football and scored all four years in the New England intercollegiate championships. By his junior year he was the top athlete in football and track, a distinction that by tradition would confer the captaincy for both teams. He was not selected captain of the football team, a decision that was unfortunately no surprise, because top candidates in both sports the previous year, both African Americans, had been denied the honor. The track team, however, elected Drew its captain unanimously.[1]

Two events inspired a career in medicine: His sister died in 1920, two years before he entered Amherst, from tuberculosis brought on by complications of influenza; and he was hospitalized for an infected football injury, which brought him in contact with his future occupation. Otto Glazer, chair of biology at Amherst, sparked an interest in science.[2]

After he graduated from Amherst in 1926, he taught biology and chemistry and coached football and track at Morgan College in Baltimore, MD, for two years to earn money for medical school. He had six hours of English at Amherst, two short of entrance requirements for medical school at Howard. He had an opportunity to attend Harvard Medical School, but they wanted to defer his admission for a year. Not wanting to wait, Drew chose McGill University in Quebec instead, a decision that led to speculation that one factor in his choice may have been the reputation of Canadian schools as an environment more supportive of people of color.[1]

An honor student at McGill, he was elected to Alpha Omega Alpha. After a five-year curriculum, Drew was awarded MD and CM (master of surgery) degrees in 1933, second in a class of 137. He took a one-year residency in medicine at Montreal General Hospital, where he worked with John Beattie studying shock and resuscitation.[2]

He wanted further training in surgery in the U.S., but because of his race his options were restricted to the Freedman Hospital in Washington, DC, and Meharry Medical College in Nashville, TN, the only postgraduate training programs open to African-American physicians. A one-year position at the former facility kept him close to home, a fortunate circumstance, because his father died in 1935. The loss left Drew as his family's primary support. He applied for a position in the department of surgery at the Howard University College of Medicine. Its dean, Numa P.G. Adams, already had his eye on the young trainee. In 1935 Adams gave him an entry position as instructor of pathology. The next year, Drew served both as an assistant in surgery and resident at Freedmen's, followed by an appointment as assistant surgeon at the hospital in 1937 and 1938.[1]

In 1935 Adams hired a white surgeon from Yale, Edward Lee Howes, to act as chief of surgery for five years and modernize the department at Howard. Adams' and Howes' goal was to mentor a young African-American surgeon to eventually take over as chair. Drew was the obvious candidate for the position. Funds from the Rockefeller Foundation allowed the protégé to get further training in surgery and do research at New York's Presbyterian Hospital under Allen Whipple in 1938.[1]

Blood and plasma

Drew had a background in fluid resuscitation and shock in Montreal, QC, so he welcomed an opportunity to work with John Scudder to set up an experimental blood bank at Presbyterian in 1939. They researched all aspects of blood preservation and transfusion therapy. Drew's doctoral research, published in 1940, focused on every aspect that affected blood storage: anticoagulants, preservatives, storage conditions, shapes of containers, and ranges of temperatures.

He found that plasma, unlike whole blood, could be stored without refrigeration and without deterioration during transport. It could substitute for whole blood during resuscitation in any recipient without regard to blood type.[3] Scudder described Drew's dissertation as "a masterpiece," and "one of the most distinguished essays ever written, both in form and content."[3]

The relevance of Drew's research became manifest with World War II. Britain's need for medical supplies, including blood and plasma for transfusion, became desperate when the Battle of Britain began in July 1940. Despite America's resolve not to become militarily involved in the early years of the war, in June the Blood Transfusion Betterment Association (BTBA), a cooperative group of New York hospitals, anticipated the need to supply the Allies with plasma and began to organize a relief program, "Blood for Britain" (a better-known, pithier slogan than the original "Blood Plasma for Great Britain").[4]

Each hospital had its own system to collect blood and used serum and plasma as it was needed at each facility. Now they wanted to cooperate in a large-scale effort to send serum and plasma overseas. A myriad of questions had to be addressed: the age and blood pressure of donors; should donors be fasting; whether to collect serum or plasma; blood collection by gravity or suction; the concentration of citrate in collection bottles; the shape of collection bottles; how much merthiolate to add as an antiseptic; the temperature of storage; and the all-important issues of bacteriological and toxicological control.[4]

The call for volunteers went out on August 15, and 20 of 22 donors were accepted at Presbyterian Hospital. By October, nearly 10,000 appointments for donors were made at eight hospitals. Shipment to England was due to begin in November.

In September, just weeks into the program, the need for a fulltime medical director became obvious. "The mounting difficulties which we encountered forced us to take a radical step," wrote Stetten. The board was unanimous in their choice for fulltime director: Charles Drew. "Since Drew, who is a recognized authority on the subject of blood preservation and blood substitutes, and, at the same time, an excellent organizer, has been in charge, our major troubles have vanished."[4] By January 1941, in its five months of operation nearly 14,556 persons donated more than 6,151 liters of plasma to Britain.[5]

It became increasingly apparent that the U.S. would become involved in the fighting, and blood would be needed. With a national organization and local chapters, the American Red Cross was the ideal association to expand the blood collection program throughout the country despite its prior lack of involvement in blood donation activities. In February, Drew was named director of the first American Red Cross blood bank at Presbyterian Hospital. The National Research Council (NRC) named him assistant director for blood procurement. Among his innovations was the "blood mobile," a van roomy enough to allow blood collection and refrigerated storage.[6]

The country might have been united against foreign enemies, but it remained divided by race. A national program of blood donation inevitably highlighted the question of the racial identity of the donor, even though the science of blood typing was long established. The Blood for Britain program labelled its units of plasma by race before delivery overseas.[4] The original blood bank in Chicago, IL, continued to label its units by race, as certainly banks did in the Deep South.[5] The War Department issued a directive that gave lip service to science but only served prejudice.

For reasons which are not biologically convincing but which are commonly recognized as psychologically important in America, it is not deemed advisable to collect and mix Caucasian and Negro blood indiscriminately for later administration to members of the military forces.[5]

Procurement policies had to be made on a national scale, including the question of racial segregation of blood. When the Red Cross decided to adopt the policy of the War Department in April 1941, Drew resigned his positions both with the Red Cross and NRC.[7]

Drew's silence about the circumstances of his resignation surprised some African-American leaders at the time. "[It] seems strange that his country could find no further use for the services of a citizen who had been of such viral expert assistance in the critical hour," wrote W. Montague Cobb of Howard University. "One hears that it was thought that a Negro would not be acceptable in a high place in a national program."[8]

Given Drew's thorough knowledge of blood donation and transfusion and his dedication to racial advancement, it is doubtless that official donor policies contributed to his decision to leave the program. Edward Cornwell III, current chair of surgery at Howard, wrote, "He was not an activist by nature, and he was cautious about publically criticizing a policy of the Armed Forces during wartime."[9] In 1944, Drew later wrote a letter to the director of the federal Labor Standards Association on the issue.

I think the Army made a grievous mistake, a stupid error in first issuing an order to the effect that blood for the Army should not be received from Negroes. It was a bad mistake for 3 reasons: (1) No official department of the Federal Government should willfully humiliate its citizens; (2) There is no scientific basis for the order; and (3) They need the blood.[9]

Howard

True to Adams and Howes' agreement to have an African American surgeon trained at Howard succeed the latter, Drew was named professor and head of the department of surgery at Howard University and chief surgeon of Freedmen's Hospital. His profile in the National Library of Medicine website summarizes his educational mission at Howard.

Drew could at last pursue his larger ambition: training young African American surgeons who would meet the most rigorous standards in any surgical specialty and to place them in strategic positions throughout the country where they could, in turn, nurture the tradition of excellence. This, Drew believed, would be his greatest and most lasting contribution to medicine.[3]

In 1948 Drew's first class of surgical residents passed the certification examination of the American Board of Surgery, two receiving top marks. To promote the wide acceptance of African Americans as surgeons, Drew was an advocate of his graduates to hospitals and communities throughout the country. He often paid their expenses to attend national meetings to present their work and searched for training opportunities for his best residents.

Despite his achievements he faced discrimination at the professional level. The District of Columbia chapter of the American Medical Association (AMA) excluded him from membership, which made him ineligible for the national organization. At the time, membership in the AMA was often a requirement for privileges at many hospitals and placement in training programs in medical and surgical specialties. Exclusion from the AMA was therefore a *de facto* barrier against racial minorities.[3] He became a Fellow of the American College of Surgeons (ACS), but posthumously, a year and a half after he died. One of his profiles notes he refused to join the ACS because the organization did not accept other well-qualified African-American surgeons.[7]

He was recognized in other quarters for his accomplishments. He served as consultant to the Surgeon General on the status of surgical facilities in the European theater after the war. The National Association for the Advancement of Colored People gave him its highest award, the Spingarn Medal, in 1944 for his work on blood preservation and plasma infusion. He was awarded honorary degrees from the Virginia State College (1945) and Amherst College (1947). He was an ABS examiner in 1948.

Death

In the wee hours of April 1, 1950, Drew and three other physicians started a long drive to Tuskegee, AL, to attend the annual meeting of the John A. Andrew Clinical Society. He had a full schedule the day before, with 6:30 am morning rounds with residents, a mastectomy at Freedmen's Hospital, a two-hour lecture, department business the entire afternoon, and two student functions on campus after dinner with his family. He still had evening rounds to make, so it was not until 11:00 pm when he got back home to pack.[9]

They had made it to Haw River, a small town on state route 49 just east of Burlington, NC, Drew at his turn at the wheel. When he apparently fell asleep, the car drifted onto the shoulder of the road and overturned several times. None of the occupants were restrained. Two were unharmed; another suffered fractures of the humerus and scapula and an injury to the knee. Drew, however, suffered crush injuries to the head, chest, and leg.

An ambulance took Drew to Alamance General Hospital in Burlington. Three local surgeons, including brothers Harold (an orthopaedic surgeon) and Charles Kernodle (a general surgeon trained in thoracic surgery), met Drew and began intravenous infusions. The hospital had no blood bank, so he never received a transfusion. Decades later in an interview with Patrick Craft, a family medicine physician in Oxford, NC, Charles Kernodle said he could not remember whether he was given plasma. Drew died two hours after his arrival at the hospital.[10]

A myth arose about Drew's death: He had been turned away from a white-only segregated hospital, a story perpetuated in *Time* magazine (March 29, 1968) and the hit TV show M*A*S*H (season 2, episode 9). The fable had its roots in a 1959 play by Edward Albee, *The Death of Bessie Smith*, where the famous blues singer dies upon being turned away from an all-white segregated hospital in the South. While it was true that Smith died after a car crash, she was taken directly to an all-black hospital where she died.

Kernodle and his colleagues recognized the severity of Drew's wounds and tried to send him to Duke University Hospital in Durham, NC, 35 miles away. "He was too critical to go to Duke," said Kernodle in his conversation with Craft. "They recommended supporting as best we could.... I treat patients to the best of my ability, black or white, rich or poor."[10]

C. Mason Quick, then an intern at the Kate Bitting Reynolds Hospital in Winston-Salem, NC, a segregated facility for African Americans, confirmed the severity of Drew's wounds and the appropriateness of the treatment. Summoned to check on Drew by Samuel Bullock, one of Drew's friends in the car, he was able to get there before Drew died. "[Drew] got fluids and was treated aggressively," Quick said to Craft. "The chest was just torn up, practically opened up." John Ford, another Drew colleague in the car, was the one who had suffered the orthopaedic injuries. In a letter to Quick, Ford wrote:

We were taken to Alamance General Hospital... where we received excellent care. I informed the physicians on duty as to who Dr. Drew was. They went to him immediately, and of course, there was nothing to be done because of the extensive injuries. His face was blown up like a balloon indicating a superior vena cava syndrome... I have nothing but praise for the excellent care provided me while at that hospital.[10]

Cornwell notes that a number of later articles by prominent African-American surgeons have subsequently been written to set the record straight, including an article written by him. In 1989, the attendees of the inaugural meeting of the Society of Black Academic Surgeons met in Durham, NC, and made the 30-mile trip to Haw River on state route 49 to the memorial marking the site of Drew's car crash. Joining them were Harold and Charles Kernodle.[11]

Legacy

Drew made fundamental contributions in the biochemistry of blood preservation and plasma processing that provided a scientific basis for large scale plasma donation in the months before America's involvement in World War II. His administrative leadership helped assure the success of the Blood for Britain program, which became the framework for the blood donor program of the American Red Cross. These achievements place Drew in the first rank of academic surgery of his generation.

Today we see many circumstances that only add to the poignancy of his death: a car crash before modern lifesaving restraint systems, trauma center care, and especially the one area where he is indelibly identified, the ready availability of blood products in the care of the injured. His lasting gift is the tradition of clinical service and surgical education at the department of surgery at Howard University. Graduates of the Howard University School of Medicine and its residency in general surgery are Drew's enduring legacy.

4

References

1 Cobb WM. Charles Richard Drew, MD, 1904–1950. *J Natl Med Assoc.* July 1950;42(4):238-246.

2 The Charles R. Drew Papers: Biographical Information. Available at: https://profiles.nlm.nih.gov/ps/retrieve/Narrative/BG/p-nid/336. Accessed November 20, 2017.

3 The Charles R. Drew Papers: "My chief interest was and is surgery," Howard University, 1941–1950. Available at: https://profiles.nlm.nih.gov/ps/retrieve/Narrative/BG/p-nid/339. Accessed November 21, 2017.

4 Stetten D. The blood plasma for Great Britain project. *Bull NY Acad Med.* 1941;17(1):27-38.

5 Schneider WH. Blood transfusion between the wars. *J Hist Med.* 2003;58(2):187-224.

6 The Charles R. Drew Papers: Becoming "the Father of the Blood Bank," 1938–1941. Available at: https://profiles.nlm.nih.gov/ps/retrieve/Narrative/BG/p-nid/338. Accessed November 22, 2017.

7 Rutkow IM. Moments in surgical history: Charles Richard Drew. *Arch Surg.* 2000;135(10):1233.

8 Cobb WM. Charles Richard Drew, MD, 1904–1950. *J Natl Med Assoc.* 1950;42(4):238-246.

9 Cornwell EE III, Chang DC, Lefall LD Jr. The Southern Surgical Association history of medicine scholarship presentation. Dr. Charles Drew, a surgical pioneer. *Ann Surg.* 2006;243(5):612-618.

10 Craft PP. Chalres Drew: Dispelling the myth. *South Med J.* 1992;85(12):1236-1240.

11 Hoover EL. Dr Charles R. Drew: Facts, fiction and legend. *J Natl Med Assoc.* 2005;97(6):837-838.

Legends

1 Charles Richard Drew, by Betsy Graves Reyneau (1888–1964). National Portrait Gallery.

National Portrait Gallery, Smithsonian Institution; gift of the Harmon Foundation.

2 Charles Drew teaching interns and residents during rounds at Freedmen's Hospital. Scurlock Studio Records, Archives Center, National Museum of American History, Smithsonian Institution.

3 Charles Richard Drew. National Library of Medicine.

4 Historical marker, state route 49, Haw River, NC. Photo by Patrick Jordan, Burlington, NC, Historical Marker Database, *HMdb.org*.

2

The history of the scalpel: From flint to zirconium-coated steel

American College of Surgeons
Inspiring Quality: Highest Standards, Better Outcomes
100+*years*

AUTHORS
Jason B. Brill, MD
Evan K. Harrison, MD
Michael J. Sise, MD, FACS
Romeo C. Ignacio, Jr., MD, FACS

CORRESPONDING AUTHOR
Jason B. Brill, MD
Residency in General Surgery
Naval Medical Center
San Diego, CA

The surgical knife, one of the earliest surgical instruments, has evolved over 10 millennia. While the word "scalpel" derives from the Latin word "scallpellus," the physical instruments surgeons use today started out as flint and obsidian cutting implements during the Stone Age. As surgery developed into a profession, knives dedicated to specific uses also evolved. Barber-surgeons embellished their scalpels as part of the art of their craft. Later, surgeons prized speed and sharpness. Today's advances in scalpel technology include additional safety measures and gemstone and polymer coatings. The quintessential instrument of surgeons, the scalpel is the longstanding symbol of the discipline. Tracing the history of this tool reflects the evolution of surgery as a culture and as a profession.

Origins

Pinpointing a specific period of time when a cutting implement became the first surgical knife depends largely on perspective. Shells, razor-like leaves, bamboo shoots, and even fingernails may all be viewed as early surgical instruments. Thumbnails for newborn circumcisions, scarification via plant stems, and venesection with sharks' teeth served as the first examples of sharp tools for procedures on the human body.[1,2] John Kirkup, MB, BS—a retired surgeon and honorary curator of the Historical Instruments Collection at the Royal College of Surgeons of England—researched the history of surgical tools for more than 20 years.[3] According to Dr. Kirkup, circumcision with sharpened stones, one of the earliest recorded elective procedures, evolved into knives used for basic procedures.[4] Excavations of archaeological sites dating to the Paleolithic and Neolithic periods revealed knives for surgical use as early as 10,000–8,000 BC.[5] Blades were initially composed of flint, jade, and obsidian, with specific pieces chosen for their sharp edges. Fracture and flake techniques were then employed to refine these early blades into cutting instruments with desired characteristics, making these objects among the first human-refined tools.[6]

A particularly well-preserved prehistoric blade mounted onto a handle was found in 1991, preserved in ice near the Austrian-Italian border (see Figure 1). These types of tools were used for scarification, venesection, lancing, and circumcision. In fact, these instruments were still used for many of the same purposes by Alaska Native tribes well into the 19th century.[7] Evidence of obsidian blades used for more complex procedures such as craniotomies appeared around 4000 BC in prehistoric Anatolia, modern-day Turkey. Some archeological specimens are still sharp enough to incise skin.[8]

1

Transition to modern scalpels

Metal blades replaced sharpened stone: first it was copper (3500 BC), followed by bronze and then iron (1400 BC). But it wasn't until 400 BC that the concept of a surgical knife was first described by Hippocrates.[9] He used the term "macairion," a smaller version of a Lacedaemonian sword called a "machaira," to describe the surgical tool. The machaira was a broad-cutting blade with a single edge and sharp point, containing the same essential features of the modern scalpel as defined by Stedman's Medical Dictionary: "A pointed knife with a convex edge."[10,11] In Rome, Galen and Celsus used an instrument with this shape—a small, sharp blade for specialized used for incision and drainage, tendon repairs, and vivisections (see Figure 2).

2

The Romans named their version of this tool the "scallpellus," the diminutive form of the word scalper ("incisor" or "cutter").[12] With the collapse of the Roman Empire, surgical innovation flourished in the Islamic Golden Age. Albucasis (Abū al-Qāsim Khalaf ibn al-'Abbās al-Zahrāwī, 936–1013) in the Caliphate of Córdoba (modern Spain) used a scalpel that held a retractable blade.[13,14] Surgical instruments became even more varied and specialized with the Renaissance in the 14th and 15th centuries. Embellishments to the scalpel included fixed and folding blades and specialized tips, such as lancets, bistouries, and double-edged blades called catlins.

Barbers working during the Renaissance period, including fathers of modern surgery such as Guy de Chauliac and Ambroise Paré, used ornamented scalpels with artistic flourishes that enjoyed wide popularity for several hundred years.[15] The requirements of antisepsis and asepsis in the late 19th century subjected instruments to caustic chemicals and pressurized steam sterilization, so nonmetallic decorations became obsolete (see Figures 3 and 4).

3

4

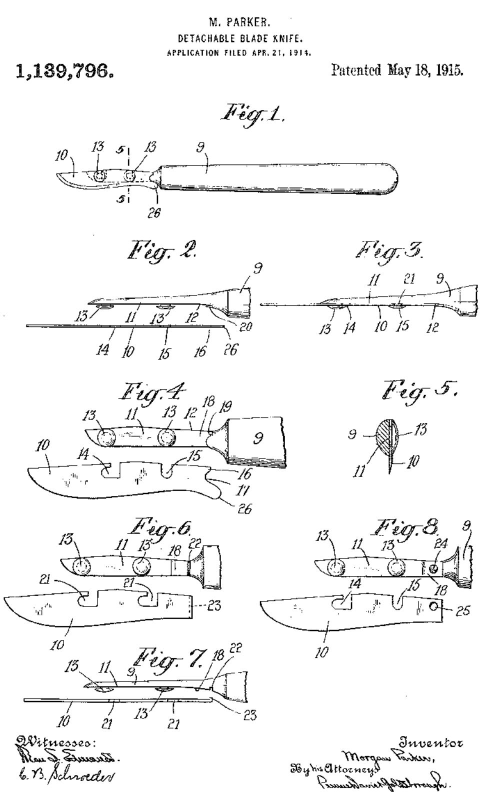
RCPSG

Disposable scalpels

King C. Gillette founded the American Safety Razor Company (later the Gillette Safety Razor Company) in 1901 to produce and market a handle-and-frame device that held disposable razors. John Murphy, MD, FACS, a Chicago, IL, surgeon and one of the founders of the ACS, adapted Gillette's razors into a tool that could be used when performing surgical operations. Dr. Murphy's version featured interchangeable blades, although it required extra instruments to complete a blade exchange.[16]

In 1914, Morgan Parker, a 22-year-old engineer, invented the two-piece blade-and-handle medical scalpel that is used in ORs today.[10] It allowed rapid mass-produced, sharp blades to be used and exchanged on standard reusable handles. According to legend, Mr. Parker's uncle, a New York, NY, surgeon, became impatient with the cumbersome process of the blade exchange in his busy practice. A glance at Mr. Parker's elegant solution reveals its genius (see Figure 5). He stated the following in his original patent application:

For the purpose of securing the blade to the handle, headed studs are preferably provided on the handle adapted to co-act with suitable slots in the blade. When such headed studs and slot are employed, the blade may be readily secured upon the handle and when in position will be held so rigidly as to preclude the possibility of movement relative to the handle.[17]



5

When Mr. Parker presented his scalpel at the ACS Clinical Congress of 1915 in Boston, MA, its reception encouraged him to take it to production. Mr. Parker, an engineer but not a businessman, sought a partner. The first name listed alphabetically in the phone book under "medical suppliers" was C.R. Bard. Together, they formed the Bard-Parker Company, which became one of the iconic names in surgery. They developed cold sterilization to avoid superheating, which killed microorganisms, but also dulled the blade. The rib-back handle replaced those that bore the paired studs in 1936 in order to ensure one-way fitment between the blade and handle.

The numbering system of blades and handles is arbitrary, a fact that likely confirms the suspicions of generations of surgical interns. As part of the Bard-Parker marketing scheme, each new blade and handle design was given a new number and occasionally a letter that denoted a "new and improved" model (for example, #15C).[18] As a result, a given number has no relation to size, shape, sharpness, or even a place in the product timeline.

Modern additions

In the modern era, hardened alloys, such as 316L and 440C stainless steel, replaced carbon steel in most settings. Stainless steel had superior corrosion resistance, and reusable handles benefited most from the high chromium content of stainless steel. Retracting blades, a concept dating to the time of Albucasis of the 10th century, became an increasingly common safety feature. Nickel and chromium plating became less common. Recent technological improvements include zirconium nitride, diamond, and polymer coatings that enhance the cutting edge. For all the improvements evident in contemporary surgical technology, electron microscopic images actually confirm that the edge of Neolithic obsidian blades exceed today's steel scalpels in sharpness.[19]

Conclusion

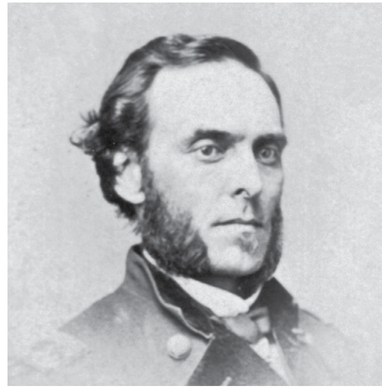
The scalpel, since its first use as a medical knife by the Romans, has been a symbol of the surgeon. Its evolution in many ways mirrors the progress of those wielding it. Prehistoric humans used stone tools occasionally for medical uses. The Greeks and Romans advanced both knowledge and skill while creating dedicated surgical knives. The barber-surgeons refined techniques as they refined the instruments used for them. Asepsis mandated sweeping changes in both scalpel and surgical practice. Today, the modern surgeon relies on a wide array of technologically advanced and ever-changing equipment, yet the operation still begins with the scalpel, the profession's oldest instrument.

References

1. Scultetus J. *The Chyrurgeon's Storehouse.* London, UK: Starker; 1674.
2. Pankhurst R. An historical examination of traditional Ethiopian medicine and surgery. *Ethiop Med J.* 1964;3:157-167.
3. Kirkup J. The history and evolution of surgical instruments VI: The surgical blade: From finger nail to ultrasound. *Ann R Coll Surg Engl.* 1995;77(5):380-388.
4. Jacobs MS. Circumcision. *Ann Med Hist.* 1939;1(3):68-73.
5. Rezaian J, Forouzanfar F. Consideration on trephinated skull in the Sahre-e Sukte (Burnt City) in Sistan. *Res Hist Med.* 2012;1(4):157-168.
6. Moser L, Pedroti A. The Neolithic settlement of Lugo di Grezzana (Verona): Preliminary report. In: Belluzzo G, Salzani L, eds. *From Earth to Museum: Exhibition of Prehistoric and Protostorical Finds of the Last Ten Years of Research From the VeroneseTerritory.* Legnago, Italy: Fondazione Foroni; 1996.
7. Ackerknecht EH. Primitive surgery. *Am Anthropol.*2009;49(1):25-45.
8. Shadbolt P. How Stone Age blades are still cutting it in modern surgery. CNN. Available at: www.cnn.com/2015/04/02/health/surgery-scalpels-obsidian/index.html. Accessed November 10, 2017.
9. Adams F. *The Genuine Works of Hippocrates, Vol. II*. London, UK: Sydenham Society; 1849.
10. Ochsner J. The surgical knife. *Bull Am Coll Surg* 1999;84(2):27-37.
11. Stedman TL. *Stedman's Medical Dictionary for the Health Professions and Nursing*. Philadelphia, PA: Lippincott Williams & Wilkins; 2005.
12. Bliquez L. Tools of the empire. In: *The Tools of Asclepius: Surgical Instruments in Greek and Roman Times*. Boston, MA: Brill; 2015.
13. Elgohary MA. Al Zahrawi: The father of modern surgery. *Ann Ped Surg.* 2006;2(2):82-87.
14. Ahmadi SA, Zargaran A, Mehdizadeh A, Mortazavi SMJ. Remanufacturing and evaluation of Al Zahrawi's surgical instruments, Al Mokhdea as scalpel handle. *Galen Medical Journal* [online]. 2013;2(1):22-25. Available at: www.gmj.ir/index.php/gmj/article/viewFile/42/27. Accessed December 19, 2017.
15. Rutkow IM. On scalpels and bistouries. *Arch Surg.* 2000;135(3):360.
16. Ochsner J. Surgical knife. *Tex Heart Inst J*. 2009;36(5):441-443.
17. Parker M. Detachable-blade knife. U.S. Patent US 1139796A. Available at: http://pdfpiw.uspto.gov/.piw?Docid=01139796. Accessed December 19, 2017.
18. Arrow AK. Solving the mystery of the scalpel blades: What do the numbers mean? *Plast Reconstr Surg*. 1996;97(4):861-862
19. Buck BA. Ancient technology in contemporary surgery. *West J Med*. 1982;136(3):265-269.

Legends

1. Flint dagger of Ötzi the Ice Man. Image © South Tyrol Museum of Archaeology/Harald Wisthaler, Bolzano, Italy.
2. Example of a Roman scallpellus and similar instruments. Courtesy of Historical Collections & Services, Claude Moore Health Sciences Library, University of Virginia, Charlottesville.
3. Surgical set from the American Revolutionary War. Displayed in the Smithsonian National Museum of American History, the set includes wood and iron handles and required routine sharpening of the blades.
4. Detachable blades from circa 1900. Courtesy of the Royal College of Physicians and Surgeons of Glasgow, Scotland.
5. Morgan Parker's original patent. Source: United States Patent and Trademark Office, *uspto.gov.*



3

"Yes, I shot the President, but his physicians killed him." The assassination of President James A. Garfield

American College of Surgeons
Inspiring Quality: Highest Standards, Better Outcomes
100+*years*

AUTHORS
John D. Ehrhardt, Jr.
J. Patrick O'Leary, MD, FACS

Department of Surgery, Florida International University, Herbert Wertheim College of Medicine, Miami, FL

CORRESPONDING AUTHOR
John D. Ehrhardt, Jr.
FIU HWCOM
11200 SW 8th St., AHC2
Miami, FL 33199

President James A. Garfield suffered two gunshots on July 2, 1881, but did not die until 80 days later of complications from sepsis. He might have survived had his injuries not been contaminated, either by the gunshots themselves or the interventions that followed. "Yes, I shot the president," said Charles Guiteau, Garfield's assassin. "But his physicians killed him."

The drama of Garfield's struggle to survive his injuries evoked enormous national interest, a harbinger of the medical dramas and documentaries of today. D. Willard Bliss, a former Civil War surgeon, and his handpicked consultants underwent daily scrutiny by the professional community and lay press. As the President succumbed to his injuries, the surgeons' reputations suffered. A primary criticism was the supposed lack of antiseptic interventions in Garfield's care, especially when probing the wound with unwashed hands.

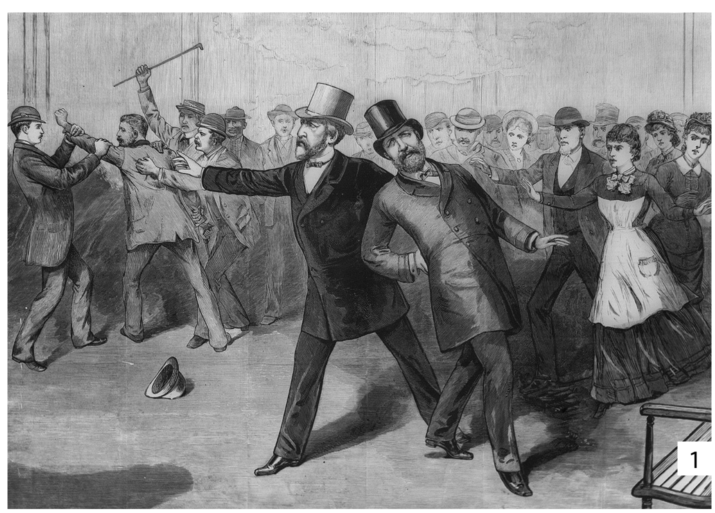
Inserting a finger into the wound, however, was a basic part of examination of a gunshot wound at the time. Many American surgeons had not accepted Listerian antisepsis at the time of the event, and aseptic techniques, such as scrupulous handwashing and wearing surgical gloves, had not yet been developed. In the context of surgical practice of the era, his surgeons followed the standards of care of the time.

Robert Reyburn, professor of surgery at Howard University in Washington, DC, was called in consultation soon after President James A. Garfield was shot in 1881. One of the core group of surgeons involved in his care, he acted as their scribe. Reyburn was one of the school's first five faculty members and had served as its dean for one year in 1870–1871. Long after the assassination he became dean once more from 1900 to 1908. His records of Garfield's condition and interventions up to his death, reprinted in the *Journal of the American Medical Association* in 1894, 13 years after the event and long after the controversies that followed the assassination had waned, provide nearly all of the descriptions and quotations in the present article.[1]

The shooting

Charles Guiteau, a frustrated office-seeker, shot Garfield twice in the flank as the Chief Executive waited for his train inside the Baltimore and Potomac railroad station in Washington, DC, on the morning of July 2, 1881 (Figure 1). It was 20 years before Congress asked the Secret Service to protect the President after the assassination of William McKinley in 1901. Garfield's 17-year-old son Harry and the President's closest advisors rushed to the stricken man on the floor of the depot and began to call for help.

Smith Townshend, a local health officer, emerged from the crowd, the first physician on the scene. He found the President in shock, his blood covering the floor around him. He gave him an ounce of brandy as a stimulant along with one drachm (or dram; 8 drams to an ounce) of aromatic ammonia spirits. Garfield was moved to the less public second floor of the building and was carefully laid on a mattress on the floor. He continued to bleed.



1

Robert Todd Lincoln, Secretary of War, summoned D. Willard Bliss, his close friend, a former military surgeon in the Civil War, and now a practicing surgeon in the capital (Figure 2). By the time the surgeon arrived, the President was in trouble.

2

The President was deathly pale, almost pulseless… a very feeble pulse of about 40 beats per minute, and a marked pallor of the face; skin cold and covered with a clammy perspiration.[1]

Bliss found two wounds, a shallow flesh wound at the posterior aspect of Garfield's left shoulder and a more ominous one four inches to the right of the 12th thoracic vertebrae. He tried to explore the latter injury with his finger to trace the path of the bullet. He felt the shards of Garfield's 11th rib but not the bullet. When he guided a probe into the wound it could only be passed three or so inches before it stopped. The President was placed with the gunshot wound dependent to encourage drainage.

In short order eight physicians joined Bliss and Townshend at the scene. The doctors retired to a private corner of the train depot where they reviewed what Bliss had found and offered their suggestions. Bliss, the most experienced of the group, was in charge of the President's care from the beginning. Reyburn began to take the notes that would become the official medical history of the President's care.

Clinical course

Garfield repeatedly asked to be taken to the White House. The group decided to transfer him to the official residence, with dispatch but also great care. He complained of "extreme thirst," so he was given small sips of water. His surgical team decided it would not be appropriate to undress him at that stage of his injury. He was given subcutaneous injections of morphine (1/4 grain; 1 grain, about 60 mg) and atropine (1/96 grain) to relieve pain in his lower extremities and to stimulate his system. Over the first day after his injury he continued to vomit, had a tachycardia to 158, and his temperature fell to 96.5°F. His doctors did not expect him to survive the night.

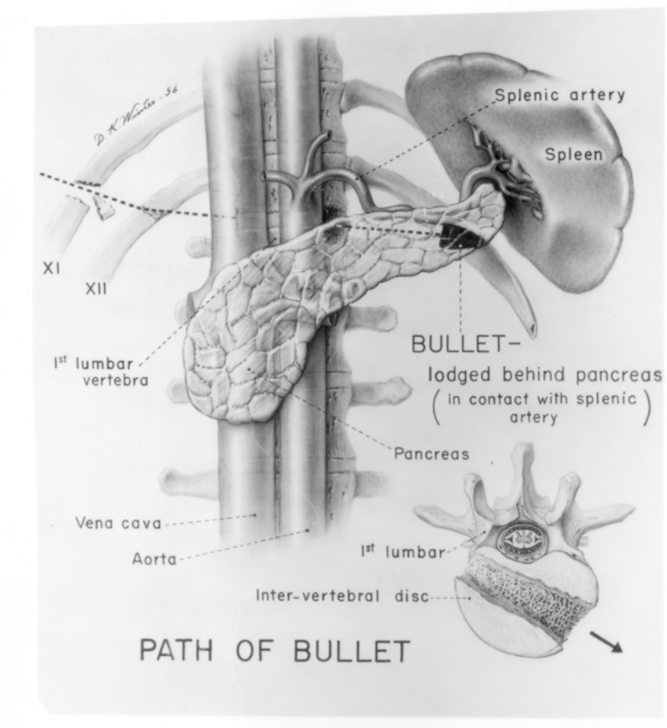
Urgent calls were made for two of the country's most prominent surgeons, D. Hayes Agnew, professor of surgery at the University of Pennsylvania, and Frank Hamilton of Bellevue Hospital in New York. Agnew arrived the early hours of July 4, and Hamilton shortly after. Told by Bliss to examine the President as though he was their own patient, the two consultants reexamined the him, including probing the wound with their fingers.

The first two days after the event had been stormy, but the vomiting had disappeared and he was actually drinking some milk and lime water "with relish." Troublesome was severe pain in his legs and groin, which they ascribed to contusion of his spinal cord. The President's overall condition had improved, an indication that the kidneys, intestines, and liver had been spared injury and the peritoneum had not been violated.

Agnew, Hamilton, and Bliss made the crucial decision not to explore the wound. The location of the bullet was still unknown, and extensive dissections to find it, they believed, would complicate the President's course unnecessarily. By the end of the week the President appeared to confirm the wisdom of their strategy. He awoke refreshed and free from pain and was without fever. He was able drink chicken broth with some egg white. His legs were still heavy and weak, and the skin of his feet and ankles was sensitive to touch. An ominous new sign had emerged: He had developed jaundice. He had fevers daily, for which he received quinine.

The wound began to discharge “healthy looking pus,” and on one occasion discharged a shard of bone and some bits of clothing. A two-inch tube was fixed to the skin to facilitate drainage, and it was occasionally changed when it became occluded. Agnew made a counter incision toward the end of Garfield’s fourth week to enlarge the opening in his flank over the rib. Another fragment of bone was removed, and the wound was rinsed with carbolic acid.

Still troubled by his failure to remove the bullet, Bliss invited Alexander Graham Bell to search for the projectile with his newly-invented metal detector. Bell concluded that the bullet lay in the right side of the abdomen. The President’s autopsy would show, however, that the bullet had crossed the midline and lay in the left side of the retroperitoneum (Figure 3).



3

There were signs that the area of infection had spread beyond the path of the bullet. After Bell’s examination, a softer tube that seemed to track toward the pelvis was passed about four inches into the abdomen, a greater distance than the previous drains. As a large volume of pus followed, “profuse and laudable in character,” the President had some relief of pain. A new area of induration appeared toward the anterior superior iliac spine over the iliac fossa, a region that had not been previously involved. At a later exploration they were able to pass the tube a full 12 inches toward the ilium.

Heretofore Garfield was able to drink sips of milk and broth, a bit of beefsteak, a few berries, and the like, but never a full meal. Midway through the second month after his injury, he was unable to eat anything. His condition “excited very grave apprehensions in the minds of the attending surgeons.” Faced with signs of collapse, with a heart rate of 130 and hypothermia, the surgeons decided on nutritive enemas, consisting of one egg yolk, an ounce of bullion, a half-ounce of whisky, one-and-a-half ounces of milk, and 10 drops of tincture of opium. The concoction was warmed to 100°F. The response was gratifying. “The administration of these enemas was highly beneficial to the President, and he showed the restorative and invigorating effect of their use almost immediately.”

In truth the enemas provided no nutrition. “In spite of all our efforts to nourish the President,” Reyburn wrote, “he is emaciating so rapidly that it is distressing to look at him.” At the time of his shooting his attendants had trouble moving his bulky 210-pound frame. By the end of the second month of his confinement he weighed only 130 pounds.

His lack of oral intake may have set him up for his next complication, suppurative parotitis of the right parotid gland. Despite an incision into the infected gland, pus appeared in his external auditory canal and drained into his mouth, bypassing Stenson’s duct. A large boil appeared below his right ear, followed by others in his axilla and trunk. He struggled with thick sputum from a productive cough, a sign he had bronchopneumonia. By the end of the eighth week of confinement, he had sacral bedsores.

Garfield had enough. His slow demise occurred during the hot Washington summer. Fans blew air over ice to get the temperature indoors to 75°F, but most of the time his room was closer to 90°. He and his wife, Lucrecia, saw the New Jersey shore community of Elberon as a place where the ocean air might give him a better chance of recovery. In early September a specially outfitted rail car took Garfield to the resort town. Temporary rails were laid to take the President’s car directly to the door of the beach cottage where he would stay for the last days of his life. Mercifully, death came on September 19, 1881, two-and-a-half months after he was shot.

Autopsy

Bliss, Reyburn, and three other physicians performed the autopsy of Garfield's already embalmed body.[2] The elusive bullet was lodged behind the pancreas, to the left of the vertebral column (Figure 3). They saw the fractured 11th rib but discovered that the 12th rib was also broken. The bullet had burrowed through the body of the first lumbar vertebra but spared the spinal cord. They found the retroperitoneal abscess that tracked to the iliac fossa.

They found a rent in the splenic artery that they concluded was a ruptured splenic artery aneurysm. In support of their contention was about a pint of bloody fluid in the area but no collection in the free peritoneal cavity that would indicate fatal exsanguination. He had a right lower lobe bronchopneumonia.[2]

Reyburn noted that all of the spaces around the area of the 11th rib and the retroperitoneal abscess that extended into the iliac fossa had been addressed with drainage procedures. From a surgeon's point of view everything that could have been addressed had been. Understandably defensive after years of debate and second guessing about Garfield's care that will be described below, he quoted a number of surgical authorities who claimed gunshot wounds to the vertebral column were uniformly fatal.

From a modern perspective, there were other significant factors that contributed to Garfield's death: hemorrhagic shock that went without resuscitation, inadequate nutritional support throughout the course of care, and unchecked sepsis from the injured area, likely the space that tracked to the ilium, and bronchopneumonia.

A finding that did not receive comment at the time, either by Garfield's surgeons or their critics, was a fist-sized collection of pus and bile beneath the liver, gall bladder, and transverse mesocolon that was nowhere near the track of the bullet. In 2012 Theodore Pappas of Durham concluded the most likely cause was gall bladder perforation from acalculous cholecystitis, a posttraumatic complication that was first described in 1947 and a not-infrequent complication of prolonged intensive care in the 1970s. Such an undrained collection of pus may have led to Garfield's deterioration in mid-August and contributed to his final downhill course.[3]

A concerned nation

The shooting and Garfield's struggle of survival were matters of intense public interest. According to Gert Brieger, William Welch Professor of the Institute of the History of Medicine at Johns Hopkins, it was the first medical case that was consistently reported in the lay press and the medical literature.[4] Bliss, Agnew, and Hamilton became national celebrities, pestered by the press for updates and comments on Garfield's condition.

Physicians and the lay public became increasingly outspoken in their criticism as early as the second week after the assassination attempt. Physicians far removed from the case, some of them surgeons, gave their opinions on his care and what should be done. The lay public became so familiar with the case that people debated surgical options and knowingly used then-sophisticated surgical terminology.[5]

In an attempt to satisfy the public interest Bliss and his consultants gave daily updates of the President's general condition. Aside from his vital signs, they gave few details of his condition or care. For example, in mid-August when his surgeons had their "very grave apprehensions" whether he would survive, they reported the following:

The President was somewhat restless and vomited several times during the early part of the night. Since three o'clock this morning he has not vomited, and has slept tranquilly most of the time. Nutritious enemata are successfully employed to sustain him. Altogether the symptoms appear less urgent than yesterday afternoon. At present his pulse is 110; temperature 98.6°; respiration, 18.[2]

One reason the summaries were deliberately vague was because the President himself read the paper and the daily progress notes that were released to the public. Reyburn wrote:

We were placed in a very embarrassing position. On the one hand we did not wish to dishearten our patient by circulating discouraging reports of his condition, and on the other hand we wished to do our duty to ourselves and to the people of the whole country, who watched with such intense eagerness every word of intelligence that came from us .[1]

Given only limited information, many concluded that Bliss was dishonest, interested only in hiding the severity of Garfield's condition. Bliss had an authoritarian manner that was abrasive in civilian life. Among his colleagues he was curt and blunt. His unconcern about public opinion made him seem closed mouthed and secretive. He won no friends among the press. Bliss's reputation suffered as his patient's condition deteriorated. After Garfield died headlines joked, "Ignorance is Bliss."

Reyburn, who had assisted in Garfield's care from the first day, was impressed by Bliss's devotion to the President's medical care. True to his military background, Bliss assumed full leadership and ownership of the task once he was called to serve Garfield at the train station, the first surgeon at the scene. Whatever his shortcomings of personality, he had a stubborn sense of responsibility for his patient.

Continued debate

The clinical controversy at the time was the management of the President's wound. "In gunshot wounds, the science of surgery requires certain things to be done," wrote William Hammond, in a symposium organized by the *North American Review* literary magazine in December 1881, just three months after Garfield's death. The requirements included "all foreign bodies, such as pieces of clothing, spiculae of bone,… should be removed from the track of the wound as soon as discovered, and the bullet itself should be extracted if its removal can be effective without the infliction of serious additional injury." He criticized the failure of Bliss and his colleagues in not exploring the wound and doing more to control bleeding in the first hours of Garfield's injury.[6]

John Ashhurst of Philadelphia disagreed. The decision made by Bliss and his colleagues was correct: The wound should not have been explored. He thought that an extensive exploration for the ball would have been too dangerous, either damaging an artery or entering the peritoneum, then thought to be a near-mortal injury. The autopsy finding of a ruptured splenic artery aneurysm and the odd ricocheting course of the bullet in Garfield's body proved his point.[16] Ashhurst may have had a bias—he was junior to Agnew at Penn and would later occupy Agnew's chair as professor.

Today's surgeon might see that the President's surgeons probably did not want to wander into the chest and create a pneumothorax, or create mischief in the retroperitoneum, then as now a hazardous area to explore blindly. It would have been no easy matter to control bleeding from a lacerated splenic artery, a left-sided structure, from an extension of Garfield's gunshot wound on the right side of his back.

Another criticism was that the surgeons were so obsessed with locating the bullet that they contaminated the wound when they repeatedly put their unwashed fingers it. Probing the wound with a finger was a customary surgical practice for gunshot wounds after the Civil War. Hammond quoted Léon Legouest, professor of surgery at the Val-de-Grâce military hospital in Paris. "The first thing the surgeon who is called to a case of gunshot wound should do is to explore the wound," Legouest wrote. "The finger is the best exploring instrument."[6]

Reyburn wrote that Bliss and his colleagues took every measure to prevent infection given their understanding of germ theory.

[The] wound of the President was dressed antiseptically, and this continued to be the case during the entire time of the treatment. The most scrupulous cleanliness of the instruments, and surgical appliances was observed, and also of the antiseptic solutions used for the daily washing out of the wound, and every effort was made to render them as aseptic as possible. … The carbolic spray was also invariably used during the [daily] dressing of the wound.[1]

At the time of Garfield's assassination, germ theory had just started to take hold in America. Thomas Gariepy, historian at Stonehill College in Massachusetts, traced the acceptance of antisepsis in America.[7] Surgeons in the U.S. were quick to adopt carbolic acid as an antiseptic in wound dressings after Lord Joseph Lister in Glasgow started its use in 1867, then as a spray during surgery in 1871. But when Lister visited the U.S. in 1876 during the Philadelphia U.S. centennial celebration, skeptics in Europe and Great Britain already were questioning whether carbolic acid was as effective as the he claimed.

In 1881 when Garfield was shot, acceptance of the antiseptic management was not uniform in America. Like Lister's critics abroad, many in the U.S. had difficulty reproducing Lister's results. Befitting the founders of their country, American surgeons were independent and characteristically pragmatic. They distrusted anything complicated, which included the various carbolic acid solutions and spray devices that Listerism required. To the frustration of the country's Listerians, surgeons in the U.S. "[downplayed] theory over praxis."[7] The foundations of asepsis, which would revolutionize surgical practice as the primary means of controlling infection during operation, were just being developed in Germany with the discovery by Robert Koch of bacteria in wound infections in 1878.

Ashhurst doubted that a more aggressive attempt at disinfecting the wound would have been beneficial. "I am not, individually, an advocate or great admirer of what is called 'Listerism,' he said. "I believe that … disturbance of the wound … would have done more harm than asepticism would have done good."[6]

According to Reyburn, Garfield's surgeons took every measure to prevent infection given their understanding of germ theory, including the use of carbolic acid solutions to irrigate the wound and spray over the field during dressings. It was also used to soak the dressings and clean the instruments. Writing more than a decade after the event, Reyburn wrote, "It must be remembered that the technique of antiseptic … was not so thoroughly appreciated or carried out by operating surgeons in 1881 as it is in 1892."[1]

Conclusion

Reyburn reminded his readers that criticism of Garfield's care must take into account the state of knowledge and practice at the time, by surgeons confronted by the patient at the scene. Bliss and his colleagues had the misfortune of having to manage a celebrity patient in full view of the country. Today's legal guarantees of privacy of medical information allow physicians to care for patients away from the public, with protocols to provide truly newsworthy information.

The surgical tradition of review of deaths and complications (D&C; also "M&M," morbidity and mortality) is a foundation of modern surgical practice. The analysis of the President's care was before the entire nation, from the uninformed and unqualified to the country's foremost surgeons. The best D&C conferences today are structured and informative. The scientific and clinical literature guide analyses.

One aspect where Garfield's review was superior to the modern D&C conference: Garfield's surgeons conducted a post-mortem examination. Autopsies are seldom performed today and are literally "a thing of the past." They found evidence of a cause of death, the splenic artery aneurysm, which they had not suspected. Their honest and complete reporting allowed a surgeon more than a century later to identify an unaddressed source of sepsis, gall bladder perforation from acalculous cholecystitis.

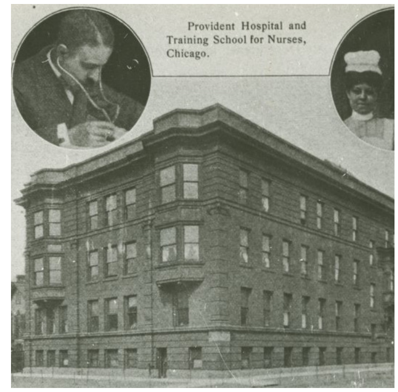
Bliss did not deviate from the standard of care in 1881, but he lost the public narrative, demonstrating the hazard of conducting surgery in full view of public scrutiny. Bliss, Agnew, and their colleagues served the President with uncommon devotion under the contemporary standards of care. J. Marion Sims of New York had also written his views of the case for the *North American Review*. "[With] this injury it is a marvel that he lived so long"[6]

References

1. Reyburn R. Clinical history of the case of President James Abram Garfield. *JAMA.* 1894;22:411-417;460-464;498-502;545-549;578-582;621-624;664-669.
2. Bliss DW, Reyburn R, Woodward JJ, et al. Complete medical record of President Garfield's case: Containing all of the official bulletins together with the official autopsy. Washington, DC: Charles A. Wimer Publishing, 1881.
3. Pappas TN, Joharifard S. Did James A. Garfield die of cholecystitis? Revisiting the autopsy of the 20th president of the United States. *The American Journal of Surgery.* 2013;206(4):613-618.
4. Brieger GH. A portrait of surgery: Surgery in America, 1875–1889. *Surg Clin No Amer.* 1987;67(6):1181-1216.
5. Adams JH. History of the life of D. Hayes Agnew, M.D., LL.D. Philadelphia, F.A. Davis, 1892.
6. Hammond WA, Ashhurst J Jr, Sims JM, Hodgen JT. The surgical treatment of President Garfield. *North American Review.* 1881;133(301):578-610.
7. Gariepy TP. The introduction and acceptance of Listerian antisepsis in the United States. *J Hist Med Allied Sci.* 1994;49(2):167-202.
8. Ridpath JC. Life and Work of James A. Garfield. Chicago: Jones Brothers & Company, 1882; 517-650.
9. Brieger GH. American surgery and the germ theory of disease. *Bull Hist Med.* 1966;40(2):135-145.
10. Rich NM, Burris DG. "Modern" military surgery: 19th century compared with 20th century. *J Am Coll Surg*. March 2005;200(3):321-322.
11. Senn N. The dawn of modern military surgery. *Surg Gynecol Obstet.* 1908;6(5):477-482.

Legends

1. James A. Garfield's assassination, published in Frank Leslie's Illustrated Newspaper. From Internet Archive Wayback Machine. Images in American Political History.
2. D. Willard Bliss, ca. 1865. From the National Library of Medicine.
3. Path of the bullet, illustration from the autopsy report. From Official Bulletins and Autopsy, 1881.



4

Daniel Hale Williams, MD: "A Moses in the profession"

AUTHORS
Alisha J. Jefferson, MD
Tamra S. McKenzie, MD, FACS
Department of Surgery, East Tennessee State University, Johnson City, TN

CORRESPONDING AUTHOR
Alisha Jefferson, MD
PO Box 70575
Johnson City, TN 37614

Daniel Hale Williams (1856–1931) was the most prominent African-American surgeon in the U.S. in the late 19th and early 20th centuries. While he is best known for his achievements in surgery (second repair of a stab wound to the pericardium in 1893; among the first to repair a penetrating wound to the spleen in 1902) his signal achievements were as an advocate for equal access to medical care and training for African Americans.

Williams had a significant impact on the major health institutions of black America. After graduating from Chicago Medical College in 1883, he was denied appointment to hospitals in Chicago due to his race. He opened Provident Hospital in 1891, the first black hospital in the country for patients who required inpatient care and a facility to train black nurses and doctors. He reorganized Freedmen's Hospital in Washington, DC, as its chief of surgery from 1894 to 1898, reforming its school of nursing and starting a training program in surgery. He was a leader in the formation of the National Medical Association in 1895 and served as its inaugural vice-president.

The success of his annual clinics at Meharry Medical College, which began in 1900, motivated the black community in Nashville, TN, to open an inpatient facility, the forerunner of a wave of black hospitals across the U.S. In 1913, he became a charter member of the American College of Surgeons and its first black Fellow. Ulysses Dailey, surgeon and former president of the National Medical Association, called Williams "a Moses in the profession."

Helen Buckner wrote a well-referenced biography of Daniel Hale Williams, *Daniel Hale Williams, Negro Surgeon* (New York, Pitman Publishing, 1968).[1] All of the details in this profile come from her book unless otherwise referenced. She described in detail his contentious years in Washington, DC, at Freedmen's Hospital and his difficulties at Provident Hospital. Another source, especially for Williams' impact on African-American health institutions, came from W. Montague Cobb, professor at Howard University and a chronicler of African American history. Cobb wrote two profiles of Williams in the *Journal of the National Medical Association*.[2,3]

Early life and education

Daniel Hale Williams was born on January 18, 1856, the fifth of six children of Daniel Williams, Jr., and Sarah Price Williams, in Hollidaysburg, PA (Figure 1). His father's family, a racial mix of German immigrants, Native American, and free blacks, settled in York County, PA. They were active in the abolitionist movement as members of the National Equal Rights League. Williams' mother, with the same interracial heritage, came from a free family in Annapolis, MD, headed by a clergyman. The Williams family did well until the father died of consumption during a visit to Sarah's family.


1

In the aftermath of the passing of the elder Daniel Williams, the Williams children were separated. Eleven-year-old Daniel was taken out of school and sent to Baltimore, MD, as a shoemaker's apprentice. One year later, out of loneliness, he asked an acquaintance of his father for a rail pass to Rockford, IL, where his mother had resettled with her family. Their reunion, however, was brief. Williams' mother left him and his sister, Sally, under the care of her family and in the company of his cousins.

In Rockford Williams worked odd jobs on lake boats and learned to cut hair. With the restlessness of their mother, the two Williams children migrated to Edgerton, WI, where Daniel opened a barbershop of his own at age 17. When the business failed he joined an established barber shop in Janesville, WI, a larger town a few miles away.

Harry Anderson, its owner, impressed by the independent, hard-working lad, took him and Sally in to board in his home. Daniel cut hair part time and tried unsuccessfully to finish high school. He tried music for a year, singing tenor and learning to play the guitar and bass fiddle. With Anderson's encouragement, Daniel entered a private school, Haire's Classical Academy, where he completed his secondary education in 1877. He cut hair part time, played in a dance band, and attended services at the Unitarian Church.

His older brother was a successful lawyer, so Williams tried reading law, which held little interest for him. Instead he was drawn to medicine. In 1878, he became an apprentice to Henry Palmer, a prominent surgeon and civic leader in both Janesville and the entire state of Wisconsin. In 1880, after two years with Palmer, he entered Chicago Medical College, which later became the medical department of Northwestern University. Now immersed in his medical studies, Williams relied on Anderson for support.

He struggled with his studies but got by with low passing grades. During finals week one year he fell ill in the midst of a smallpox epidemic, which left him with pockmarks on his nose. His clinical experience was at the South Side Dispensary, Mercy Hospital, and St. Luke's Hospital.

After graduation from medical school in 1883, and a year as intern at Mercy Hospital, he opened a practice in a well-to-do South Side neighborhood where both white and black families resided. He was one of only three black physicians in the city. As he built his practice he taught and demonstrated anatomy at the Chicago Medical School from 1885 to 1888. He had privileges at the South Side Dispensary and got a job as surgeon to the City Railway Company. He established a reputation as a skilled surgeon. In 1889, Illinois Governor Joseph Fifer appointed Williams to the State Board of Health.

However, none of the established hospitals in Chicago would grant privileges to a black surgeon. He was fortunate that he could operate at the Dispensary. Without access to inpatient facilities, he was confronted by the limited educational and practice opportunities for black physicians.

Provident Hospital

In 1890, Reverend Louis Reynolds, pastor of St. Stephen's African Methodist Church, approached Williams with a concern. His sister Emma had come to join him from Kansas City, hoping for admission in one of the city's training programs for nurses. She had been turned down by all of them because she was black.

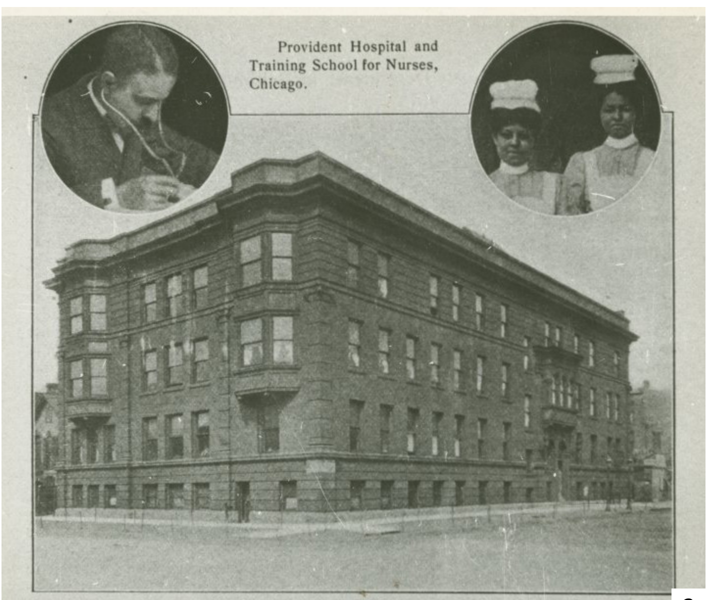
The solution was a hospital, not restricted to either race, which would train black nurses. He and other black physicians would benefit, as it would be an inpatient facility for their patients. Another pressing need would be met: intern training positions for black medical school graduates. The idea had merit. Chicago's black community was growing, supporting 200 black-owned enterprises, 20 churches, and three newspapers. As a member of the state board of health, Williams knew that more hospitals were needed for all races.

Williams organized rallies in support of a hospital in the African-American communities of the west and south sides of Chicago. He won over black pastors and lay leaders. City businesses, both black- and white-owned, pledged money to the project. An important early contribution was made by Reverend Jenkins Jones, who secured a down payment from the Armour Meat Packing Company for a three-story brick house on the corner of 29th Street and Dearborn.

Frederick Douglass donated the proceeds of a lecture to the hospital fund. Members of the community gave what they could: a wringer for the hospital laundry, lace for the nurses' caps, and books for a patient library. White philanthropists donated, as did white churches and synagogues.

As momentum grew, resistance began to build. Some resented that a separate facility had to be built at all; why not integrate the existing hospitals? Another said that a black-owned hospital had never been tried before; what made Williams believe that he could succeed? William's dedication and resolve overcame the doubters.

In January 1891 the articles of incorporation were drawn up in the name of the Provident Hospital and Training School Association, with every donor as a member. An advisory board of white civic leaders and medical professionals was named; the hospital trustees and executive and finance committees were all black. In May 1891 the hospital opened its doors (Figure 2).



The first hospital and school established in this country by colored people for their own race. The founder, Dr. D. H. Williams is one of the best surgeons in the country. 100 graduates have gone out from the school.

2

Success depended on having excellent clinicians on his staff. His priority was quality, regardless of race, so his staff had both black and white members. He availed himself of consultants from the city's medical schools, such as Christian Fenger and Frank Billings, who were his past associates at the Chicago Medical School.

Austin Curtis became Provident's first surgical trainee under Williams later that year. (He later became professor of surgery at Howard University and chief surgeon at Freedmen's Hospital.) The first class of nursing students enrolled the year following, including Emma Reynolds.

Repair of the pericardium

Williams is best known as the second surgeon to successfully repair a laceration of the pericardium in July 1893. The patient, a 26-year-old man, was admitted to the Provident Hospital one evening after suffering a stab wound just left of his sternum. During the night he continued to bleed from his wound. By morning he was in shock, so Williams was forced to operate.

With five other surgeons in attendance as observers, he extended the stab wound toward the sternum on either side in the direction of the border of the costal cartilage. The internal mammary vessels had been transected. To expose and ligate the vessels, he removed a segment of the costal cartilage.

The bleeding controlled, Williams found a one-and-a-quarter inch laceration of the pericardium. No hemopericardium was present, and there was enough room to inspect the heart. There was a laceration of the right ventricle near the right coronary artery, but it was not bleeding. He left it alone and sutured the pericardium closed. The patient's recovery was complicated by a two-and-a-half-liter pleural effusion, which Williams drained three weeks after the original operation. The patient walked out the hospital a month later. Williams found him at work at the Union Stockyards two years later.

Williams believed he had done something unprecedented: exploration of a cardiac stab wound and suture of a pericardial laceration. After a search in the National Library of Medicine, he thought he established his priority. He reported his success in the *Medical Record* in 1897 (Figure 3), but he had missed an 1895 paper, just two years before his, which reported repair of the pericardium done in 1891 by Henry Dalton in the *Annals of Surgery*.[4,5] Still, it remained a great achievement that would be acknowledged for generations.[2,3]

STAB WOUND OF THE HEART AND PERICARDIUM—SUTURE OF THE PERICARDIUM—RECOVERY—PATIENT ALIVE THREE YEARS AFTERWARD.

By DANIEL H. WILLIAMS, M.D.,

SURGEON, FREEDMEN'S HOSPITAL, WASHINGTON, D. C.

THE following case is deemed of sufficient importance to be reported three and a half years after its occurrence. The writer's illness about the time of the patient's recovery and a change of duties to his present position have prevented previous publication.

James Cornish, an expressman, aged twenty-four years, during an altercation received a stab wound through the fifth costal cartilage, injuring the internal mammary vessels and wounding the pericardium and heart. The kind of knife and length of blade could not be determined from the patient.

He was admitted to Provident Hospital, Chicago, July 9, 1893, at 7:30 P.M., with a stab wound about one inch long, three-fourths of an inch to the left of the sternum, through and in the long axis of the fifth cartilage. A probe recognized only a superficial wound, but during the night there were such persistent

3

Freedmen's Hospital

In 1893 he was named professor of surgery of Howard University and surgeon-in-chief of Freedman's Hospital, a 220-bed facility for blacks in Washington, DC. He was recommended by Walter Q. Gresham, Secretary of State under the Grover Cleveland administration, in addition to the leadership of the Chicago medical community. Franklin Martin, founder of the American College of Surgeons, wrote:

I have known intimately Dr Daniel H. Williams for more than ten years. I know him to be a man of honor and as a member of society a superior gentleman. Professionally he stands at the top of the medical profession of Chicago. He is a surgeon of great scientific ability, and his executive ability as demonstrated in the organization and equipment of Provident Hospital of Chicago, is beyond question.[1]

While he was reluctant to leave the 12-bed Provident Hospital, the opportunity to take the most prominent position in surgery at Howard and the largest medical facility for blacks was irresistible. "If it's service to your race you're thinking of," Gresham said, "Freedmen's needs you more than Provident."[1]

He arrived in Washington several months late, delayed by a hunting wound that was slow to heal. He had to overcome the resentment of local physicians who mistrusted an outsider, and the incumbent, Charles Purvis, who had stayed on faculty and still served as secretary of the medical staff organization for Freedmen's. Created by an act of Congress and located in the District of Columbia, the Freedmen's Hospital was under the authority of the Federal Government. Its administration had been passed around a number of departments. By the time Williams arrived the facility was in the Department of the Interior, led by its newly appointed Secretary, Hoke Smith. With much bigger tasks facing him, Smith gave Williams freedom to do as he liked, as long as he stayed within its meager budget.

The hospital under Purvis' administration had no formal departmental organization. It had a men's ward, one for women, and one for "confinement" cases. Nursing was substandard and staffed by attendants with minimal training. When it came time for medication, a nurse stood at the center of the ward and clapped her hands. "All you eleven-o'clockers, take your medicine!" she shouted.[1] The death rate in the facility was more than 10 percent.

He reorganized the hospital into seven departments: medicine, surgery, gynecology, obstetrics, dermatology, urology, and respiratory. He added departments of pathology and bacteriology even though the facilities and equipment were hopelessly inadequate. To replace the existing staff of four entrenched fulltime physicians, Williams enlarged the medical staff to "20 gentlemen who have achieved eminent success as practitioners in their respective lines of work."[1]

Both the nursing and operating room staffs were substandard. The care provided by nursing students under strict supervision was an improvement. He got Sarah Ebersole, the night supervisor at Presbyterian Hospital in Chicago, to move to Washington as his nursing superintendent. Purvis had started a nurse training program at Freedmen's the year before Williams arrived, a haphazard curriculum of didactic lectures. The trainees were given no formal instruction on direct patient care. In contrast, Ebersole and Williams instituted a rigorous 18-month training program that included practical work on the wards and was equal to that of any in the country.

The surgical assistants at Freedmen's were lazy, so he fired them. With the money saved, he started a training program for black interns. Here, too, motivation and intelligence would be an improvement. Most importantly, it opened training opportunities to black medical graduates. A tough taskmaster, he demanded full attention during operations. He once sent a trainee out the operating room because he let his eyes drift away from the patient while administering anesthesia.

His predecessors used carbolic acid spray and adhered to the concept of "laudable pus" as a sign of healthy wound healing. Williams introduced steam sterilization and aseptic technique.[3] He started a hospital ambulance service. His unquestioned leadership had a profound effect. At the end of his first year, he had only eight deaths out of 533 operations, a mortality rate of only 1.5 percent. He operated anywhere in the body and had spectacular surgical successes that added to his reputation.

Williams believed that the black community did not accept the professional ability of black physicians and surgeons. His solution was controversial: public operations. Every Sunday afternoon, the public was welcome to observe an operation at Freedmen's Hospital conducted by a black surgeon and staff. In defense of Williams, Cobb noted that the patient's identity was for the most part hidden.[2] The surgical amphitheater was a longstanding tradition as the centerpiece of surgical instruction, and viewing operations conducted by John Murphy at Mercy Hospital was a popular event at annual meetings of the Clinical Congress of the ACS well into the 1920s.[6]

National Medical Association

Excluded from Washington's professional organizations because of his race, there was no forum where Williams could present his cases and receive the opinions of his peers. The Medical Society of the District of Columbia (MSDC) restricted its membership to white physicians, a policy it held from its founding in 1717. Black physicians in Washington, including Purvis, formed a racially integrated rival group, the National Medical Society (NMS), in 1870. At the annual meeting of the American Medical Association (AMA) that year, they tried to win recognition by the national group on the basis of the racist membership requirements of the local AMA society, the MSDC. They were soundly defeated by Southern delegates on the basis of the perceived right of professional organizations to set their policies, and by Northern delegates, from a reluctance to create disharmony within the organization. This policy was maintained by the AMA long into the 20th century, allowing racial exclusion to persist until the Civil Rights Act of 1964.[7]

In 1884 Williams and an interracial group of physicians revived the NMS and formed the Medico-Chirurgical Society of the District of Columbia (MCSDC), dedicated to the interchange of medical ideas and information among practitioners of all races. Within a decade other African-American medical societies formed in Texas (1886), North Carolina (1887), Georgia (1893), and Arkansas (1893), using it as a model. At the Cotton States and International Exposition world's fair in Atlanta in 1895, representatives from these organizations, including Williams, formed the National Medical Association (NMA). Williams was named its inaugural vice-president.[8]

Accusations and disappointment

Under Interior Secretary Hoke Smith, in the Democrat Grover Cleveland administration, Williams was free to re-organize Freedmen's the way he wanted. Things changed with the presidential election of 1896 and the election of Republican William McKinley, who named Cornelius Bliss Secretary of the Interior in 1897. "Now," observed Buckner, "Freedmen's was indeed a political football."[1]

Bliss suspected that the charities in the District of Columbia, including Freedmen's, were mismanaged and corrupt. One of his Republican allies, Senator James McMillan, had come out with a report on Freedmen's Hospital. It accused Williams of incompetency. At a hearing of McMillan's committee, Williams was pointedly asked about details of his purchases of books, instruments, and even hospital linen. Discrepancies were questioned in detail and aggressive follow-up questions implied malfeasance. As the hearing unfolded, Williams' counsel, Judge Jerry Wilson, asked, "So my client is charged with felonious theft?"[1] Hearing those words, Williams suddenly realized the gravity of the accusations against him. He fell to the ground in a dead faint.

The motivations behind his prized achievements, the training programs for nurses and black physicians, were questioned. Purvis, still smarting from his ouster by Williams, saw his chance. He said that Williams' changes in the nursing program, which Purvis had actually started, were unnecessary. Purvis claimed that his ouster as chief surgeon was politically motivated and caused by Secretary Smith's objection to a speech that Purvis had made. Williams then had to field questions whether he won his appointment not from a Civil Service examination, but through patronage.

Williams, weary of the brouhaha, resigned his position at Freedman's in February 1898, just a year into the new presidential administration. In accordance with the new regulations, the Civil Service Commission submitted candidates to an examination. The leading candidate was rejected by the new Secretary. Instead he chose Austin Curtis, Williams' former trainee at Provident, who finished a distant second in the test but whose wife had been especially useful to the chair of the Republican National Committee during the election.

Williams escaped Washington to Chicago with his new bride Alice (née Johnson). Much had changed at Provident Hospital. The facility had plans to move to a much larger 65-bed facility the next year. But the hospital that he founded had no role for him other than staff surgeon. George Cleveland Hall, now surgeon-in-chief and chief of staff at the hospital, made no sign of yielding either position to Williams. The latter, not wanting to create a controversy, reopened his old office and resumed his practice at Provident, and later Cook County Hospital.

The disaster at Freedmen's and his disappointment on his return to Provident changed him. In contrast to the ebullient, outgoing Hall, Williams became a solitary, somber figure. To add to his misery, Alice miscarried in 1899 and in the aftermath of her long recovery came the prognosis that she would never have a baby.[1]

Meharry

When he returned to Chicago, black patients from Alabama and Georgia sought him out to operate on them. The need for a medical and surgical center in the South was obvious, he concluded. What better place than the Tuskegee Institute in Alabama under Booker T. Washington? Washington had visited Freedmen's Hospital and was impressed by Williams' reorganization. He invited him to Tuskegee to inspect the clinic there and suggest improvements. Now back in Chicago, Williams was ready to do in Alabama what he had done at Provident and Freemen's.

However, when the two met during a visit by Washington to Chicago, the latter was decidedly cool to the idea. A short visit by Williams to Alabama was one thing; transforming the institute's small dispensary into a hospital was quite another. Washington's letters in response to Williams became brief and terse, and eventually they broke correspondence. The dissolution of Williams' relationship with the most prominent figure in black America depressed him.

In 1899 George Hubbard, president and dean of Meharry Medical College in Nashville, TN, invited Williams to hold clinics there. The clinics would be seven- to 10-day sessions where he would see patients and perform operations. Williams agreed, eager to recommit himself to surgical education and service to an African-American community that badly needed modern clinical service.

Meharry was the primary source of medical doctors for the black South. By the turn of the century, half of its 410 graduates were in practice below the Mason Dixon line. The curriculum was woefully inadequate. Robert Boyd, professor at Meharry who became the first president of the NMA, saw patients and performed deliveries in the basement below the school's offices. This was the only clinical experience some of the Meharry students would get before they graduated and began their practices.

In 1900 the first of Williams' demonstrations were held in Boyd's makeshift facility, operating by candlelight. The clinics were an immediate success. Williams saw firsthand the deficiencies at Meharry. Later that year he returned to Nashville and addressed the town's black community leaders. He described how he started the Provident Hospital and encouraged them to do the same. Williams evoked Frederick Douglass' advice to him when he started his term as surgeon-in-chief at Freedmen's: "The only way you can succeed is to override the obstacles in your path," he said. "Hope will be of no avail. By the power that is within you do what you hope to do."[1] That September, the black community opened a facility in a large house that accommodated 12 beds at first, and eventually 33. Meharry's professors had an operating room for their practices. When Williams visited, he had a place to demonstrate modern surgery.

Williams' speech in Nashville was published and his words motivated other black communities to open inpatient facilities in Knoxville, Kansas City, St. Louis, Louisville, Memphis, Birmingham, Atlanta, and Dallas. In a few years more than 40 African-American community hospitals opened in 20 states.

An operating surgeon

Williams was invited to many of the new facilities, speaking and usually doing operations. By all accounts he continued to show surgical dexterity long into his career. Supremely confident in this ability and knowledge, he made bold decisions that were counter to surgical orthodoxy. At Provident in 1902, he repaired a stab wound to the spleen, preserving the spleen when the conventional recommendation would be to remove it. The patient recovered with his spleen intact, preserving its immunological function, a priority that was recognized decades later in the 1960s and 1970s.

He was among the first to recognize the risk of abdominal injury in stab wounds to the chest. A patient had been stabbed in the chest below the nipple, in the sixth interspace. The pericardium had been lacerated without injury to the heart or lung. He noted, however, two tears in the diaphragm where the knife had pierced it through-and-through. Not liking what he saw he made a second incision in the abdomen and found a laceration of the transverse colon. The conventional approach was to enlarge the diaphragmatic injury to make sure nothing below it was injured. Williams was convinced that he would not have found the injury to the colon through a relatively small incision in the diaphragm. The lesson was that a penetrating injury, seemingly high in the chest, can still enter the abdomen, a dictum that is now a basic principle in trauma to the torso.[9]

For injuries to the extremities, Williams saw amputation only as a last resort. He went to extremes to salvage limbs, especially in the young. He took the time to painstakingly get the fractures to heal and the wounds covered with skin. It might take months of hospitalization, but patients walked out of Provident on their own.

Sad end and a final first

Williams resigned from the staff at Provident in 1912, unable to fight an internecine battle with Hall, his successor as surgeon-in-chief when he left for Washington. Since his return to Chicago, Williams, a stellar instructor at the bedside and in the operating theater, ran weekly clinics at Provident that attracted students and doctors from across America. To Hall, the clinics were unwieldy affairs and impracticable for the rest of the hospital, so he closed the popular events.

Williams had a busy practice and at times had patients of both races at five Chicago hospitals. When Williams' practice at St. Luke's became successful, the facility's rich white clientele irritated Hall. The surgeon-in-chief demanded that Williams bring all of his patients, rich and poor, white and black, to Provident.

Behind the overt demands were a background of slurs, slights, and rumor mongering that made miserable the lives of Williams, his wife Alice, and their friends. In 1917, two years after the death of Booker T. Washington, Williams was on a trip with Washington's assistant and confidant Emmett Scott. It was well known that Hall had Washington's confidence. With Washington's death Scott was free to explain why Washington was so cool to the idea to start a black inpatient facility at Tuskegee. Hall had spread falsehoods about Williams, Scott said. The mildest among them was that Williams had the ambition to be named surgeon-in-chief at Tuskegee.

Even with this revelation, Williams kept his silence. His friends could not understand Williams' resignation and refusal to confront Hall directly. In the first year after Williams' resignation from Provident, the hospital lost 250 patients; in the second, 300. It took five years to rebuild the number of patients to the level it had been.

In 1913, Williams was elected as a charter member of the ACS, its first black member. Franklin Martin of Chicago organized the first meeting of the ACS in Washington, DC. Acceptance of a surgeon as a Fellow of the ACS required review of 100 cases by a credentials committee, five letters of recommendation by colleagues, and a pledge not to engage in fee splitting. John B. Murphy, Albert Ochsner, and Franklin Martin, all founding members of the College, supported his application. Murphy wrote, "[Dr. Williams] has had great experience and a studious career, surgical training far above average. Moral standing exceptional. Ethical standing perfectly good."[10]

John O'Shea noted the controversy that Williams' candidacy generated at the Board of Regents meeting that reviewed applicants for the first convocation of the ACS. "At least one Southern surgeon expressed a strong opinion that recognizing Dr. Williams as a Fellow and the notoriety that would follow would be a source of considerable social problems."[10] Most of the Regents supported Williams, and Ochsner threatened to resign if Williams was rejected. Williams's application was accepted.

"A Moses in the profession"

His travel to black hospitals and clinics decreased as he and Alice spent more of their time in a summer home they maintained in Park County, north of Chicago. She preceded him in death by several years, of complications of Parkinson's disease. Williams suffered a series of strokes and died in 1931 at age 75.

His accomplishments in American medicine go far beyond the second successful repair of the pericardium. He founded the first hospital for blacks in the country, advanced the training and education of black nurses and surgeons, and made substantial contributions to the most prominent institutions in black America at the time: Freedmen's Hospital, Howard University, Meharry Medical College, and the National Medical Association. The honors bestowed on him during his lifetime, although heartfelt, seem relatively modest: honorary degrees from Wilberforce University and Howard University, a portrait at Meharry, and fellowship in the ACS.

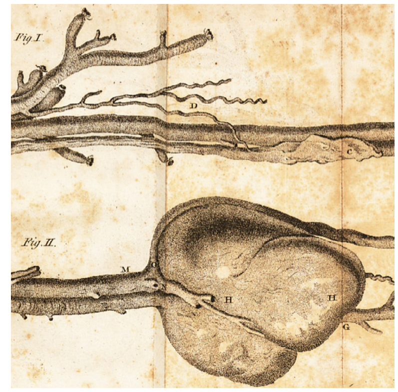
The most succinct description of his stature came in an article by Ulysses Dailey, quoted in an article by W. Montague Cobb. "He was a medical missionary," Dailey wrote. "A veritable Moses in the Negro profession."[3]

References

1. Buckler H. Daniel Hale Williams. Negro Surgeon. New York: Pitman Publishing, 1968. Available at: http://www.archive.org/stream/danielhalfwillia013550mbp/danielhalfwillia013550mbp_djvu.txt. Accessed December 16, 2017.
2. Cobb WM. Daniel Hale Williams – pioneer and innovator. *J Natl Med Assoc.* 1944;36(5):158-159.
3. Cobb WM. Dr Daniel Hale Williams. *J Natl Med Assoc.* 1953;45(5):379-385.
4. Williams DH. Stab wound of the heart and pericardium – suture of the pericardium – recovery – patient alive three years afterward. *Med Rec.* 1897;51(13):437-439.
5. Dalton HC. Report of a case of stab wound of the pericardium, terminating in recovery after resection of a rib and suture of the pericardium. *Ann Surg.* 1895;21:147-152.
6. Wangensteen OH, Wangensteen SD. The surgical amphitheatre, history of its origins, functions, and fate. *Surgery.* 1975;77(3):403-418.
7. Baker RB. The American Medical Association and race. *AMA J Ethics.* 2014;16(6):479-488.
8. Morris KS. The founding of the National Medical Association. Yale Medicine thesis digital library, 2008. Available at: http://elischolar.library.yale.edu/cgi/viewcontent.cgi?article=1359&context=ymtdl. Accessed December 17, 2017.
9. Williams DH. Penetrating wounds of the chest, perforating the diaphragm, and involving the abdominal viscera. *Ann Surg.* 1904;40(5):675-685.
10. O'Shea JS. Louis T. Wright and Henry W. Cave: How they paved the way for fellowships for Black surgeons. *Bull Am Coll Surg.* 2005;90:22-29.
11. Beatty WK. Daniel Hale Williams: Innovative surgeon, educator, and hospital administrator. *Chest.* 1971; 60: 175-182.
12. Dupre M, O'Leary JP. The first successful closure of a laceration of the pericardium. *Am Surgeon.* April 1997;63(4):372-374. PMID 9124763
13. Gordon R. Daniel Hale Williams: Pioneer black surgeon and educator. *J Invest Surg.* 2005;18(3):105-106.
14. Olivier AF. In proper perspective: Daniel Hale Williams, MD. *Ann Thorac Surg.* 1984;37(1):96-97.
15. Aris A. One hundred years of cardiac surgery. *Ann Thorac Surg.* September 1996;62(3):636-637. PMID 8783985
16. [No author.] The first Negro medical society: A history of the Medico-Chirurgial Society of the District of Columbia, 1884-1939. *J Amer Med Assoc.* 1943;121(2):159-160.

Legends

1. Daniel Hale Williams, MD. Courtesy of the National Library of Medicine.
2. Provident Hospital and Training School for Nurses, Chicago, founded by surgeon Daniel Hale Williams, also depicted, in 1891. Schomburg Center for Research in Black Culture, Photographs and Prints Division, the New York Public Library. The New York Public Library Digital Collections.
3. Williams' article in the Medical Record, 1897. Article in public domain.



5

John Hunter, the father of scientific surgery

AMERICAN COLLEGE OF SURGEONS
Inspiring Quality:
Highest Standards, Better Outcomes
100+years

AUTHORS
Kelly A. Kapp, MS4
Glenn E. Talboy, MD, FACS
Department of Surgery, University of Missouri,
Kansas City School of Medicine, Kansas City, MO

CORRESPONDING AUTHOR
Kelly Kapp, MS4
UMKC School of Medicine M4-129
2411 Holmes St.
Kansas City, MO 64108

In era of bloodletting and imbalances of the four humors, John Hunter (1728–1793) challenged tradition and defined surgical scholarship. He introduced the modern approach to surgery: Begin with a thorough understanding of anatomy and physiology, meticulously observe the symptoms of disease in a living patient and post-mortem findings of those that died of it, then, on the basis of the comparison, propose an improvement in treatment, test it in animal experiments, and try the procedure on humans. He used the approach with success to treat popliteal artery aneurysm with ligation of the superficial femoral artery in 1785. The site of his operation, the adductor canal, is one of a handful of anatomic structures better known by its eponym.

He rejected the prevailing approach to surgically enlarge gunshot wounds to retrieve the projectile and remove foreign bodies based on his wartime observations of soldiers recovering from gunshot wounds. He made lasting contributions in dentistry and comparative anatomy. His thousands of specimens are preserved today in the Hunterian Museum at the Royal College of Surgeons in London, England.

Edward Jenner, discoverer of variolation, was his favorite and most famous student. Other pupils were the next generation of leaders in British surgery, including John Abernathy, Henry Cline, Astley Cooper, William Blizard, and Anthony Carlisle. His trainees from the U.S. became leaders of American surgery: John Morgan, Phillip Syng Physick, Wright Post, and William Shippen. They embodied Hunter's legacy as the creator of the modern surgical scientist.

Early years and professional career

John Hunter's life has attracted interest for more than 200 years (Figure 1). Wendy Moore, a medical journalist in London, wrote a well-received biography in 2005 titled *The Knife Man*.[1] James Palmer, a surgeon in the early 19th century, compiled Hunter's major publications in four volumes in 1835 and added a short biography that includes many of Hunter's letters to Edward Jenner, his favorite house pupil.[2] Stephen Paget, surgeon and son of Sir James Paget, one of the foremost surgeons of Victorian England, wrote a biography in 1897 that included letters to Hunter's family and contemporaries.[3] Most of this article draws facts from their books.

1

Born in 1728 in East Kilbride, Scotland, Hunter was the youngest of 10 children. He had little formal education. Moving to London in 1748, he was initially hired as a dissection assistant by his older brother, physician William Hunter, a famed anatomist whose lasting contribution would be in obstetric anatomy. John proved to be a gifted anatomist himself and was soon running practical dissection classes and giving lectures.[1]

William arranged for John's entry into the top level of London surgery. Soon after his arrival the younger Hunter studied with William Cheselden, a sexagenarian and long established as one of London's most celebrated surgeons, at Chelsea Hospital for the summers of 1749 and 1750 until the latter's infirmity forced his retirement. In 1751 John then apprenticed in surgery with 38-year-old Percival Pott, just named surgeon at St. Bartholomew's Hospital two years previously and on the brink of his own illustrious career. After he qualified in surgery, Hunter began work at St. George's Hospital in 1754, first as assistant, then house surgeon.[2] His natural dexterity and prior experience with his brother served him well in surgery, along with an insatiable curiosity and boundless energy.

He became a partner in his brother's school of anatomy, with his share of lectures and demonstrations. He fell short of his older brother's talent for demonstration and teaching, but his skill was in dissection, which he pursued with passion and a zeal for describing what he found. His first publication was in 1762 on the descent of the testes in an appendix to a publication written by his brother, *Medical Commentaries*, a screed in which William defended the Hunter brothers' priority on the anatomy of the descent of the testis and the role of the lymphatics on the return of tissue fluid to the circulation.[4]

Hunter's articles fell into three broad themes: anatomy and surgery, dentition, and comparative anatomy. He was especially interested in processes that sustained life and, when they ceased, caused death. He suspected that it had something to do with the generation of heat and electricity, so several of his papers dealt with thermogenesis among animals and vegetables and the electric organs of rays (torpedoes) and electric eels. On the other side of the ledger he studied decay of organs after death, beginning with what happened to the stomach after death. He speculated on the process that kept the stomach intact during life, and when it disappeared at death, allowed the organ to burst. Naturally he was interested in a man who recovered after seeming to drown, and whether he could revive a clergyman who was condemned to hang.[1]

Exhaustion brought on by 10 years of intense study, plus a respiratory illness that risked consumption, forced him to seek a warmer climate. He attached himself to the Royal Navy during its siege of Belle Îsle in 1761, then with the army on the peninsula until armistice in 1763. The salubrious climate gave time for recovery and an opportunity to study gunshot wounds. Published after his death, *A Treatise on Blood, Inflammation, and Gun-Shot Wounds* was a signal contribution. Among its most significant conclusions were that gunshot wounds should not be enlarged (the term then used was "dilation") for debridement and removal of the projectile and that amputation should only be done as a last resort.[2]

The reunion with his brother upon his return to London in 1764 was not congenial, so a partnership was out of the question. John was sore that William had appropriated John's discovery of the connection of uterine and placental vessels, a grudge he would harbor long into old age. In 1765 he opened a surgical practice in his London home where he lived with his wife, poet Anne Home, and four of their children. Even though he had only two publications—the addendum on testicular descent and addenda to another article—he was named Fellow of the Royal Society in 1767 on the basis of his command of science.[3]

He never acquired the wealth of his contemporaries. Over his first decade in practice his income was only around £1,000 a year, then a modest sum among London's successful surgeons. He spent far more than he could afford on bodies for dissection and overpaid for curiosities. Like all surgeons and anatomists of the day he engaged grave robbers, ironically called "resurrectionists," to procure bodies for study and examination. John Hunter's home on Leicester Square had two entrances: a respectable one for patients and students, one more sinister for the deliveries of corpses. Paget noted the legend that Hunter and his house were the model the main character and home of Robert Louis Stevenson's *The Strange Case of Dr. Jekyll and Mr. Hyde*, a topic thoroughly covered by Lloyd Axelrod of Boston in 2012.[3,5]

He paid £500 cash to procure the corpse of the Irish Giant, Charles Byrne, the London Circus attraction. Justifiably afraid that his body would wind up on a dissection table, the almost eight-foot-tall giant had arranged before his death for his body to be buried at sea. Somehow his coffin instead was filled with rocks and his skeleton was on display in the anatomic collections of John Hunter.[3]

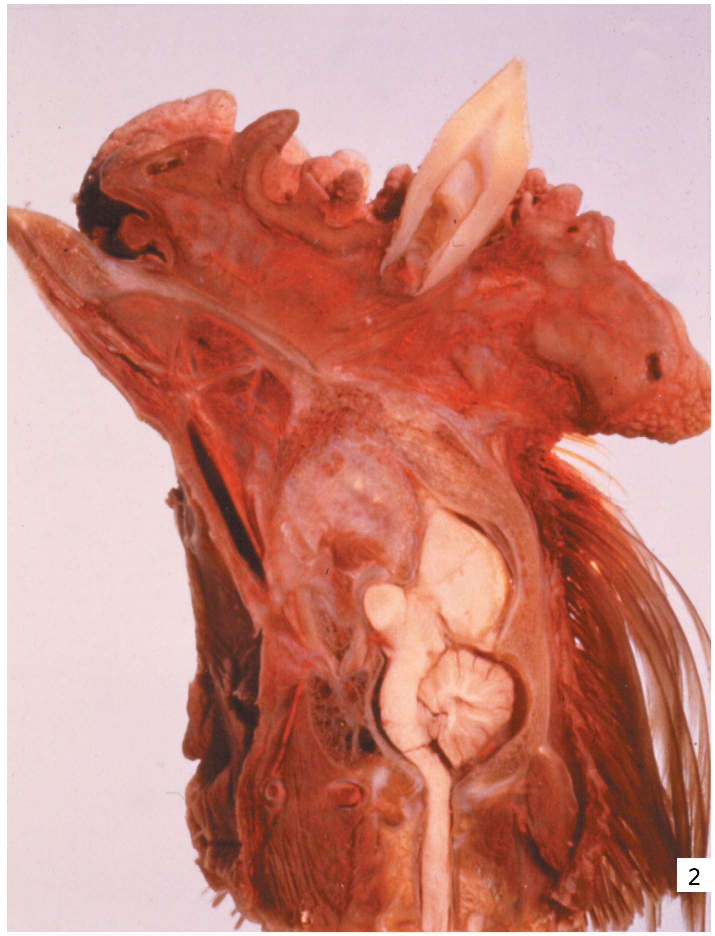
Nothing with regard to human anatomy escaped his attention. He described the circulation of the placenta, the olfactory nerves, and the development of the fetus in the womb. Beyond descriptive anatomy he wrote in depth on more complex developmental and pathological processes: bone growth and remodeling, inflammation, the pathology of gunshot wounds, venereal disease, and malformations of the heart. His interests included the pathology of infectious conditions, such as tuberculosis, suppuration in abscesses, and osteomyelitis. He researched inflammation in gunshot wounds, wound healing, and cancer pathology.[2] In the latter area he made distinctions between early and late stages of cancer of the breast and rectum and the involvement of regional lymph nodes as cancer spread.[1] His personal collection of more than 10,000 pathologic preparations of human anatomy and pathology largely came from his operations and post-mortem examinations.[3]

Popliteal aneurysm

Hunter was the first to use an inductive, scientific approach to medicine and surgery. He began with a thorough understanding of anatomy and physiology. He made close observations of a disease in a living patient, then made certain he performed the post-mortem dissection. The link between the pathology in the dead to the symptoms in the living suggested critical improvements in treatment. He hypothesized an operation, tested it on animals, and then completed his experiment by performing the procedure on a patient.[1]

The operation for which Hunter was most famous is ligation of the superficial femoral artery for popliteal aneurysm, then a fatal condition that caused death by gangrene or rupture. Prior to his innovation the standard operation was ligation of the popliteal artery above and below the tumor, then opening the aneurysmal sac and scooping out the accumulated clot. The technical difficulty was the difficult exposure caused by confinement of the large aneurysm between the thick hamstrings and insertions of the posterior calf muscles, and the risk of bleeding if ligatures tore through vessels already weak from the aneurysmal process. The procedure was so frightening and outcome so hopeless that some surgeons recommended primary above knee amputation, then as now a debilitating operation.[2]

Hunter created experiments to test his concepts of pathology, such as grafting a human tooth onto a cock's comb to prove the feasibility of tooth transplantation, a procedure he advocated to replace a tooth lost to decay and extraction (Figure 2). However, his experiment to test the development of collateral circulation, ligation of the external carotid artery of a stag, is apocryphal. The antler on that side first became cold and stopped growing. Over two weeks it became warm and once more began to grow, a confirmation of his hypothesis that collateral vessels would develop in response to an occluded artery. Careful review by Lloyd Stevenson, a medical historian at Hopkins and McGill University, revealed that Hunter never wrote a report on his experiment, nor was there such a specimen among the thousands of items in the Hunterian Museum.[6]


2

Sir Richard Owen, the famous 19th century naturalist and paleontologist, was the first to document the stag experiment before a meeting of the Hunterian society in 1879, 86 years after Hunter's death. He got the story as an assistant at the Hunterian museum under its conservator William Clift, who in turn heard the story from William Bell, Hunter's assistant who prepared specimens and experiments for the surgeon. Stevenson argues that from his knowledge of human pathologic anatomy, Hunter knew that arterial collateralization was a feature of occlusion of native vessels, and the leg likely would survive the therapeutic ligation of the superficial femoral artery.[6]

A relevant experiment was conducted by his brother-in-law and student, Everard Home, the younger brother of Hunter's wife. He stripped the muscular coats off a dog's femoral artery until the wall was so thin blood could be seen flowing through it. The injured vessel did not dilate but healed in a fibrous tube no larger than the native vessel.[2] This proved to Hunter that the pathology of aneurysmal disease lay in the vessel wall itself. Ligation of the vessel where it was already weak explained the hazard of the conventional surgical treatment for popliteal aneurysm.

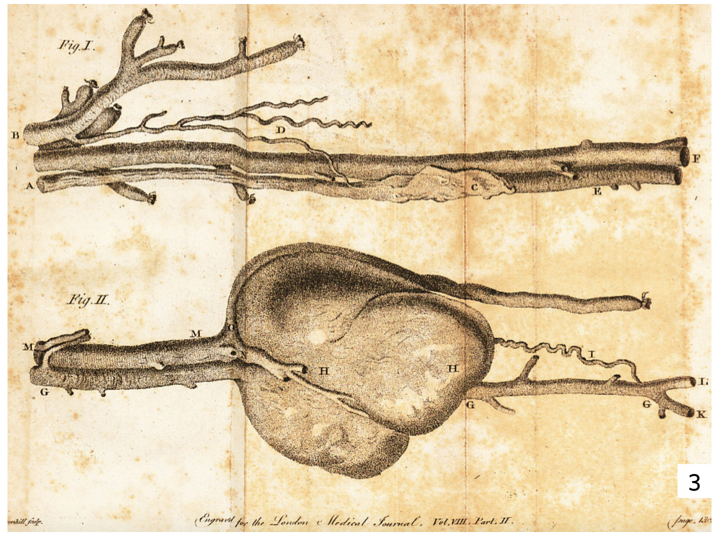
Hunter's insight was to ligate the artery above the knee in the anterior thigh where it was normal. The superficial femoral artery could be exposed medially through a limited incision as it passed through the adductor canal above the popliteal fossa where it became the popliteal artery.[7] He knew from his vast knowledge of human arterial disease that collateral vessels enlarged in arterial occlusive disease. And if he had really ligated the external carotid arteries on one of the stags in Richmond Park, he had further experimental evidence that collateral circulation might compensate for the surgical occlusion of a major vessel.[2]

He had a chance to test his concept in a 45-year-old coachman who had a popliteal aneurysm for the past three years. It was so large it filled the back of his knee, pushed the tendons of his hamstrings apart, and embarrassed venous and lymphatic flow to the point where his leg was swollen and discolored. Through an incision along the inner margin of the sartorius muscle, Hunter exposed the superficial femoral artery. He passed a probe behind it and pulled a doubled length of thread around the vessel so that once the loop was cut he had two ligatures on the vessel. He took care to tie each ligature "so slightly as only to compress the sides together."[2] He then placed two more a little lower. The four ligatures, he hoped, would even the pressure on the vessel so that it was less likely to open when the ligatures were pulled away from the field.

Immediately after surgery the leg distal to the operative site was actually warmer than before, the aneurysm a third of its original size. The skin healed without complication, aside from a concerning discharge of blood in the second week after surgery that required reapplication of a tourniquet and a pressure dressing. The man walked out of the hospital six weeks after his operation and resumed his occupation. The incision healed firmly, aside from bits of ligatures working themselves out of the wound over the next few months, occasionally with some pus. Fifteen months after surgery he died during a febrile illness, no doubt brought on by driving a coach in the raw London winter.

Procuring his limb required "some trouble and considerable expense," but Hunter usually got the specimens he wanted (Figure 3).[2] Externally there was no evidence of swelling, but dissection found a firm egg-sized popliteal aneurysm filled with clot. A vessel entered the popliteal artery below the aneurysm, evidence of a collateral vessel, but he could not find a tributary above his ligature. Interestingly, the popliteal vein was obliterated, but three large venous tributaries were present, an indication of venous collateralization.[8]

It was the first surgical operation to be developed on the basis of a scientific study. Since the publication of the operation by Home, the space in the middle third of the thigh occupied by the superficial artery has since been called Hunter's canal, one of a handful of anatomic structures that is best known by its eponym.[7]



3

Dentistry

When Hunter returned to London after his war service, he found a niche in the closed and competitive London surgical community: dentistry. Preventive dental care was unknown, and the mania for sugar to sweeten tea led to an epidemic of caries.[1] "The state of dental surgery… was perhaps lower than that of any department of professional science or practice," wrote Palmer. "The treatment of teeth was still consigned to the hands of the ignorant mechanic, whose knowledge was limited to the forcible extraction of aching teeth."[2]

After his return to London, Hunter entered into a partnership with dentist James Spence, whose practice afforded the opportunity to study the anatomy and diseases of teeth. Hunter gave teeth their familiar names, such as "molar," "incisor," "cuspid," and "bicuspid." He recognized the role of gum disease in the loss of teeth. He recorded his observations and study in the first comprehensive study on the anatomy and diseases of teeth, a two-volume treatise that became the definitive text in the field and established his reputation among London's surgical elite. Its sales gave him a measure of financial stability.[1]

Hunter's solution to the loss of teeth after extraction was to take the appropriate tooth from a human donor, generally someone who needed the money, and attempt to get the tooth to establish itself in the host's socket. The practice, a transaction between the poor to the rich, occasionally worked but only for a short time before the donor tooth was rejected. To test the concept Hunter successfully grafted a human tooth into a cock's comb, one of the most famous specimens in his collection (Figure 2). However, he made many attempts before he had the single success, an indication of its actual effectiveness.[2]

Comparative anatomy

Thought to be the inspiration for Hugh Lofting's *Doctor Dolittle*, Hunter accumulated an unparalleled collection of more than 3,000 animals, both live and preserved specimens.[1] From his days at sea at Belle Îsle and on the Iberian Peninsula he was interested in the fauna of foreign lands, with a particular interest in sea birds, lizards, and marine creatures. Captain James Cook gave him choice specimens from his explorations of New South Wales and the South Seas. One of the most celebrated was the skull of a kangaroo.[1]

He maintained a property called Earl's Court, two miles outside London near Brompton, to accommodate his ever-growing collection of animals, including hedgehogs, pheasants, toads, silkworms, leopards, and an eagle. Queen Victoria gave him a bull. He also had the remains of the first giraffe exhibited in Europe. Buffalo and zebras grazed the fields around his home. Some animals were dangerous. His leopards once got loose and chased a neighborhood dog.[3]

Hunter used his collection for scientific study. From his unparalleled knowledge of animals, he used specific species to illustrate a particular aspect of anatomy or physiology. For example, Hunter thought the carotid arteries of the camel and the swan were particularly suited for the study of collateral circulation.[2]

Skeletons and preserved specimens were housed at his home. In 1785 he moved his specimens to greatly expanded quarters at Leicester Square, the place where he also accepted bodies through a backdoor entrance. The house thus was a truly fantastic place, full of curiosities in its public areas, and a more ominous secret area.[5]

Students

Hunter lacked brilliance as a teacher. He gave private lectures on anatomy and surgery, but the numbers of participants seldom exceeded 20. Still, his example inspired a generation of the country's brightest young surgeons, who followed him on rounds. An estimated 1,000 surgeons spent time in study under Hunter, where they saw his inductive approach to the study of surgery.[1]

Some he accepted into his home as house pupils. Edward Jenner was among the first. He came to London in 1770 to complete his study of medicine when he was 21, and Hunter was 42. He followed the master everywhere: on the wards at St. George's, in the company of Hunter's wound dressers, to the West End to see wealthy patients, on the quay awaiting specimens from Captain Cook's travels. After he left his mentor's home in 1773 to begin his own practice as a country doctor in his native Gloucestershire, teacher and student, now close friends, maintained a frequent correspondence until Hunter's death.

Hunter's students included future prominent British surgical luminaries as John Abernathy, Henry Cline, Astley Cooper, William Blizard, and Anthony Carlisle. He also had American trainees, including John Morgan, Phillip Syng Physick, Wright Post, and William Shippen. Physick became Hunter's house pupil in 1789. When asked by Physick's father for a list of books that his son would study, Hunter went to the dissecting room where the cadavers lay. "These are the books your son will learn under my direction," the surgeon said. "The others are fit for very little."[1] After his return to Philadelphia in 1792, Physick became professor at the University of Pennsylvania and the Pennsylvania Hospital, where he introduced Hunter's approach to surgery to a new nation.

Hunter's house pupils and students embodied Hunter's lasting legacy as the creator of the surgical scientist. A quote from a letter to Jenner in 1775 summarized the master's lesson to his trainees. Jenner had asked his opinion on an experiment on hedgehogs that had posed problems. The nature of the study has been lost, but the master's response is a precis of the Hunterian approach. "Why think?" Hunter asked. "Why not try the experiment?"[2]

Death

Hunter suffered angina pectoris, and had his first attack at age 45 in 1773. It might have been complicated by syphilis, which he may have given himself when he inoculated his own penis in his studies on gonorrhea. After another major setback in 1777, the year after he had been appointed surgeon extraordinary to George III, he had more frequent episodes, which seemed to accelerate his aging. Hunter, the experienced anatomist, knew exactly his disease. He made sure that upon his death two specimens be preserved: his Achilles tendon, which ruptured in 1767 and healed through secondary ossification, and his heart.[1]

His fame did Hunter no good at St. George's. His rivals appeared to be determined to push him out of the facility. They set requirements for trainees, such as a full apprenticeship with a surgeon before acceptance for a training position. No longer could Hunter pluck William Clift, an orphaned, penniless lad from Cornwall, and shape him completely into a surgeon and eminent naturalist in his own right. They mandated that surgeons make regular visits to patients at the facility, with full knowledge that Hunter was physically unable to meet his obligation.[3]

In 1793, in a meeting for the admission of prospective students under the new regulations, Hunter advocated for two of his applicants. He knew that he would be unsuccessful, but he lost his temper. He was in a fury when he suddenly stopped speaking and collapsed dead. He was 65.[1]

His request for postmortem examination was given to Home, his brother-in-law, who was now an established surgeon in practice with Hunter. He had assumed a greater part of Hunter's surgical practice and lecture schedule as the master's infirmity progressed. They had a close but troubled relationship from the day Home became his assistant in 1772, the year before Jenner's departure. As a relation he looked forward to taking the latter's place as favored pupil, but he was disappointed. Jenner was like a son to Hunter, and in comparison Home was dull and clumsy. He suffered through six years as an underling before leaving to join the Navy. Upon his return he still suffered in comparison to Hunter's younger, brighter acolytes. As a relation, he was often the closest target for the master's impatience and barbed comments.

As Hunter's colleagues gathered at the dissection table at St George's, Home laid the great man open. The coronary heart disease and the ossified Achilles tendon were confirmed. Then, inexplicably, he closed the incision without removing the specimens. As the body was taken away, the Hunterian collection was literally left without the heart of its founder.[1]

The story of Home and the destruction of Hunter's priceless manuscripts, papers, and correspondence is a story equally compelling as the fictions of Drs. Doolittle and Jekyll and Mr. Hyde. Most of his fortune was spent in the acquisition and upkeep of his collections, estimated to be worth £70,000, so his death left his wife, son, and daughters nearly penniless. His household was dismissed, save Clift, who stayed as caretaker of the museum. In the midst of war, the English government under William Pitt refused to acquire the priceless collection. In 1799, six years after Hunter's death, the government bought all 13,687 pieces of the collection for the bargain price of £15,000. The museum was placed under the custody of the Company of Surgeons, renamed the following year the Royal College of Surgeons. Clift was named its first curator.[3]

Home was the sole family member who prospered after his death. Already giving his lectures, he stepped into Hunter's practice and position at Saint George's. In 1801 he demanded that Clift hand over "all of Hunter's papers—manuscripts, casebooks, lecture notes, catalogs, and letters," wrote Moore. "[They] were delivered to Home's house in a cart."[1]

Over the next 20 years Home enjoyed enormous scientific productivity, reading an unprecedented 92 papers to the Royal Society, for which he won its Copley Medal and served its vice-president. In the highest circles of surgery, he served as sergeant surgeon to George III in 1808, was knighted in 1813, and was elected president of the Royal College of Surgeons in 1822.

Clift and the trustees of Hunter's museum, now under stable management, had spent years trying to wrest control over Hunter's papers back from Home. In 1823 Home and Clift shared a chaise to a meeting when Home mentioned that his house had suffered a fire that required the fire brigade to be called. When asked, he casually said that he had been burning Hunter's manuscripts. Clift broke down in tears.[3] On the verge of being discovered of plagiarism, Home tried to burn the evidence. His jealousy of Hunter's favored house pupils was satisfied: He made certain to destroy Hunter's correspondence with Jenner and Physick.[1]

Epilogue

Clift had the foresight to copy as much of Hunter's important unpublished work as possible, such as *A Treatise on Blood, Inflammation, and Gun-Shot Wounds*. Some Home had left untouched. Some of his work could be deduced from his writing and correspondence to others, such as Jenner. Still, the loss was immense. Unknown were the contributions Hunter may have made to Jenner's discovery of variolation (1796) and his contributions to evolution, anticipating Charles Darwin's *On the Origin of Species* (1859).

Hunter suffered one final posthumous drama. His widow could not afford the burial at Westminster Abbey that he deserved. Instead his remains were interred in a modest service attended only by immediate family and a handful of friends at St. Martin's-in-the-Fields where the rules prohibited a memorial plaque. In 1859, when coffins at the church were moved for re-interment, the decision was made to move Hunter's coffin to a place of honor in the north aisle of the Abbey. Francis Buckland, a surgeon and naturalist like Hunter, took the task of locating Hunter's remains among the 3,060 in St. Martin's church. After 16 days of searching he found it. There were only three left to examine.[3]

Home's senseless destruction did not diminish Hunter's legacy. The items in the Hunterian Museum might be viewed as curiosities of an age long past. The sheer volume and variety of the collection reflects the intellectual power of a man who set the example of today's surgeon scientist.

References

1 Moore W. *The Knife Man. Blood, Body Snatching, and the Birth of Modern Surgery.* New York: Broadway Books, 2005.

2 Palmer JF, ed. The Works of John Hunter, F.R.S. London, Longman, Rees, Orme, Brown, Green, and Longman, 1837.

3 Paget S. *John Hunter. Man of Science and Surgeon.* London: T. Fisher Unwin, 1897

4 Hunter W. *Medical Commentaries.* London: A. Hamilton, 1764.

5 Axelrod L. Strange case of Dr. Jekyll and Mr. Hyde – and John Hunter. *Am J Med.* 2012;125(6):618-620.

6 Stevenson LG. The stag of Richmond Park: A note on John Hunter's most famous animal experiment. *Bull Hist Med.* 1948;22:467-475.

Legends

1 Robert Thom. John Hunter: Founder of Scientific Surgery, from "History of Medicine," 1952. From the collection of Michigan Medicine, University of Michigan, Gift of Pfizer, UMHS.

2 Human tooth transplanted on a cockerel's comb. Blood vessels injected with dye demonstrate establishment of blood flow with the native vessels. Courtesy of the Hunterian Museum, Royal College of Surgeons of England.

3 Figure from Home's 1787 account of Hunter's operation for popliteal aneurysm. Top: Branches of the femoral artery into its main superficial (A) and profunda (B) branches. (C) superficial femoral artery at the site of ligation. (D) collateral from the profunda to the superficial femoral artery. (E) the superficial femoral artery above the popliteal fossa, (F) the femoral vein. Bottom: The popliteal artery (G) with the aneurysm sac (H). (I) collateral vessel from either the profunda or the superficial femoral artery. (K, L) posterial tibial and peroneal (fibular) arteries. (M) popliteal vein with two tributaries (N,O).

6

Everett Evans, nuclear war, and the birth of the civilian burn center

American College of Surgeons
Inspiring Quality:
Highest Standards, Better Outcomes
100+*years*

AUTHORS
Jeremy M. Powers, MD
Michael J. Feldman, MD
Evans-Haynes Burn Center, Division of Plastic and Reconstructive Surgery, Department of Surgery, Virginia Commonwealth University Health System (VCU Health), Richmond, VA

CORRESPONDING AUTHOR
Jeremy M. Powers, MD
Box 980154
1250 E. Marshall St.
Richmond, VA 23298-0154

Everett Evans, a civilian burn surgeon, conducted Cold War-era clinical and basic science research that predicted thermal burns as the major injury caused by the explosion of an atomic bomb. In 1947, in anticipation of the civilian casualties that would occur if an atomic bomb was dropped on an American city, he founded the first civilian burn center in the U.S. in Richmond, VA, to provide the necessary large-scale care. He called for training and standardized protocols in burn care, and the establishment of burn centers in strategically located cities throughout the country.

During Operation Ranger, a series of five open-air atomic bomb explosions at the Nevada Test Site in 1951, Evans studied the radiation and heat exposure from a nuclear blast. While acknowledging the undoubted significance of radiation exposure, lacerations, and fractures, Evans saw that nearly all victims exposed to the blast would suffer a flash burn, a new type of injury caused by the sudden exposure to the intense heat of a nuclear blast.

To treat the thousands of injured who would require specialty care of their burns, he envisioned a center to act as a hub for specialized burn care for an entire civilian community. Evans's creation, the modern burn center, was an early product of military-civilian partnership that introduced a new concept in health care delivery, system-based care.

Training and career

Everett Idris Evans (1910–1954) had a productive academic career as a general surgeon and burn specialist at the Medical College of Virginia (MCV) in Richmond from 1942 until his untimely death in 1954 (Figure 1).[1] After receiving MD and PhD degrees from the University of Chicago, he interned at the Pennsylvania Hospital in Philadelphia, began his residency in surgery at MCV in 1939, and spent a research year at the Massachusetts General Hospital. After completing his residency at MCV in 1942, he joined its faculty. He quickly rose in rank and was named professor of surgery and director of the surgical research laboratories at MCV in 1948.[2,3]


1

Evans founded the first civilian burn center in the U.S. in 1947 as a research center studying burn metabolism and the combined effects of thermal and radiation injury as would occur in an atomic bomb attack. As a member of the Committee on Atomic Casualties of the National Research Council and the National Academy of Sciences, he served on committees on blood and blood derivatives and surgery and chaired the subcommittee on burns.[1] He visited Hiroshima in 1947 as a surgical consultant to the Atomic Bomb Casualty Commission, the joint American-Japanese program to study the long term biological and medical effects among the victims of the atomic bomb detonations of 1945.[4] The Medical Research Board of the Department of the Army funded his work on the stress response in severely burned patients, fluid resuscitation, and the treatment of burn shock.[5-8]

Operation Ranger

Evans saw that primary morbidity from an atomic blast would be thermal injury (Figure 2).[9,10] He investigated the interaction of radiation and thermal burns on animals, human volunteers, and his patients at MCV. "[Dr Evans was] an excellent clinical surgeon and superb teacher," said Isaac Bigger, chair of the department of surgery at MCV during Evans's time on faculty, "but his greatest interest and forte was in research. ...[His] most important contributions were the result of his unusual ability to organize research projects and to stimulate others to achieve the best work of which they were capable."[1]

2

He applied his talent for organized research during Operation Ranger, the series of five atmospheric nuclear blasts carried out in 1951 at the Nevada Proving Ground (Figure 3). With William Ham, a physicist at MCV, Evans and his research team studied the biological and medical effects of atomic blasts.[11] Film badges, fabrics, and other material and instruments measured radiation and temperature exposures at different distances from Ground Zero. He found that approximately 20 percent of the energy released by an atomic blast was the instantaneous exposure to intense heat such that "evasive action by exposed personnel would be difficult, if not impossible."[12]

3

The phenomenon was given the apt term "flash burn." Evans found that the heat from a 24-inch Army searchlight approximated the injury caused by an atomic blast, a model that he later used on human volunteers.[8] Unprotected skin was more at risk from a flash burn than from clothing catching fire. Cotton and wool, especially worn as multiple layers, were protective, but the material used to make Army ponchos posed a special hazard. Their report stressed the protective effect of a simple foxhole from the combined effects of flash burn injury and radiation. Taking cover in a four-foot-deep foxhole reduced radiation energy exposures 25-fold.[12]

In addition to official recognition for his work from the Surgeon General, Evans also later received a tongue-in-cheek award from his colleagues at the test site: membership in the "Royal Order of Radiated Desert Rats" (Figure 4).

4

The civilian burn center

The utter destruction of Hiroshima and Nagasaki in August 1945 sparked dozens of articles that appeared in professional journals and the lay press that speculated the consequences of similar blasts on American cities. In 1947 Herman Pearse and J. Thomas Payne of the University of Rochester predicted that thermal injury would be the "largest and most important category (numerically) of atomic-bomb injury [with] 90 percent of all persons requiring medical attention in the first week [following a blast] will have burns, and 60 to 85 percent of all patients will be burned."[13]

The tragic images from Japan became more horrifying and immediate when President Truman announced the successful detonation of a Soviet nuclear bomb in September 1949. Within months Evans published the first of two influential articles in the *Journal of the American Medical Association*.[9,10] While the hazard of gamma and neutron radiation was undeniable, he wrote, burn injury would be the predominant priority of the treatment after an atomic bomb explosion on a civilian population.

He summarized in a straight-forward manner the implications of his research. In a city of 250,000, at least several thousand would survive the blast with significant flash burn injury. Lacerations and fractures would certainly occur, as well as the feared early and late effects of radiation. But thermal injuries would be near-universal among those within a roughly 14-square-mile area from 1,500 to 4,000 yards from ground zero.

Few surgeons had expertise in the field, and the public had no knowledge of the simplest methods of burn treatment. He wrote

One can conclude that unless proper training…of large numbers of physicians and/or the public in burn therapy is instituted at once, the handling of large numbers of burn casualties after bomb attack on any of our cities must necessarily end in complete chaos and panic, with the accompanying inexcusable loss of many lives which might have otherwise been saved.[9]

However grim his predictions, Evans felt that those of Pearse and Payne were overly dire because they assumed an "unwarned population (9)." His solution was to prepare for an atomic blast in an American city. Thousands of rescue and first aid workers were needed to be trained in resuscitation, the application of burn dressings, and the initial management of concomitant traumatic injuries.[9]

Evans outlined five priorities of emergency management of the burn patient: (a) relief of pain; (b) emergency dressing; (c) prevention and treatment of burn shock; (d) salt and water requirements to insure adequate urinary output; and (e) the most feasible antibiotic therapy to aid in the prevention of infection. His guidelines reflected his belief that resources and expertise would be limited in a disaster situation. Many of his specific recommendations changed over time, such as the use of closed dressings, in which burn wounds were wrapped in compressive dressing of fine mesh gauze with outer layers of thicker cotton, and left in place for several days without change or debridement.

Resuscitation was another guideline that has undergone many modifications since Evans's articles. He recommended the use of whole blood and plasma transfusions in the early phases of burn shock. Knowing that blood products would not be readily available in the disaster situation, however, he wrote that with burns less than 20 percent body surface area (BSA), "if fluids are taken well by mouth, little or no plasma or blood is necessary."[9] He developed a simplified burn resuscitation formula, subsequently called the Evans formula, which was one of the first to take into account patient weight as well as percent BSA involved in burn injury.[2,3,7]

Evans then introduced the concept of the civilian burn center. "Finally, if bomb attacks are expected," he wrote, "we would be wise to give consideration to the setting up of special burn centers in strategically located cities in the several parts of this country." There surgeons and other trained medical personnel proficient in burn care and resuscitation would provide coordinated treatment of burn shock, and emergency surgery for lacerations, fractures, and blunt and penetrating injuries that would accompany a nuclear blast.[10]

Evans established the first civilian burn center in the U.S. at the Medical College of Virginia in Richmond in 1947, where he conducted his clinical research. Later the same year, the U.S. Army Wound Study Unit at the Halloran General Hospital in Staten Island, NY, was moved to the Brooke General Hospital at Fort Sam Houston in San Antonio, TX, under a new name, the Surgical Research Unit (SRU). While its initial focus was not specifically burn care, the threat of nuclear warfare led to the establishment of the second U.S. burn center at Brooke in 1949.[3] The center was later renamed the U.S. Army Institute for Surgical Research and would become the premier burn research center in the world.

The concept of organized burn care evolved over several decades. With urban growth and industrialization, the country had suffered significant burn disasters in the early 20th century, most notably the Rialto Theater Fire of 1921 in New Haven, CN; the Coconut Grove Fire of 1942 in Boston, MA; and the Texas City, TX, Fire in 1947. Sixty percent of the 500 casualties admitted to Pearl Harbor Naval Hospital after the December 7, 1941, attack involved burns.[3]

Each catastrophe demonstrated the advantages of a dedicated ward with professional staff for burn patients.[14,15] An inquiry into the care of the injured at Pearl Harbor revealed the lack of standardized burn care. In response the National Research Council established a subcommittee on burns in July 1942 with Allen Whipple of New York as its chair. In 1943, Whipple was the first to advocate for organized teams of surgeons, medical specialists, nurses, and orderlies that were "able and willing to stand the stress and strain of caring for severely burned patients."[3]

Evans, who succeeded Whipple as task force chair, expanded the team into a comprehensive system that coordinated the unique and complex needs of burn patients: the burn unit. From the first burn units in Richmond and San Antonio, more than 175 U.S. hospitals have developed specialized burn units. Today more than half of the nation's hospitalized burn patients receive treatment at burn centers.[16] Services provided at modern centers include the treatment of complicated facial and hand burns, the treatment of pediatric burns, and special attention to reintegrating burn patients into productive roles in society through physical and occupational therapy, nutrition, and psychological support. Contributions of burn research centers have added to the understanding of the metabolic response to injury, burn shock, resuscitation, the treatment of inhalation injury and invasive burn wound infection, and the advantages of early excision and grafting of deep burns. The validity of the burn center concept is shown by the decreasing mortality rates for increasingly large surface area burns.[16,17]

Controversy

Nearly a half-century later, Evans's research attracted criticism from Cliff Honicker, a writer specializing in environmental issues. Writing in the *Washington Post*, Honicker claimed that "secret and unethical Cold War experiments were performed," and that Evans failed to apprise people involved in his experiments of the non-therapeutic nature of his tests. Referring to the use of tagged red cell studies in shock and resuscitation, Honicker wrote that the use of radionuclides risked damaging untagged red cells, which he called, "the most chilling part of the experiments." "[Did] Evans knowingly put patients in harm's way?" the writer asked.[18]

The defense of Evans came swiftly from Eugene Trani, professor of history and president of Virginia Commonwealth University, the parent institution of MCV. He set the record straight on the use of radionuclides, at the time a new way of measuring blood volume and the accepted research method to assess fluid and blood replacement needs during burn shock. The patients under study, Traini wrote, were severely ill and if they died, it was almost certainly from the severe burns they had sustained, and not from the nuclide tests. They had verbally consented to the research project, which was the standard at the time. (Federal requirements for institutional review board oversight of human research were established in 1971.)

A separate study involved 44 white students from MCV and 22 black students at Virginia Union University who were subjected to dime-sized searchlight-induced flash burns of varying degrees. Evans and his research team also subjected themselves to the burns, and had undergone considerable personal risk with their field experiments at active nuclear test sites. Trani went on to summarize the scientific and clinical contributions that arose from Evans's research. Moreover, Evans wrote an article on ethics in surgical research in 1950. With regard to Honicker's criticism, Trani wrote that he "misreads the record, misrepresents the work of scientists, and moralizes about past research practices." The university president concluded, "The work of MCV's investigators … and the former patients of MCV deserve better."[19]

Conclusion

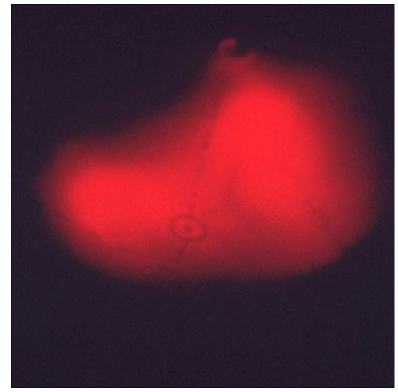
In Bigger's words, Evans's premature death in 1954 at age 44 "brought to close a brief but brilliant career in surgery."[1] Dr Evans' research seeking to understand the impact of an atomic bomb blast led to a model of atomic thermal injury and one of the first formulas for resuscitation based on weight and body surface area burned. He predicted that burn victims would be the principal casualty of nuclear war, and recognized the need for coordinated burn care, which led to the establishment of the country's first civilian burn center in 1947. Never used for a nuclear attack in the U.S., burn centers that came from Evans' work remain integral to the modern system of trauma care.

References

1. Bigger IA. Everett Idris Evans. Blades B, editor. *Trans Amer Surg Assn.* April 28, 1954: 390392.
2. Branski LK, Herndon DN, Barrow RE. A brief history of acute burn care management. In: *Total Burn Care.* Elsevier; 2012.
3. Cancio LC, Wolf SE. A history of burn care. Handbook of Burns. Vienna: Springer Vienna, 2012.
4. Lederer SE. Going for the burn: Medical preparedness in early Cold War America. *J Law Med Ethics.* 2011;39(1):48-53.
5. Evans EI, Bigger IA. The rationale of whole blood therapy in severe burns: A clinical study. *Ann Surg.* 1945;122(4):693-705.
6. Evans EI. Physical agents and trauma: Shock and burns. *Ann Rev Med.* 1950;1(1):287-302.
7. Evans EI, Purnell OJ, Robinett PW, et al. Fluid and electrolyte requirements in severe burns. *Ann Surg.* 1952;135(6):804-817.
8. Evans EI, Brooks JW, Schmidt FH, et al. Flash burn studies on human volunteers. *Surgery.* 1955;37(2):280-297.
9. Evans EI. The burn problem in atomic warfare. *J Am Med Assoc.* 1950;143(13):1143-1146.
10. Evans EI. Atomic burn injury. *J Am Med Assoc.* 1951;145(17):1342-1345.
11. Fact Sheet. Operation RANGER [Internet]. 1-5. Available at: http://www.dtra.mil/Portals/61/Documents/NTPR/1-Fact_Sheets/RANGER%20-%202017.pdf?ver=2017-02-07-081711-993. Accessed December 13 2017.
12. Ham WT, Butterfield WJH, Williams RC. Thermal and ionizing radiation measurements performed at Operation Ranger. De-classified report of the Atomic Energy Commission. Mar 19, 1952.
13. Pearse HE, Payne JT. Mechanical and thermal injury from the atomic bomb. *N Engl J Med.* 1949;241(17):647-653.
14. Cope O. Care of the victims of the Coconut Grove fire at the Massachusetts General Hospital. *N Engl J Med.* 1943;229(4):138-147.
15. Saffle JR. The 1942 fire at Boston's Cocoanut Grove nightclub. *Amer J Surg.* 1993;166(6):581-591.
16. Brigham PA, Dimick AR. The evolution of burn care facilities in the United States. *J Burn Care Res.* 2008;29(1):248-256.
17. Pruitt BA, Wolf SE. An historical perspective on advances in burn care over the past 100 Years. *Clin Plast Surg.* 2009;36(4):527-545.
18. Honicker C. Burning secrets. In a Virginia hospital, a Cold War time of strange experiments. *Washington Post*, June 19, 1994.
19. Trani EP. No burning secrets. *Washington Post*, July 3, 1994.

Legends

1. Everett Idris Evans. From the Transactions of the American Surgical Association. Philadelphia, J.B. Lippincott Company, 1955.
2. The patient's skin is burned in a pattern corresponding to the dark portions of a kimono worn at the time of the explosion. Japan, circa 1945. U.S. War Department. National Archives and Records Administration.
3. Ranger Fox explosion, Nevada Test Site, February 6, 1951. National Nuclear Security Administration.
4. Certificate of Membership in the "Royal Order of Radiated Desert Rats." William T. Ham Papers, Tompkins McCaw Library, Virginia Commonwealth University.



7

Following the light: A history of the percutaneous endoscopic gastrostomy tube

AMERICAN COLLEGE OF SURGEONS
Inspiring Quality:
Highest Standards, Better Outcomes
100+*years*

AUTHORS
Andrew T. Strong, MD[1]
Jeffrey L. Ponsky, MD, FACS[2]
[1]*Department of General Surgery, Cleveland Clinic, Cleveland, OH*
[2]*Cleveland Clinic Lerner College of Medicine, Case Western Reserve University School of Medicine, Cleveland OH*

CORRESPONDING AUTHOR
Andrew Strong
Department of General Surgery
Cleveland Clinic
Desk A100
9500 Euclid Avenue
Cleveland, OH 44195

In 1980 the glow of the stomach of an infant undergoing endoscopy inspired the development of percutaneous endoscopic gastrostomy (PEG), one of the most common interventions in medicine. Before then the placement of a gastrostomy required an open laparotomy, reserved mostly to support the nutritional requirements of adults with severe neurologic impairments and children with severe developmental delay. The two groups had a higher risk for general anesthesia, so an open operation solely to place a gastrostomy was seldom done.

Jeffrey Ponsky and Michael Gauderer, colleagues in surgical endoscopy and pediatric surgery in Cleveland, OH, devised a procedure to draw a tube from the mouth, down the esophagus and stomach, and out of the left upper quadrant of the abdomen. Thus no laparotomy was needed where one had always been required. PEG was among the first innovations that expanded endoscopy from a diagnostic tool for observation to a therapeutic instrument essential in the practice of gastroenterology and general surgery.

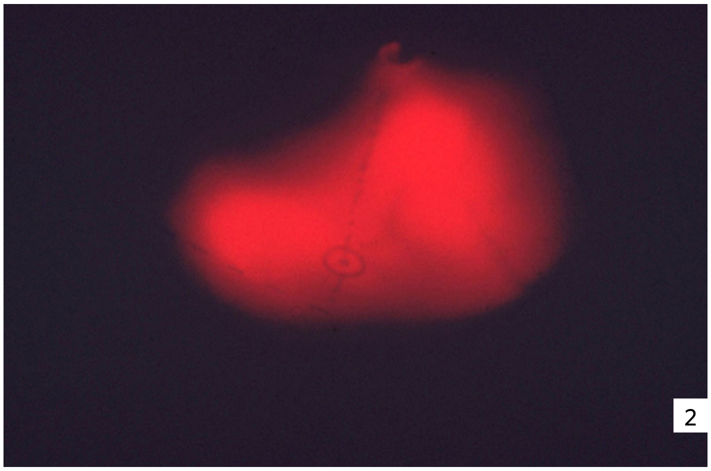
1

The glow

In 1979 two surgeons in Cleveland, OH, Jeffrey Ponsky at the University Hospital and Michael Gauderer at the Rainbow Babies and Children's Hospital (Figure 1), saw that the light from an endoscope in an infant undergoing endoscopy was visible outside the abdomen. With the stomach outlined in light, they recognized that a tube might be placed directly into the stomach from a percutaneous approach. Their insight led to an endoscopic procedure for gastrostomy, an operation heretofore restricted to open surgery. It was among the first procedures that defined minimally invasive surgery (MIS), a concept that revolutionize the field.

Fiber optic endoscopes, invented in 1960 by Basil Hirschowitz, C. Wilbur Peters, and Lawrence Curtiss at the University of Michigan, had yet not been widely applied to pediatric conditions. None of the gastroenterologists at Rainbow Hospital did the procedure, so Ponsky, then director of surgical endoscopy at University Hospital, performed endoscopy when it was needed in pediatric patients.

One was an infant under Gauderer's care. Ponsky did the procedure under anesthesia in the operating room, the lights dimmed so he could better see the image at the objective of the endoscope. Standing by, Gauderer was impressed by glow of the infant's stomach (Figure 2). It was clear there was nothing between the stomach and the abdominal wall. Their interest piqued, in a hospital corridor after the procedure Gauderer and Ponsky tried to figure out a way to use the endoscope to guide a tube into the stomach without laparotomy.



2

A new concept

They gathered the items they needed for a prototype. A flexible de Pezzar tube could be drawn through the mouth and the esophagus without trauma, but how could it pass through the walls of the stomach and the abdomen?

The crucial item was the Argyle Medicut intravenous cannula. Its shape was ideally suited to the task: a simple, conical plastic tube with a long taper that ended in a fine opening where it entered a blood vessel. It did not have a hub or side wings to help secure it to the patient's skin. Aside from the increasing diameter of the catheter, there was nothing to encumber drawing it, and the end of a de Pezzar tube behind it, out the stomach and abdomen. Ponsky and Gauderer sutured a silk thread to the tube and drew the loose ends out of the tip of the Medicut to act as a leash with which they could pull on the catheter (Figure 3).

Then a bit of endoscopic choreography was needed to pull the assembly in the desired direction. After distention of the stomach during endoscopy, a site for the gastrostomy was chosen based on the glowing silhouette of the stomach. A small incision was made in the skin and anterior sheath to allow the tube to pass more easily, through which a Medicut punctured the stomach with a quick stab under direct vision. The endoscopist grasped a silk thread passed through the lumen of the catheter and drew it out of the mouth.

The silk, once tied to the leash, was then used to draw the de Pezzar tube back down the esophagus and into the stomach. Once the tapered tip of the Medicut appeared on the surface, a steady pull with a stout clamp onto the catheter drew the rest of the Medicut and the length of the de Pezzar tube following it out of the stab incision. They added rubber cross bars to help it stay in position and keep it from being enlarged. In a period of months, they used the procedure to place gastrostomies on 12 infants and children and 19 adults.[1]

Gauderer presented the procedure at the annual meeting of the American Pediatric Surgical Association, and Ponsky at the Digestive Disease Week meeting, both in May 1980. Publications followed in December and the following year.[1,2] Over the next several years, Ponsky and his research fellows studied wound healing and maturation of the PEG tract.[3]

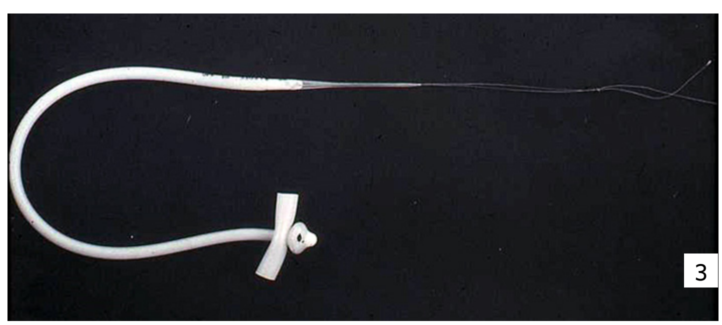
Once the concept of a minimally invasive procedure for gastrostomy was introduced, other techniques followed. As opposed to the "pull technique" developed by the Cleveland group, a "push technique" was introduced to eliminate the step of pulling the tube through the mouth and esophagus.[4] A catheter introducer used by interventional radiologists was adapted to salvage dislodged tubes.[5] The anchor technique helped to ensure adequate apposition of the stomach and the anterior abdominal wall.[6] The single lumen infusion catheter was another surgical device adopted as a PEG.[7] The one-step gastrostomy button was an appealing, low-profile device, which is frequently used in pediatric patients.[8] For particularly difficult cases, laparoscopic assistance was introduced as an option before laparoscopic gastrostomy become more commonplace.[9] None of the innovations, however, matched the simplicity, utility, and safety of the original "pull technique" PEG procedure.

Significance

Easy to assemble using items found on the shelves of most hospitals, PEG had commercial potential. The market was predicted to be limited, mostly newborn infants with a small number of surgical conditions, and neurologically compromised older patients. Gauderer and Ponsky had difficulty finding a small medical device company as a partner. The numbers of procedures grew, and by 2001, 20 years after it was invented, 216,000 PEGs were done annually.[10]

PEG inverted the conventional view of medical progress, where an idea starts with bench research, then a disciplined clinical process of testing first in adults, then is applied with caution to children. PEG was first done on a newborn infant, after a clinician happened to notice the bright glow of a stomach during endoscopy. Application in adults came later, followed by experiments to confirm fibrous wound healing.

PEGs today continue to be commonplace on procedure schedules in endoscopy suites throughout the world. Among the first therapeutic endoscopic procedures, it helped establish the concept of the flexible endoscope as a surgical instrument. Surgical interventions based on endoscopy, such as natural orifice transluminal endoscopic surgery (NOTES), thus have roots in PEG. Therapeutic endoscopy is a clinical space shared by surgeons, gastroenterologists, and engineers. Progress in the field requires novel ideas, cooperation, and research across medical and engineering disciplines.

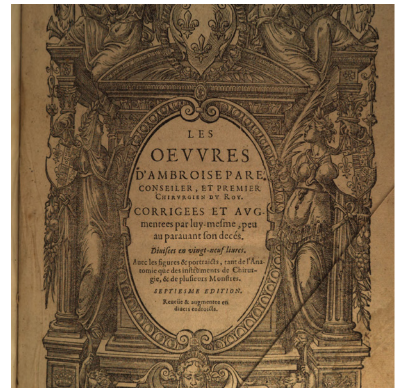

3

References

1. Gauderer MW, Ponsky JL, Izant RJ. Gastrostomy without laparotomy: A percutaneous endoscopic technique. *J Pediatr Surg*. 1980;15:872-875.
2. Ponsky JL, Gauderer MW. Percutaneous endoscopic gastrostomy: A nonoperative technique for feeding gastrostomy. *Gastrointest Endosc*. 1981;27:9-11.
3. Mellinger JD, Simon IB, Schlechter B, Lash RH, Ponsky JL. Tract formation following percutaneous endoscopic gastrostomy in an animal model. *Surg Endosc.* 1991;5:189-191.
4. Sacks BA, Vine HS, Palestrant AM, Ellison HP, Shropshire D, Lowe R. A nonoperative technique for establishment of a gastrostomy in the dog. *Invest Radiol.* 1983;18:485-487.
5. Russell TR, Brotman M, Norris F. Percutaneous gastrostomy. A new simplified and cost-effective technique. *Am J Surg.* 1984;148:132-137.
6. Wu TK, Pietrocola D, Welch HF. New method of percutaneous gastrostomy using anchoring devices. *Am J Surg.* 1987;153:230-232.
7. Sabnis A, Liu R, Chand B, Ponsky J. SLiC technique. A novel approach to percutaneous gastrostomy. *Surg Endosc* 2006;20:256-262.
8. Gauderer MW, Olsen MM, Stellato TA, Dokler ML. Feeding gastrostomy button: Experience and recommendations. *J Pediatr Surg*. 1998;23:24-28.
9. Edelman DS, Unger SW, Russin DR. Laparoscopic gastrostomy. *Surg Laparosc Endosc.* 1991;1:251-253.
10. Gauderer MWL. Percutaneous endoscopic gastrostomy—20 years later: A historical perspective. *J Pediatr Surg*. 2001;36(1):217-219.

Legends

1. Michael Gauderer (left) and Jeffrey Ponsky, 1981. Photo courtesy of Dr. Ponsky.
2. A contemporary photo of the glow from an infant abdomen illuminated from within by an endoscope.
3. An early version of a fully assembled PEG tube. Components included a 16 French DePezzar catheter, segments of a tubular drain acting as “T” segments to keep the tube in place, the Medicut intravenous cannula, and silk suture.



LES
OEVVRES
D'AMBROISE PARE,
CONSEILER, ET PREMIER
CHIRVRGIEN DV ROY.
CORRIGEES ET AVGmentees par luy-mesme, peu
au parauant son decés.
Diuisées en vingt-neuf liures.
Auec les figures & portraicts, tant de l'Anatomie que des instruments de Chirurgie, & de plusieurs Monstres.
SEPTIESME EDITION.
Reueüe & augmentee en
diuers endroicts.

8

Ambroise Paré: The gentle barber-surgeon

American College of Surgeons
Inspiring Quality:
Highest Standards, Better Outcomes
100+years

AUTHORS
April M. Tanner, MD
Mark C. Weissler, MD, FACS
Department of Otolaryngology, University of North Carolina, Chapel Hill, NC

CORRESPONDING AUTHOR
April Michelle Tanner, MD
170 Manning Dr., CB 7070
Physician Office Building Room G190
Chapel Hill, NC 27599-7070

Ambroise Paré (1509?–1590), often called the Father of Modern Surgery, was a French barber surgeon. Because of his innovative approach to surgery and patient care, he was elevated to the position of master surgeon. Despite his humble beginnings, his persistent pursuit of surgical education, coupled with his keen reflective observations on patient outcomes, led to an exceptional career in Paris and as surgeon to four French Kings. His progressive ideas moved surgery from the dogma of the Renaissance. His lasting legacy is the ethic of gentleness in surgery.

1

Early life

Ambroise Paré was born in Bourg-Hersent, France, in 1509 or 1510 during the War of the Holy League (Figure 1). His father's success as a master carpenter enabled both Paré and his brother to pursue medical careers. Another of his three siblings, a sister, married a barber surgeon. At 13, to prepare him for medicine, his father sent Paré to the village clergy to learn Latin, an absolute requirement for a career in medicine or surgery. It is unknown exactly how long young Ambroise spent attempting to learn Latin, but we know he was unsuccessful.[1]

Undeterred, he moved to Paris to begin apprenticeship under a master barber surgeon in the early 1530s. He spent most of his time sweeping the shop and trimming beards.[2] The only time Paré was allowed to attend lectures or read surgical texts was during the late night and early morning hours when the shop was closed. Master barber surgeons prohibited apprentices from attending lectures at the university because they were needed for work. Between haircuts, trims, and shaves Paré was taught phlebotomy and leeching. After several years of toil he received his diploma as a full-fledged barber-surgeon.[1]

During his years in training Paré absorbed the lessons of his predecessors, prominently Guy de Chauliac (c. 1300–1368), the influential French surgeon of the Middle Ages famous for his contributions to the field of surgery.[3] De Chauliac's most famous quote continues to inspire to the present day.

Let the surgeon be well educated, skillful, ready, and courteous. Let him be bold in those things that are safe, fearful in those that are dangerous; avoiding all evil methods and practices. Let him be tender with the sick, honorable to the men of his profession, wise in his predictions; chaste, sober, pitiful, merciful; not covetous or extortionate; but rather let him take his wages in moderation, according to his work and the wealth of his patient, and the issue of the disease and his own worth.[1]

Paré embraced the nobility of his profession expressed by de Chauliac, both in how he conducted his life and how he practiced surgery.

Medical training

After Paré obtained his diploma, he sought one of the coveted positions at Hôtel-Dieu de Paris as a surgical trainee.[1] Although Hôtel-Dieu was initially built as a shelter for the poor in the 7th century, the hospital, run by the clergy, also provided care to the sick. During the time of Paré, Hôtel-Dieu was a 3,500 bed facility, often with 2 or more patients per bed (4). During his training at the Hôtel-Dieu, Paré provided medical care, notably during one of the major outbreaks of cholera that swept the city. He performed autopsies and taught students from 1532 to 1536.

His formal instruction was inhibited by the strictures of the church and the traditions of the profession. The church forbade cutting on the human body, so the teaching of surgical procedures was actually quite limited during his training. Most learning was on the corpse after the patient died.[1] Medical practice was based on Galenic dogma with little, if any, advancement through direct observation and experimentation.[2]

Military service

After his time at the Hôtel-Dieu, Paré did not qualify for a license in surgery because he never mastered Latin.[4] However, he was welcome in the French military. Despite his years of training, he performed his first amputation during the expedition. At the Siege of Turin during 1536–1537, Paré saw the common practice of cauterizing gunshot wounds with boiling oil, with the predictable inflammatory response of fever, pain, and swelling of the wound.[5] During the conflict he ran out of medical supplies, including the oil. He saw how boiling oil damaged tissues. Stephen Paget, biographer and a surgeon like his famous father, Sir James Paget, translated Paré's account of what happened next.

At last my oil ran short, and I was forced instead thereof to apply a digestive made of the yolks of eggs, oil of roses, and turpentine. In the night I could not sleep in quiet, fearing some default in not cauterizing, that I should find the sounded to whom I had not used the said oil dead from the poison of their wounds; which made me rise very early to visit them, where beyond my expectation I found that those to whom I had applied my digestive medicament had but little pain, and their wounds without inflammation or swelling, having rested fairly well that night; the others, to whom the boiling oil was used, I found feverish, with great pain and swelling about the edges of their wounds. Then I resolved never more to burn thus cruelly poor men with gunshot wounds.[1]

This was the start of his divergence from medical dogma.[2] Freed from authority and tradition, he tried different ways to treat burns. "See how I learned to treat gunshot wounds," the surgeon who never mastered Latin wrote, "not by books."[1]

The same campaign he wrote the timeless quote associated with him, "*Je le pansai, Dieu le guérit* (I bandaged him, God cured him)," a terse description of his treatment of a French officer, a Captain le Rat. The officer and a group of soldiers fired into an enemy position. When they returned fire, an arquebus shot struck the Captain's right ankle. The officer shouted, "Now they have got the Rat," a quote somewhat less memorable than Paré's laconic account![1]

As a reward for his service during four military tours, upon his return to Paris in 1541 he was granted status of master barber surgeon. In 1554, at the age of 44, he was appointed master barber surgeon to Francis I. He passed an oral exam to win designation as master surgeon, his substandard Latin graciously overlooked because of his stature and his undeniably superior surgical skill. He served as master surgeon for three additional French monarchs over more than 30 years. He died in 1590.[1]

Contributions to surgery

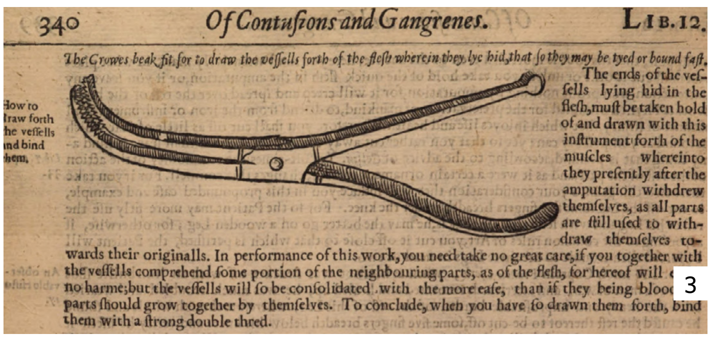
Paré wrote on a wide range of medical and surgical subjects. His Latin was awkward at best, so he used French (Figure 2). As a result, his writings immediately became widely popular and the basis of clinical practice during his lifetime.[2] As a military surgeon he saw the evolution of guns and ammunition, so one of his first books was on the treatment of gunshot wounds.[5]


LES OEVVRES D'AMBROISE PARE, CONSEILER, ET PREMIER CHIRVRGIEN DV ROY. CORRIGEES ET AVGMENTEES par luy-mesme, peu au parauant son decés. Diuisees en vingt-neuf liures. Auec les figures & portraicts, tant de l'Anatomie que des instruments de Chirurgie, & de plusieurs Monstres. SEPTIESME EDITION. Reueüe & augmentee en diuers endroicts.

A PARIS, Chez Nicolas Buon rue S. Iaques à l'enseigne S. Claude & de l'homme Sauuage. 1614. Auec priuilege du Roy.

2

Recognizing that hemostasis by bathing the freshly amputated stump in hot oil caused unnecessary pain and damage to tissues that ultimately would have to heal, Paré used ligatures to tie off individual vessels. He was advocate of gentle handling of tissues (Figure 3). He developed the *bec de Corbin* (crow's beak), a clamp designed to grasp a bleeding vessel. The approach gave victims with a penetrating neck wound, an otherwise mortal injury, a chance at survival.[6] Along with the scalpel, probe, and forceps, the clamp became one of the fundamental tools in surgery and among the significant technological advances of the era. He designed many other instruments, such as the *bec de Gruë* (crane's beak) and *bec de Cane* (duck's beak), both forceps with long, thin blades to extract bullets from deep wounds. His trepan was stabilized by a three-footed frame that made the drill more stable on the skull, an improvement over the conventional two-footed design (Figure 4).[7]



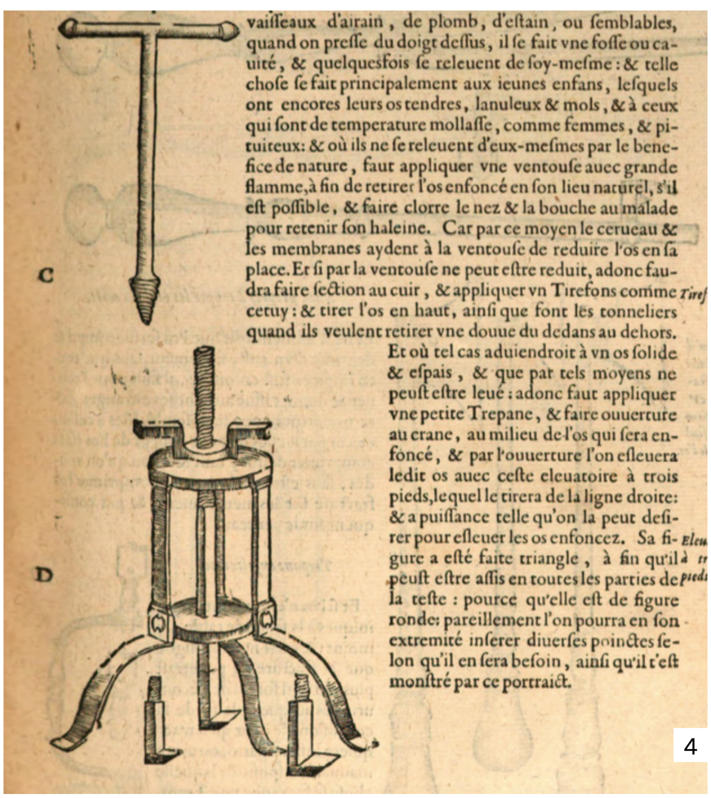
340 *Of Contuſions and Gangrenes.* LIB. 12.

The Crowes beak fit for to draw the veſſells forth of the fleſh wherein they lye hid, that ſo they may be tyed or bound faſt.

How to draw forth the veſſells and bind them.

The ends of the veſſells lying hid in the fleſh, muſt be taken hold of and drawn with this inſtrument forth of the muſcles whereinto they preſently after the amputation withdrew themſelves, as all parts are ſtill uſed to withdraw themſelves towards their originalls. In performance of this work, you need take no great care, if you together with the veſſells comprehend ſome portion of the neighbouring parts, as of the fleſh, for hereof will c no harme; but the veſſells will ſo be conſolidated with the more eaſe, than if they being bloo parts ſhould grow together by themſelves. To conclude, when you have ſo drawn them forth, bind them with a ſtrong double thred.

3



vaiſſeaux d'airain, de plomb, d'eſtain, ou ſemblables, quand on preſſe du doigt deſſus, il ſe fait vne foſſe ou cauité, & quelquesfois ſe releuent de ſoy-meſme: & telle choſe ſe fait principalement aux ieunes enfans, leſquels ont encores leurs os tendres, lanuleux & mols, & à ceux qui ſont de temperature mollaſſe, comme femmes, & pituiteux: & où ils ne ſe releuent d'eux-meſmes par le benefice de nature, faut appliquer vne ventouſe auec grande flamme, à fin de retirer l'os enfoncé en ſon lieu naturel, s'il eſt poſſible, & faire clorre le nez & la bouche au malade pour retenir ſon haleine. Car par ce moyen le cerueau & les membranes aydent à la ventouſe de reduire l'os en ſa place. Et ſi par la ventouſe ne peut eſtre reduit, adonc faudra faire ſection au cuir, & appliquer vn Tirefons comme cetuy: & tirer l'os en haut, ainſi que font les tonneliers quand ils veulent retirer vne douue du dedans au dehors. Tiref

C

Et où tel cas aduiendroit à vn os ſolide & eſpais, & que par tels moyens ne peuſt eſtre leué: adonc faut appliquer vne petite Trepane, & faire ouuerture au crane, au milieu de l'os qui ſera enfoncé, & par l'ouuerture l'on eſleuera ledit os auec ceſte eleuatoire à trois pieds, lequel le tirera de la ligne droite: & a puiſſance telle qu'on la peut deſirer pour eſleuer les os enfoncez. Sa figure a eſté faite triangle, à fin qu'il peuſt eſtre aſſis en toutes les parties de la teſte: pource qu'elle eſt de figure ronde: pareillement l'on pourra en ſon extremité inſerer diuerſes poinctes ſelon qu'il en ſera beſoin, ainſi qu'il t'eſt monſtré par ce portraict. Eleu à tr pied

D

4

Long before anesthesia he was an advocate of pain relief after surgery, and he gave opium to his patients.[4] Inspired by the example set by his medical colleagues, he emphasized care of his patients following surgery in an era where many patients were seldom seen again by a surgeon after a surgical procedure.[1,4]

A lasting contribution to the profession was the importance of modifying surgical care on the basis of empirical observations. In a time when Galenic dogma dominated medical thought and practice, Paré changed the entire approach to clinical surgery. On the basis of his innovative approach to surgery, based on empiricism and technology, Paré deserves the appellation, "Father of Modern Surgery."[2]

References

1 Paget S. Ambroise Paré and his times, 1510–1590. New York, London: G.P. Putnam's Sons, 1897.

2 Drucker CB. Ambroise Paré and the Birth of the Gentle Art of Surgery. *Yale J Biol Med.* 2008;81(4):199-202.

3 Watters DA. Guy de Chauliac: Pre-eminent surgeon of the Middle Ages. *ANZ J Surg.* 2013;83(10):730-734.

4 Shen JT, Weinstein M, Beekley A, et al. Ambroise Paré (1510–1590): A surgeon centuries ahead of his time. *Am Surg.* 2014;80(6):536-538.

5 Donaldson, IML. Ambroise Paré's accounts of new methods for treating gunshot wounds and burns. *J R Soc Med.* 2015;108(11):457-461.

6 Toledo-Pereyra, LH. Medical Renaissance. *J Invest Surg.* 2015;28:127-130.

7 Hernigou P. Ambroise Paré III: Paré's contributions to surgical instruments and surgical instruments at the time of Ambroise Paré. *Int Orthop.* 2013;37(5):975-980.

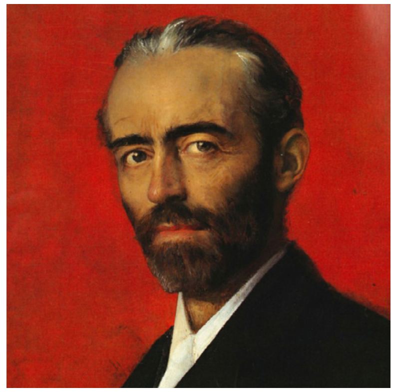
Legends

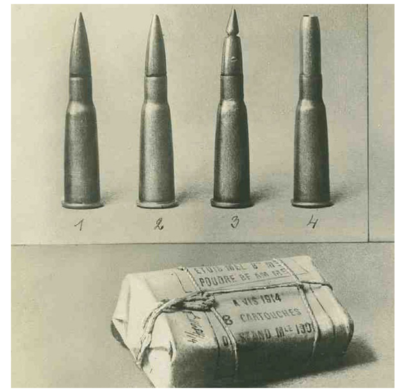
1 Ambroise Paré. Smithsonian Libraries Image Collection.

2 Title page from Paré A. *Les oeuvres d'Ambroise Paré*. Paris, Ches Barthelémy Macé, 1614.

3 Paré's bec de Gruë (crane's beak) clamp. From Johnson T. *The Works of that Famous Chirurgion Ambrose Parey, translated out of the Latin and Compared with the French by Tho. Johnson*. London: R. Cotes and Willi Dugard, 1649.

4 Pare's tripod frame for trepanation. From Paré A. *Les oeuvres d'Ambroise Paré.* Paris: Ches Barthelémy Macé, 1614





9

Kocher and the humanitarian origin of wound ballistics

American College of Surgeons
Inspiring Quality:
Highest Standards, Better Outcomes
100+*years*

AUTHORS
Patrick Greiffenstein, MD, FACS[1]
Don K. Nakayama, MD, FACS[2]
[1]Department of Surgery, Louisiana State University Health Sciences Center School of Medicine, Section of Trauma/Critical Care Surgery, New Orleans, LA
[2]Department of Surgery, University of North Carolina at Chapel Hill, Chapel Hill, NC

CORRESPONDING AUTHOR
Patrick Greiffenstein, MD, FACS
LSU Health Sciences Center, School of Medicine,
Department of Surgery, Section of Trauma / Critical Care Surgery
New Orleans, LA

While Theodor Kocher (1841–1917) is best known today for his advances in surgery and his Nobel Prize-winning work on the thyroid (1908), he made significant but far less known contributions in the field of wound ballistics. From his discoveries on how gunshots inflict human injury, he became a leading proponent of the mitigation of the destructive power of small arms fire. His advocacy contributed to an international agreement to prohibit bullets that deform in the body. Kocher worked with the armament industry to manufacture smaller caliber, non-deformable missiles that were intentionally less lethal. His concept of warfare where combatants are wounded and have a chance of recovery rather than being hopelessly maimed or killed is one of his most significant achievements.

1

Introduction

Wars in the century between the Napoleonic Wars of 1803–1815 and the First World War (1914–1918) were increasingly lethal and devastating. It was the age of science, engineering, and industry. The Western military powers took advantage of every advance, with soldiers on the front lines suffering the gruesome consequences.

Theodor Kocher (1841–1917) was the first to study wound ballistics, the biomechanical consequences of gunshots on the human body (Figure 1). He conducted his research largely before he became famous as professor of surgery at the University of Bern and for his work on surgery on the thyroid, for which he received the Nobel Prize in medicine in 1908. It is ironic that a prize made possible by the munitions industry in which Alfred Nobel made his fortune went to a researcher who studied the effects munitions have on humans.

Early life and education

Emile Theodor Kocher was born in Bern, Switzerland, in 1841, the son of a chief engineer and a mother, both of whom were devoted to his education. He received his doctorate in surgery in 1865 and trained with Demme, Lücke, Billroth, and Langenbeck. He stayed at Bern with Georg Lücke (1829–1894), then took his mentor's post as professor of surgery in 1872 when the latter moved to Strasburg. Despite numerous invitations to take professorships elsewhere, Kocher remained at Bern throughout his professional career.

He served in the Swiss militia, as did all young men of his generation, eventually rising to the rank of colonel. By maintaining a constant state of military preparedness and remaining at the forefront of military technology, the small land-locked nation in the heart of Western Europe was able to remain neutral. He later became president of the Swiss Military Pension Commission, a position he held until his death.[1]

Technology of war in the 19th century

Two major advances accounted for a dramatic escalation in the destructive power of small-arms fire. First was the Minié ball, a conical bullet of soft lead invented by Captain Claude Minié of France (1804–1879) in the mid-1840s. A spherical musket ball, due to its hydrodynamic properties, was less likely to deform and transfer its kinetic energy to the surrounding tissue. A Minié bullet of the same diameter was longer and heavier. Made of soft lead, it readily deformed and fragmented as it struck and tumbled through the body. Used extensively in the American Civil War (1861–1865) and the Franco-Prussian War (1870–1871) it produced an explosive displacement of surrounding tissue and bone, horrific wounds not seen with musket balls (Figure 2). Unanswered was how a simple change in size and shape of a bullet had such a great effect on tissue.[2]


2

The second advance in small-arm technology was the replacement of black powder by powerful nitrocellulose-based firearm propellants derived from guncotton invented in 1845 by Christian Schönbein (1799–1868). Sir Frederick Abel (1827–1902) developed a safe means for its manufacture in the 1865, revolutionizing the chemistry and armament industries.[3] Vastly more powerful than black powder, it increased the speed of the larger, heavier, Minié balls. Together, nitrocellulose and Minié balls drastically increased the momentum of the bullet, with increasingly devastating effect.[2,3]

Nitrocellulose was also “smokeless,” in that it left a negligible amount of residue in the barrel. In contrast, black powder left a corrosive residue that had to be cleaned after each use. Nitrocellulose thus allowed the development of cartridge-type ammunition and weapons that could fire many thousands of rounds repeatedly without intermittent cleaning.

Kocher’s research on ballistic injury

Kocher studied how the improvements in ammunition technology affected its target, human tissue.[4-6] While Kocher never saw combat, as a trained soldier he was well-acquainted with firearms and the principles of warfare. As a surgeon, he was eager to understand the physical properties of bullets as they pertained to the destruction of human flesh. His goal was to minimize the damage caused by gunshot wounds so that young soldiers could have a meaningful recovery from their wounds.

He explored the validity of the commonly held beliefs of ballistic injuries, and clarified the physical factors that caused excessive tissue destruction. He was the first to utilize blocks of gelatin and soap to simulate tissue, a model still used by modern ballistics researchers.

Cavitation

A prevailing theory was that the increased tissue destruction from a conical Minié bullet came from centrifugal force created by a twisted, or corkscrewed, path through tissue.[4] Another explanation was that the bullet created a hydraulic pressure wave that violently tore tissue as it pushed aside, like the wake on a boat.

To test the latter theory, Kocher fired a variety of contemporary small arms into a wooden box filled with water. The box broke apart after the bullet struck the back end of the box, indicating that it created a pressure wave that was transmitted throughout the container, causing it to split at the seams. This result is in keeping with Pascal’s law of hydrodynamics, that the pressure in a fluid-filled container will remain the same throughout the entire container.[4,5]

Another version of this experiment was later conducted by William MacCormack (1831–1901) in the 1890s.[7] He showed that a bullet fired through an empty tin box left a small hole at its exit while the same bullet fired through a water-filled can left a gaping, jagged hole at its exit. When the leaves of the exit hole in the latter were folded back to their original positions, the small bullet exit hole was recreated. He thus showed that the bullet passed through the back wall of the can first, followed by the hydraulic pressure wave that further tore the edges of the hole after the bullet exited.

Nevertheless it was Kocher's experiment that was the first to show that the destructive force of a projectile is in large part due to the hydraulic pressure wave and that there is a reciprocal relationship between this effect, called *cavitation*, and the potential penetration of the projectile into the target. These principles are the cornerstones of small arms ammunition design.

Effects of bullet temperature

Another widely-held belief was that a fired bullet became superheated and approached the melting point of lead, 325°C. At such temperatures it thus became subject to deformation when it struck its target. Kocher set out to examine this idea through a series of elegant experiments utilizing "rose-metal," an alloy of lead, tin, and bismuth that is harder than lead but with a melting point of only 65°C. Bullets made from rose-metal in the same shape as standard lead bullets retained their form when shot into an object. He thus proved superheating did not account for the deformation of the lead bullets.

Contamination of bullet wounds

Pasteur, Lister, and Koch showed that microbes were responsible for infections. Heat destroyed them, so superheated bullets were believed to be sterile. If bullets were in fact not superheated, as Kocher showed, how did gunshot wounds become infected?

Kocher fired bullets through a bacteria-laden cloth stretched across a container filled with gelatin medium. Viable bacteria appeared deep into the medium, thus proving that bullets dragged surface pathogens into tissue. In experiments that confirmed Kocher's findings, Col. Louis La Garde (1849–1920) of the U.S. Army in 1905 showed that larger caliber blunt-tipped balls and bullets carried pieces of clothing and equipment into the wound, making infection more likely.[8] Despite Kocher's and La Garde's work more than a century ago, the notion of sterile, superheated bullets persists to the present day.

Full metal jacket bullets

Kocher worked closely with Col. Eduard Rubin (1846–1920) of the Swiss Federal Ammunition Factory to create the world's first full-metal-jacket bullet: A projectile with a lead core that is fully encased in a harder metal such as steel or brass. The hard casing gave the projectile a pointed tip; its lead core maintained mass and thus momentum.

Both the armorer and the surgeon found tangible benefits with the new bullet. For Rubin the armorer, a smaller, more tapered, projectile had less drag, giving it less recoil and more accuracy. Lighter-weight bullets were easier to carry by troops, and to deliver to the front. For Kocher, the surgeon who sought to inflict less injury from military wounds, a full metal jacket bullet was less deformable and imparted far less kinetic energy than one which deformed or fragmented on impact.[2]

A bullet that wounded a soldier rather than killed him created a greater burden on the opposing force, because a wounded soldier consumed far more resources than a dead one. Thus the Swiss full metal jacket bullet had a strategic rationale. By 1890, Rubin's bottleneck shaped cartridge and full metal jacket bullet was the standard ammunition for all the major military powers.

Three tenets of ballistics

Kocher published two books and a series of articles that established the foundation of modern ballistic investigation.[6,9] He described three basic tenets of ballistics:

- Velocity, density, and tensile strength of the bullet determine its deformity on impact, not the heat caused by the muzzle blast.
- There is an inverse relationship between the cavitation produced by a bullet and its depth of penetration (a concept Kocher termed "reciproke Wirkung").
- The amount of destruction caused by a projectile is primarily a function of the inherent tissue characteristics, of which the most important is its elasticity: The more elastic the tissue is, the less it is affected by the temporary displacement caused by the hydraulic wave behind a bullet passing through it.[4]

Taming the technology of war

Kocher's deep religious convictions compelled him to apply his considerable scientific acumen to ease the suffering caused by combat injuries. He and other advocates in the field started a campaign to convince military powers to alter their small-arms ammunition to minimize the maiming effects in non-lethal wounds.

The effort to limit the destructiveness of small-arm fire began about the time Kocher received his degree in surgery in 1865. In 1863, the Imperial Russian army developed an exploding bullet intended to destroy munitions depots. Subsequent modifications made it detonate on contact with a soft target, like a human body. When used against troops it would kill not just the victim, but also kill or indiscriminately maim those who happened to be nearby.

The potential for a horrific escalation of an arms race in small-arms ammunition, and the political backlash it would attract if exploding bullets were ever used, caused the Russian military leadership to pause. In 1868 the Russian government convened military representatives from the leading European countries in St. Petersburg to arrive at a consensus to ban the use of exploding bullets in battle, the first diplomatic effort at restricting the use of certain munitions in war.

Russian Prince Gorchakov led a multinational agreement called the St. Petersburg Declaration of 1868, the first since the First Geneva Convention of 1864. Its signatories agreed to ban exploding bullets under a weight of 400 grams, on the basis that larger ordinance would kill a number of soldiers whereas a smaller projectile would only affect a single individual. This restriction conferred no greater military advantage than a conventional bullet but would invariably result in unnecessarily gruesome wounds if the target were to survive. The prohibition exists to this day.

Almost two decades later, in 1894, Kocher presented a paper entitled, "Die Verbesserung der Geschosse v. Standpunkte d. Humanität" (improvement in bullets from the standpoint of humanity) to the Eleventh International Medical Congress in Rome.[10] While "geschosse" (bullets) and "humanität" (humanity) are a striking juxtaposition in terms, it highlights Kocher's practical nature as well. While little can be done to prevent war in this world, he might have an impact by limiting the destructive effects of modern ammunition. Based on sound scientific principles that he had tested experimentally, he urged the use of ammunition for small arms that wounded rather than killed, and inflicted smaller wounds that gave a greater chance of functional recovery. Thus the new full metal jacket bullets were justifiable both strategically and morally.

The British army, however, had a different view. In 1895 it launched a military offensive in Chitral, India (near today's Pakistani-Afghan border), to quell an insurrection. The new non-deforming bullets inflicted less injury to enemy combatants than the traditional Minié balls. Later research confirmed their suspicions.[2] However, they preferred racial, rather than scientific, explanations for the lack of effect on their enemy. In a memoir of the battle at Chitral, Lt. Col. Sir Francis Younghusband, British officer and adventurer in India and the East, described the effect of gunshots in the conflict.

There is no doubt that Asiatics can stand wounds inflicted by sword or bullet infinitely better than Europeans can. Wounds that would kill a European, or at any rate lay him up for months, affect these hardy and abstemious mountaineers in a very much less severe manner.[11]

Younghusband concluded that the British military needed ammunition with more "stopping power." Neville Bertie-Clay (fl. 1887–1938), chief armorer at the British arsenal in the city of Dum Dum, India, removed the tip of the full metal jacket bullet to expose the underlying soft lead beneath. Upon impact it thereby deformed into a mushroom shape and restored some of its destructive power. Thereafter, the city's name, "Dum Dum," would be used to mean any bullet with a hollow or flat point with an exposed lead core.

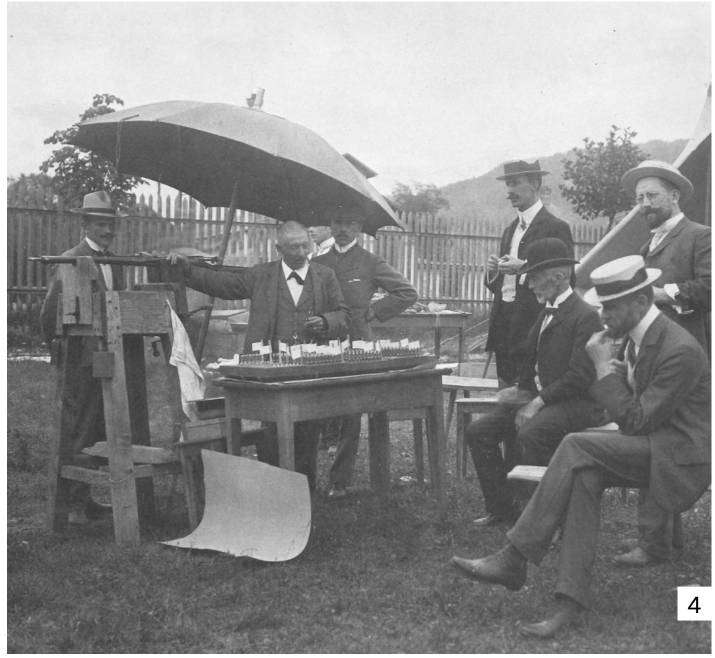
The predictably gruesome effects of dumdum bullets led to condemnation against their use. Paul Von Bruns (1846–1916), of the University of Tübingen, demonstrated their destructive effect in trials on human cadavers (Figure 3).[11]

3

Von Bruns presented his findings at the International Peace Conference at the Hague in 1899, where the question of use of expanding or deforming bullets in war was intensely debated. In the face of intense opposition, the British delegation justified the use of dumdum bullets in putting down colonial unrest. Representing the Crown, Major General Sir John Ardagh said, "[Men] penetrated through and through several times by our latest pattern of small calibre projectiles, which make small clean holes," were nevertheless able to rush on and come to close quarters. Some means had to be found to stop them.

The civilized soldier, when shot, recognizes that he is wounded and knows that the sooner he is attended to the sooner he will recover. He lies down on his stretcher and is taken off the field to his ambulance, where he is dressed or bandaged. Your fanatical barbarian, similarly wounded, continues to rush on, spear or sword in hand; and before you have the time to represent to him that his conduct is in flagrant violation of the understanding relative to the proper course for the wounded man to follow—he may have cut off your head.[12]

The Americans in the Spanish-American War (1898) had also seen that the Swiss full metal jacket bullets had much less wounding power than Minié balls.[2] William Crozier, Captain of Ordnance of the U.S. Army and attached to the American delegation at the conference, opposed adoption of the resolution on the grounds that prohibiting it would only lead to higher caliber projectiles or other means of delivering the "shocking power" to halt an enemy combatant.[13] The British and American delegates were outvoted 22–2 by the other attendees to prohibit the future use of the expanding or deforming bullet, setting parameters for the design of bullets used in warfare that exist to this day. The Hague Declaration acknowledged the sentiments of the St Petersburg Declaration as its inspiration.


4

Conclusion

Kocher lived to see the first years of World War I but not its conclusion. Due largely to his scientific efforts, the combatants used bullets that conformed to his concept of "geschosse mit humanität." In a tour of a field hospital, he noted the less destructive effects of the new ammunition. "I've seen soldiers shot clean through the chest," he said, "who heal from their injuries and return to the line just a few weeks later, having recovered from a wound that would have left them lingering for months."[4] Unfortunately, other advances in weaponry—the tank, flame-thrower, shrapnel grenade, and most particularly the machine gun and poison gas—overshadowed whatever mitigating effects modification in bullet design had on limiting death and suffering among wounded soldiers.

Nevertheless, the ceaseless devotion to medical and scientific advancement that Kocher displayed throughout his life was notably tempered by his deeply religious spiritual life, and he might have found solace in the belief that, as he once wrote, "prayer can compensate for our inadequate powers to combat death and fatal diseases."[14] He may also rest assured that, through his meticulous scientific efforts, he affected in a considerable fashion how the weapons of war serve to incapacitate the common soldier, saving lives and limbs amidst the horrific inhumanity that is modern war.

References

1 Wiese ER, Gilbert JE. Theodor Kocher. *Ann Med Hist.* 1931;3:521-529

2 Dougherty PJ, Eidt HC. Wound ballistics: Minié ball vs. full metal jacketed bullets—a comparison of Civil War and Spanish-American War firearms. *Mil Med.* 2009;174(4):403-407.

3 Davis TL. *The Chemistry of Powder & Explosives.* (Angriff Press [1992] ed.). Hoboken, NJ: John Wiley & Sons, 1943.

4 Fackler ML, Dougherty PJ. Theodor Kocher and the scientific foundation of wound ballistics. *Surg Gynecol Obstet.* 1991 Feb;172(2):153-160.

5 Kocher T. Über die Sprengwirkung der Modernen Kleingewehr-geschosse. *Cor-Bl f schweiz Aerzte, Basel.* 1875;5:3-7, 29-33, 69-74.

6 Kocher T. *Über Schusswunden. Experimentalle Untersuchunaen über die Wirkungsweise der Modernen Klein-Gewehr-Geschosse*. Leipzig: Verlag von FCW Vogel, 1880.

7 MacCormac W. Surgery. Address of the president of the section. *Lancet*. 1895;2:290-292.

8 La Garde LA. *Gunshot Injuries*. New York: William Wood, 1916.

9 Kocher T. *Zur Lehre von den Schusswunden durch Kleincalibergeschosse*. Kassel: Verlag von Th. G. Fischer, 1895.

10 Kocher T. *Die Veresserung der Geschosse von Standpunkte der Humanität. Atti dell´xi congresso medical internazionale*. Roma, 29 Marzo-5 Aprile 1894. Rome, Camera Dei de putati, 1895. 1 Parte Generale, pp. 320-325.

11 Younghusband FEGJ. *The Relief of Chitral*. London: MacMillan, 1895.

12 Von Bergmann E, Von Bruns P. *Handbuch der Praktischen Chirurgie*. Stuttgart: Verlag von Ferdinand Enke, 1907.

13 Yale Law School. Lillian Goldman Law Library. Crozier W. Peace conference at the Hague 1899: Report of Captain Crozier to the commission of the United States of America to the international conference at the Hague regarding the work of the first committee of the conference and its sub-committee. Available at: http://avalon.law.yale.edu/19th_century/hag99-05.asp. Accessed January 14, 2018.

14 McGreevy PS, Miller FA. Biography of Theodor Kocher. *Surgery*. 1969 Jun;65(6):990-999.

15 Bonjour E. Theodor Kocher. Bern; Paul Haupt, 1981.

16 US Surgeon General's Office. Medical and Surgical History of the War of the Rebellion (Vol 2. Part 3. P 637) 1883. Public domain, NIH-National Library of Medicine.

Legends

1 Theodor Kocher circa 1890, approximately 50 years old, portrait by Annie Hopf. From Reference 15.

2 Destructive effects of a Minié ball injury to the leg. From Reference 16.

3 German pamphlet describing Dum Dum bullets, circulated around the time of WWI, U.S. Wikipedia. Released in public domain.

4 Kocher demonstrating the explosive effects of bullets to English surgeons during a clinical congress on military operations in Thun, Germany, 1904. From Reference 15.

Special thanks to Professor Ulrich Trohler of Bern, Switzerland for his guidance. As the foremost authority on Kocher, his insight was invaluable in the drafting of this manuscript.

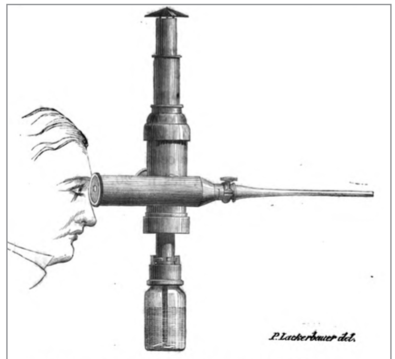


Fig. 4. — Position de l'endoscope pendant l'application.

10

The minimally invasive operations that transformed surgery

American College of Surgeons
Inspiring Quality:
Highest Standards, Better Outcomes
100+*years*

AUTHOR
Don K. Nakayama, MD, MBA
Department of Surgery, University of North Carolina at Chapel Hill, Chapel Hill, NC

CORRESPONDING AUTHOR
Don K. Nakayama, MD, MBA
170 Manning DriveG196 Physicians' Office BuildingGround Floor, C.B. 7223
Chapel Hill, NC 27599-7223

The history of minimally invasive surgery (MIS) began with the first cystoscopes in the early 19th century. Endoscopes were essentially cystoscopes applied to other organs and body cavities. Beyond dilation of strictures and biopsies of the lower urinary tracts, the first endoscopic therapeutic intervention was thoracoscopy to free the lung of adhesions during pneumothorax treatment of pulmonary tuberculosis by Hans Jacobeus in Sweden and Germany in 1912.

Laparoscopy was largely a diagnostic procedure performed by a few internists in the 1930s and 1940s, notably by Heinz Kalk in Berlin and John Ruddock in Los Angeles. Gynecologists Raoul Palmer in Paris and Hans Frangenheim in Germany began to use laparoscopy in the diagnosis of gynecological conditions and the evaluation of infertility in the 1940s and 1950s.

Kurt Semm in Munich and Kiel in the 1970s began to actively advance laparoscopic surgical operations: first gynecological procedures, then the first laparoscopic appendectomy in 1980. In 1985, Erich Mühe, a general surgeon in Böblingen, Germany, did the first laparoscopic cholecystectomy. Advances in imaging (Hopkins rod lens system) and illumination (fiber optics) in the 1950s, and imaging (solid state cameras and high definition video displays) in the 1980s, provided video images with sufficient anatomic detail to allow surgical operations of increasing complexity. Technology allowed endoscopy to realize its full potential, a true revolution in surgery.

Pioneers of endoscopy

The ability to look within a body cavity in a living patient was a long held dream in medicine. Until the early 19th century the diagnosis of a patient's malady, unless it was visible or easily palpated, was a secret that the body yielded only at surgery or autopsy, the former procedure associated with death just a little less than the latter.

Phillip Bozzini of Frankfurt had invented the original endoscope in 1806, a leather-lined box that held a candle interposed in the sightline between the examiner's eye and a speculum wedged into the urethra or vagina to inspect for signs of venereal disease, urethral strictures, and bladder stones (Figure 1).[1] In 1983, Antoine Desormeaux of Paris replaced the candle with an alcohol and turpentine-burning lamp. The light was brighter but the contraption became dangerously hot, a problem in a device held so close to the patient's perineum and the examiner's face. Desormeaux replaced Bozzini's unwieldy speculums with a long tube, creating the first true cystoscope (Figure 2). The former's other lasting contribution was the name of his apparatus, which he called "l'endoscopie."[2] In 1865, Sir Francis Richard Cruise of Dublin was the first to explore a body cavity, the empyema cavity in the thorax of an 11-year-old girl, using a cystoscope of Desormeaux's design that he modified to produce more light.[3,4]

Georg Kelling (1866-1945) in Germany was the first to examine the abdomen with an endoscope, a procedure that he called "celioscopy." He found that insufflation of the abdomen with air, a procedure that he had tried in an unsuccessful attempt at controlling gastrointestinal hemorrhage, was a good way to create working space within the abdominal cavity. The only documentation of his experience was "a memorable lecture" before the Society of German Natural Scientists and Physicians in 1901 that predicted modern laparoscopy. He said, "[Endoscopic] methods for the intestinal tract may find more use than it has been the case until now, as they are actually qualified to substitute the laparotomy in many cases."[5] He purportedly performed 45 such procedures to diagnose various lesions and tumors. Tragically, he died at age 79 in the Allied bombing of Dresden in 1945.[5]

Hans Christian Jacobaeus (1879–1937), an academic physician in Sweden who later became head of the department of internal medicine at the Karolinska Institute in 1916 and chair of its Nobel Prize committee, knew the necessity of publication to establish priority.[6] Despite the work of Cruise and Kelling, Jacobaeus has been called "the inventor of human laparoscopy and thoracoscopy."[6] He performed diagnostic laparoscopy on 17 patients with ascites, an experience which he published in 1910. He also examined two patients without ascites, a more difficult technical challenge where injury to the viscera was much higher. He took Kelling's idea of insufflation of air into the peritoneal cavity to create the distance to inspect intraabdominal structures, and used a trocar with a trap door that kept the air from escaping during the examination. He followed two years later with a second report of 97 patients, including 8 patients without ascites.[7]

In 1912 Jacobaeus began work with Ludolph Brauer at the Hamburg-Eppendorf Hospital in Germany and an advocate of therapeutic pneumothorax in the treatment of tuberculosis.[7] They used thoracoscopy to free the lung from adhesions that prevented complete atelectasis.[8] He largely abandoned laparoscopy, likely because the thoracoscopy allowed a therapeutic intervention, whereas the conditions where he used laparoscopy were mostly incurable, such as liver disease and malignancy.[9]

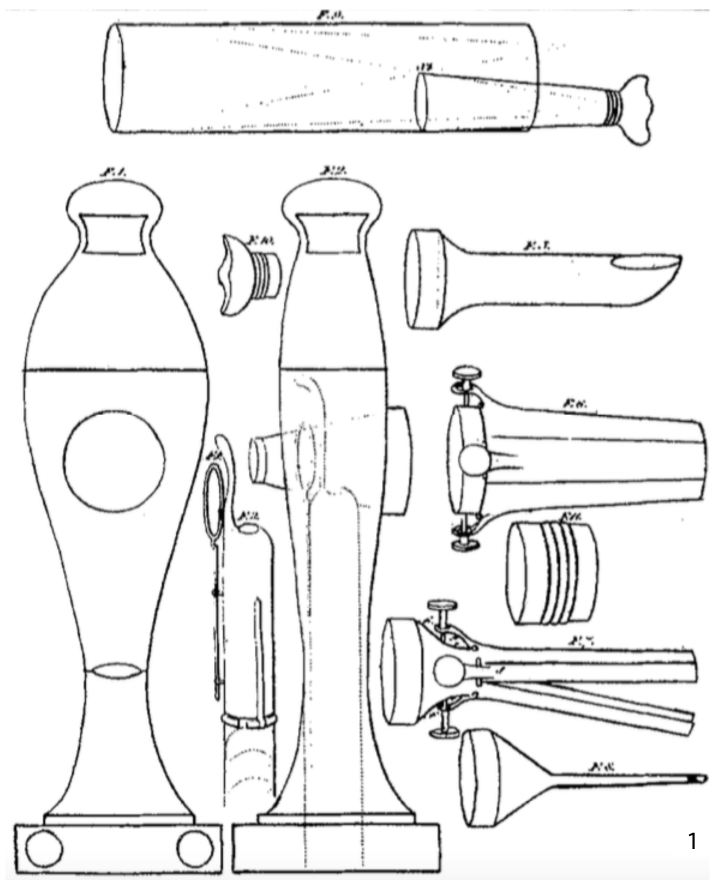
In 1911, one year after Jacobaeus's report, Bertram Bernheim of Baltimore reported the use of a sigmoidoscope to inspect the interior of the abdomen, a procedure that he called organoscopy. After working the procedure out on dogs at the Hunterian Laboratory at Johns Hopkins, he tried it on two human patients, one on a jaundiced patient with a distended gall bladder from a carcinoma at the head of the pancreas; the other, a patient suspected of a chronic gastric ulcer who had chronic appendicitis.[10] With such modest results, Bernheim's interests turned to other areas.

Pneumoperitoneum

Pneumoperitoneum was a necessary precedent to the development of laparoscopy. It originally was a radiological procedure to outline the viscera on plain films and fluoroscopy. New Yorkers Arthur Stein, a gynecologist, and William Stewart, a radiologist, introduced the modality in America in 1919. They used an anesthesia bag to inflate the free abdominal cavity with air or oxygen through a standard spinal needle.[11] Two years later, Walter Alvarez, an internist in San Francisco, reported the use of carbon dioxide for the procedure. The peritoneal cavity absorbed carbon dioxide within a few minutes, a distinct advantage over oxygen or air, which sometimes remained in the abdomen over days with prolonged discomfort.[12]

Benjamin Orndoff, the founding chair of the department of radiology at the Stritch College of Medicine at the Loyola University in Chicago, familiar with the diagnostic pneumoperitoneum, tried his hand at laparoscopy and reported his experience in 1921. After inducing the pneumoperitoneum, he also used fluoroscopy to avoid injuring the viscera when he placed a trocar for his scope.[13,14]

Janos Veres, a Hungarian internist, described his eponymic needle in a 1936 report in the Hungarian literature in a description of inducing pneumothorax for tuberculosis. His invention is familiar to all surgeons performing laparoscopic surgery today: To protect the organs from injury, he placed a spring loaded blunt obturator within a needle. The wall of the chest or abdomen pushed the blunt tipped obturator backward, exposing the sharp edge of the needle and allowing the assembly to penetrate the layers of tissue. When the tip of the needle entered a body cavity, the sudden loss of tissue resistance allowed the obturator to spring forward beyond the end of the needle, where it could protect the underlying viscera from injury. Alfred Cuschieri, one of the leading figures of surgical laparoscopy, speculated that Kurt Semm was one of the first to use the Veres needle in his pioneering work on laparoscopic surgery, which will be described below.[15]



1

Early laparoscopists

Grzegorz Litynski, a historian at the Johann Wolfgang Goethe University in Frankfurt, profiled the key contributors in the history of laparoscopic surgery in a series of articles that appeared in the late 1990s. Several important figures were in France and Germany during years surrounding World War II, a noteworthy commentary on the dedication of clinician-scientists to their work in the midst of unimaginable political upheaval and social disruption. Many of Litynski's references came from the European literature in the authors' native languages, so his articles are an important summary for English-only readers.

Heinz Kalk studied surgery at the Charité Hospital in Berlin after serving in World War I on the Western Front. Because the liver and spleen lay beyond the diagnostic capabilities of gastroscopy and radiology, he became interested in diagnostic laparoscopy. In 1928 he obtained a special endoscope with a 135-degree field of view. He designed a trocar that had a spring device that retracted its sharp point after entry, a principle much like the Veres needle. By 1942 he had performed 750 procedures, including biopsies of the spleen (which he first did in 1934), and liver (in 1935, reporting 123 biopsies in 1943). He was in the medical services of the Luftwaffe in World War II, where he put his device to use in performing diagnostic laparoscopies on soldiers suffering from epidemic hepatitis.[16]

On the American side, John Ruddock in Los Angeles had done more than 2,500 laparoscopic cases and taken 1,000 biopsies between wars in the 1930s and 1940s.[17] In 1949 he reported a diagnostic accuracy of nearly 94 percent.[18] Ruddock, like Kalk, had served in the armed forces in both wars. Contemporaries and pioneers in the same field, they faced impossible barriers of language, geography, politics, and ultimately armed conflict.[16]

Kalk and Ruddock's enthusiasm for the procedure was not generally held, especially among surgeons. It made little sense to perform laparoscopy under general anesthesia simply for diagnosis, when one could do a definitive operation through a standard incision.[16] A survey of internists and surgeons taken in 1966 documented that less than 10 percent had done a diagnostic laparoscopic procedure, and fewer than one percent had done more than 50. "After a brief stir," wrote Litynski, "most surgeons abandoned peritoneoscopy because of its limited therapeutic applications."[16]

Gynecologic laparoscopy

Gynecologists were the first specialists to fully devote themselves to laparoscopy and its therapeutic potential. Raoul Palmer, a gynecologist at the Hôpital Broca in Paris, and his wife Elizabeth started to perform laparoscopic procedures in occupied Paris in 1943. As the war drew to a close everything became scarce, from household items to hospital supplies. Raoul recognized the importance of controlling the amount of pressure within the abdomen, so he added a manometer to his insufflator, which he jury rigged from parts he found in storage areas in his hospital. Unable to drive to nearby towns because of gasoline rationing, he rode his bicycle to scrounge the carbonic acid necessary to generate carbon dioxide gas. Surgical gloves were in short supply, so the Palmers rinsed their hands repeatedly with an alcohol solution during their procedures.[19]

The Palmers first used cystoscopes outfitted with incandescent bulbs the size of a corn kernel. Attached to a 4.5 V flashlight battery outfitted with a rheostat, they often burned out during examinations. Despite the challenges of wartime, in 1947 Palmer reported an experience of 250 "coelioscopies gynecologiques"[19] that included descriptions of his instrumentation and examination techniques, "the most substantial published work on the application of laparoscopy in women's medicine at the time."[19]

The miniature light bulbs barely gave enough light to examine the pelvic organs, much less photography. In 1952 a Parisian optical firm used quartz rods to transfer light from a 150 V lamp outside the body. Despite its shortcomings – the lamp was "searingly hot," it needed a cooling system so noisy that it made normal conversation impossible, and the quartz rods were fragile and broke easily – it was the most effective means of illumination until fiber optic cold light systems became available in the 1960s.[19] Called proximal illumination, it provided enough light for photography; the Palmers even made an 8 mm color movie of a procedure in 1955.

Added to his expertise in infertility, laparoscopy made Raoul Palmer a leading international figure in gynecology. "Literally hundreds of physicians from all over the world came to the Parisian 'temple' of gynecology [the Hôpital Broca where he practiced]," said Litynski.[19]

Postwar America favored culdoscopy, inspection of the pelvis through the posterior fornix of the vagina, largely through the efforts of its primary proponent, Albert Decker, a gynecologist in New York.[20] He saw the posterior fornix as a potential access point for endoscopy, long used as a point of access for needle aspiration of the pelvic cul-de-sac to detect a collection of blood or pus, or a convenient place to begin mobilizing the uterus during vaginal hysterectomy.[21]

To create a pneumoperitoneum Decker insufflated the abdominal cavity through the cervix, gas passing into the peritoneal cavity through the uterine cavity and the Fallopian tubes. It was an established gynecological procedure, called the Rubin test, to confirm patency of the Fallopian tubes in the evaluation of infertility. (Shoulder pain from gas irritating the undersurface of the diaphragm confirmed patency of the tubes and a positive test.) Once the abdomen was thus distended, sturdy assistants held the patient in a knee-chest position as he made a small incision in the posterior fornix for an endoscopic examination of the pelvis.[22]

Hans Frangenheim was alongside the Palmers as the foremost figures in gynecological laparoscopy in postwar Europe. After service in the German air force during the war he was assigned work in an American hospital in Allied-occupied Germany. There he completed surgery and gynecological training and found a job in Wuppertal at a women's clinic.[20]

Frangenehim tried culdoscopy but found it cumbersome and inadequate in visualizing the pelvic organs. After study of Kalk's papers, he decided an anterior approach would give simple access to the pelvic organs without the difficult position that culdoscopy required. When he visited the Palmers in Paris in 1955, he saw the Palmer's insufflator and recognized it to be far superior to hand injection by syringe and needle. He made his own device in 1959, a modified anesthesia machine that pumped carbon dioxide into the abdomen. Like Jacobaeus earlier in the century, Frangenheim established his position in the field through his publications, including the first textbook on gynecological laparoscopy in 1959.[20]

Kurt Semm and operative laparoscopy

Kurt Semm, a German gynecologist, was the first to begin to perform laparoscopic operations beyond lysis of lung adhesions and biopsies of tumors and solid organs. A member of Nazi youth groups and a member of the Nazi army, he was captured by the Russians at war's end. Upon his release he returned to Munich, where he studied medicine and gynecology at the university and stayed on faculty at its women's clinic.

Among his duties was the Rubin test. Like Decker, Semm saw that it created enough space for laparoscopy, but chose instead to have the patient in the supine position. Semm, an inveterate tinkerer who invented toys to make ends meet in the immediate aftermath of the war, built his own insufflator in the mid-1960s with salvaged tools and parts. Later both the Palmers and Frangenheim accused Semm of stealing their designs.[23]

His chief of service, Richard Fikentscher, opposed his foray into laparoscopy, so Semm convinced a colleague at another hospital, Herbert Schwiegk, give his insufflator a trial run. Schwiegk was "overjoyed" with the device and began to use it for all of his procedures.[23] As Semm's luck would have it, Schwiegk happened to mention to Fikentscher how pleased he was with the device. The boss was not pleased. "I was called into his office, where he was shouting incredibly loud," said Senn.[23] Fikentscher relented after a visitor from Argentina happened to observe a laparoscopic procedure on one of Fikentscher's patients. "Brilliant!" the visitor said, "Gentlemen, I tell you brilliant!"[23]

In 1967 Semm took his device to a conference in Washington, DC, where he met Melvin Cohen, a Chicago obstetrician who was Interested in laparoscopy and culdoscopy. The American directed Semm to his technician, a German Jew who had escaped to the U.S. during the war. The former Nazi soldier and the Jewish refugee overcame their anathema to each other and agreed to work together to test the device. Cohen was pleased with its performance. American Cystoscope Makers, Inc. (the company that worked with Basil Hirschowitz to create the first marketable flexible endoscope in 1961),[24] recognized immediately the potential value of the insufflator. Before long hundreds of his devices were being used in America.[23]

Semm moved to Kiel and began work on laparoscopic surgical operations. Palmer had used laparoscopy to cauterize Fallopian tubes for ablation in 1962. Now in the 1970s, Semm began to use laparoscopy to address a wider array of tubal, ovarian, and uterine pathology.[25] He took each part of a surgical operation—cutting, suturing, tying knots, creating exposure—and invented the corresponding shears, needle holders, clamps, forceps, and retractors on the ends of long handles that allowed their manipulation from outside the body. Instruments were placed through fixed ports, a concept Semm popularized. He had an advantage: His father and brother owned WISAP, a medical instrument company. They were thus able "to [produce] the devices Semm wanted "almost overnight," wrote LItynski.[26]

He used a loop of suture with a slip knot already in place, called a Roeder knot, for his tubal ligations, ovarectomies (placing the entire structure within the loop then cinching it closed), and control of bleeding vessels.[27] He became adept at tying knots, both outside (extracorporeal) and inside the body (intracorporeal).[26] His work during the 1970s created many of the instruments and basic procedures of modern laparoscopic surgery.

In 1979 he reported his experience of 3,300 pelviscopies, which included myomectomy, ovariectomy, ovarian cyst resection, adnexectomy, and treatment of tubal pregnancy.[28] When the paper appeared, in Litynski's words, "[a] true storm broke loose."[26] Many disbelieved the total number of cases. Traditionalists remained unconvinced of the concept of laparoscopy. Its supporters, notably the Palmers and Frangenheim, contended that Semm emphasized only the technical performance of laparoscopic procedures without proving their safety or efficacy, such as lysis of Fallopian tube adhesions for infertility. His articles prominently featured the instruments he and his family designed, especially his diathermy device and insufflation systems. "What impressive numbers, and how little they tell us," Frangenheim wrote in 1979.[26]

Semm was undeterred. It was undeniably a revolutionary way to perform surgery. "Those … who witnessed him in action," Litynski wrote, "spoke of 'the magician of Kiel."[26] In February 1980 one medical periodical in Germany wrote, "When will the first appendix or gallbladder disappear into an endoscope?"[26] The writer did not have to wait long. Just months later in September, Semm performed the first laparoscopic appendectomy.[29,30] Later that decade in 1985 Erich Mühe, a general surgeon in Böblingen, Germany, and in 1987, Phillipe Mouret, a gynecologist in Lyon, did the first laparoscopic cholecystectomies.[31,32]

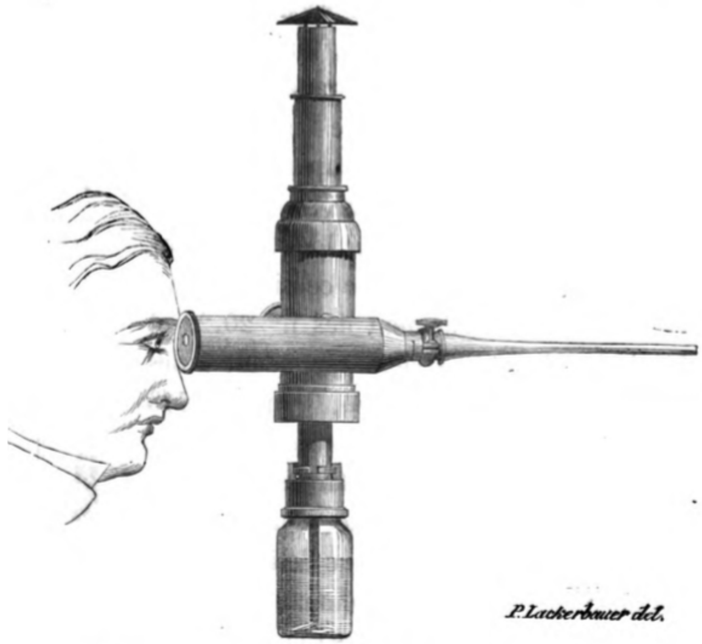


Fig. 4. — Position de l'endoscope pendant l'application. 2

A technological revolution in surgery

The future of laparoscopic surgery had to expand beyond the small number of gynecologists with a special interest in laparoscopy and into general surgical practices. Mouret did his two-and-a-half-hour cholecystectomy on his side lying on the patient's right thigh to keep his eye over the objective of the scope. "[It] had been a contortionist's exploit," he said. For laparoscopic surgery to be adopted, it simply had to be made easier to perform.[32]

Thus two technological advancements in imaging and illumination in the 1950s were key improvements in the development of therapeutic laparoscopy. The Hopkins glass rod-lens, developed by Harold Hopkins in the late 1950s, produced images 80 times better than the Galilean optics that had been used in traditional cystoscopes.[33]

Fiber optics originated in the same decade with papers published back-to-back in *Nature* in 1954 by Hopkins and Narinder Karpany at the University College in London and their rival, Abraham van Heel, at the University of Delft. Lawrence Curtiss at the University of Michigan made a key improvement by cladding each fiber with glass of a lower refractive index, which prevented the loss of light by assuring internal reflection along the length of the light-carrying fiber.[34]

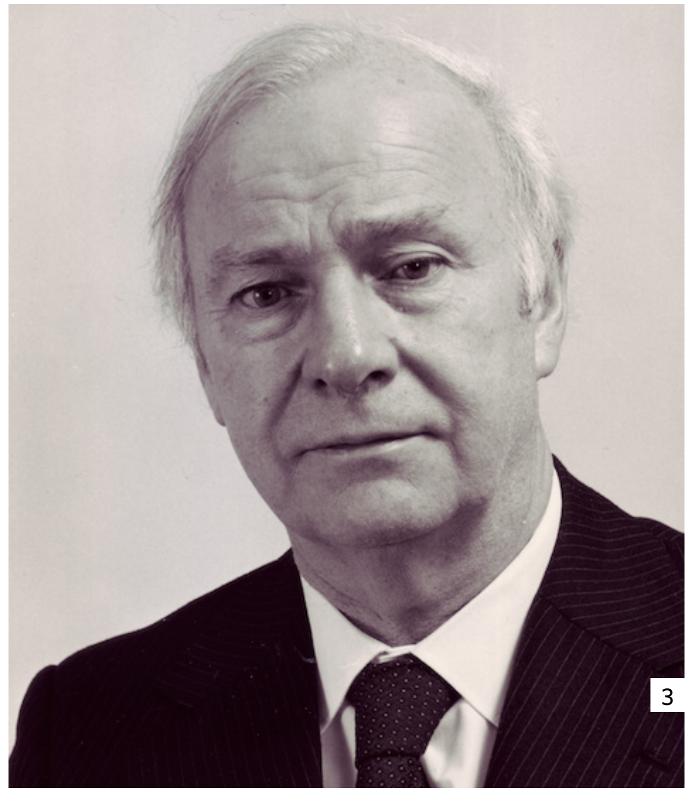
Fiber optics made two fundamental technological contributions to medicine: flexible endoscopy and proximal illumination. The former revolutionized the practice of gastroenterology; the latter provided the light needed for laparoscopic surgery. The principle was the same as the Palmer's arrangement with a high voltage light source outside the body, but now illuminated glass fibers placed on the rim of the endoscope brought light inside the body, and thus replaced the Palmers' unwieldy quartz rods.[34]

The final step was solid state camera technology of the 1980s that created the first wave of electronic digital cameras and portable video systems.[35] As video monitors improved the images on high definition displays, surgeons had the optical resolution they needed to discern the anatomic detail necessary to perform surgical operations of increasing complexity. Their eye no longer locked onto the objective of the laparoscope held by one hand, surgeons could stand, view the operation on a video display, and perform standard operations using both hands.

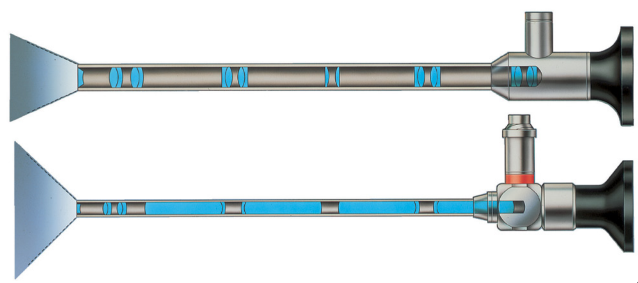
Surgery was thus transformed in the latter half of the 1980s. Arnold Pier and Friedrich Götz, two surgeons from Linnich, a town near Cologne, started to do laparoscopy for all of their cases of appendicitis. Their experience, 678 cases in a little over three years from 1987-1990, was reported in 1991. They had to abandon laparoscopy to perform an open operation in only 14 cases (2%).[36] By March 1987 Mühe had already accumulated 97 cases of video-laparoscopic cholecystectomy; in April 1989 Dubois reported 36 laparoscopic cases, of which three were converted to an open procedure.[31] In the months between submission of his article and the appearance of the publication in proof, he had added another 220 cases to his experience, with the last 180 done without complications.[37]

The procedure spread to France and the U.S. by Francois Dubois of Paris, Jacques Perissat of Bordeaux, J. Barry McKernan and William Saye of Marietta, GA, and Eddie Joe Reddick and Douglas Olsen in Nashville, TN. In 1989 tremendous interest was generated by presentations by Perissat at the Society of American Gastrointestinal and Endoscopic Surgeons in Louisville in April, and by Reddick and Olsen at the American College of Surgeons in Atlanta in October. Classes offered in the U.S. quickly became oversubscribed.[31]

Laparoscopy spread to other operations and other specialties. For patients the benefits were undeniable, with smaller, less painful incisions and faster recovery. Instrumentation improved, especially stapling devices that could be deployed through laparoscopic incisions. By the 1990s nearly all operations in every major surgical specialty could be done using laparoscopy and minimally invasive techniques, a true revolution in surgery.



3



4

References

1 Bush RB, Leonhardt H, Bush IV, Landes RR. Dr Bozzini's Lichtleiter. A translation of his original article. *Urology*. 1974;3(1):119-123.

2 Desormeaux AJ. *De l'endoscope et de ses applictions au diagnostic et au traitment des affections de l'urèthre et de la vessie*. Paris: J-B Ballière et fils, 1865.

3 Hoksch B, Birken-Bertsch H, Müller JM. Thoracoscopy before Jacobaeus. *Ann Thorac Surg*. 2002;74(4):1288–1290.

4 Gordon S. Most extensive pleuritic effusion rapidly becoming purulent; paracentesis; introduction of a drainage tube; recovery; examination of interior of the pleura by the endoscope. *Dublin Quarterly Journal of Medical Science.* 1866;41:83-90.

5 Schollmeyer T, Soyinka AS, Schollmeyer M, et al. Georg Kelling (1866-1945): The root of modern day minimal invasive surgery. A forgotten legend? *Arch Gynecol Obstet.* 2007;276(5):505-509.

6 Hatzinger M, Kwon ST, Langbein S, et al. Hans Christian Jacobaeus: Inventor of human laparoscopy and thoracoscopy. *J Endourol.* 2006 Nov;20(11):848-850.

7. Litynski GS. Laparoscopy–The early attempts: Spotlighting Georg Kelling and Hans Christian Jacobaeus. JSLS 1997;1:83-85.

8. Jacobaeus HC. The cauterization of adhesions in pneumothorax treatment of tuberculosis. *Surg Gynecol Obstet.* 1921;32(6):493-500.

9. Braimbridge MV. The history of thoracoscopic surgery. *Ann Thorac Surg.* 1993;56(3):610-614.

10 Bernheim BM. IV. Organoscopy: Cystoscopy of the peritoneal cavity. *Ann Surg.* 1911;53(6):7674-7677.

11 Stein A, Stewart WH. Roentgen examination of the abdominal organs following oxygen inflation of peritoneal cavity. *Ann Surg.* 1919;70(1):95-100.

12 Alvarez WC. Use of CO2 in pneumoperitoneum. *Am J Roentenol.* 1921 Feb;8(2):71-72.

13 Orndoff BH. Peritoneoscope, pneumoperitoneum and X-rays in abdominal diagnosis. *Ill Med J.* 1921:39(1):61-62.

14 Morgenstern L. An unlikely pioneer in laparoscopy: Benjamin Henry Orndoff, M.D. *Surg Innov.* 2008 Mar;15(1):5-6.

15 Sandor J, Ballagi F, Nagy A, et al. A needle-puncture that helped to change the world of surgery. Homage to Janos Veres. *Surg Endosc.* 2000 Feb;14(2):201-202.

16 Litynski GS. Laparoscopy between the World Wars: The barriers to trans-Atlantic exchange. Spotlighting Heinz Kalk and John C. Ruddock. *JSLS*. 1997;1(2):185-188.

17 Ruddock JC. Peritoneoscopy. *West J Surg.* 1934;42:392-405.

18 Ruddock JC. The application and evaluation of peritoneoscopy. *Calif Med.* 1949;71(2):110-116.

19 Litynski G. Raoul Palmer, World War II, and transabdomial coelioscopy. Laparoscopy extends into gynecology. *JSLS*. 1997;1:289-292.

20 Litynski GS. Hans Frangenheim–Culdoscopy vs. laparoscopy, the first book on gynecological endoscopy, and "cold light." *JSLS*. 1997;1(4):357-361.

21 Decker A, Cherry TH. Culdoscopy. A new method in the diagnosis of pelvic disease–a preliminary report. *Amer J Surg.* 1944;64(1):40-44.

22 Decker AA. Posterior colpotomy for diagnosis of pelvic diseases. *Am J Surg.* 1947;73(3):313-319.

23 Litynski GS. Kurt Semm and an automatic insufflator. *JSLS*. 1998;2(2):197-200.

24 Hirschowitz BI. Endoscopic examination of the stomach and duodenal cap with the Fiberscope. *Lancet.* 1961;1(7186):1074-1078.

25 Semm K. New methods of pelviscopy (gynecologic laparoscopy) for myomectomy, ovariectomy, tubectomy, and adnectomy. *Endoscopy*. 1979;11(2):85-93.

26 Litynski GS. Kurt Semm and the fight against skepticism: Endoscopic hemostatis, laparoscopic appendectomy, and Semm's impact on the "laparoscopic revolution." *JSLS*. 1998;2(3):309-313.

27 Semm K. Tissue-puncher and loop-ligation. New aids for surgical-therapeutic pelviscopy (laparoscopy). *Endoscopy*. 1978 May;10(2):119-124.

28 Semm K. Change in the classic gynecologic surgery: review of 3,300 pelviscopies in 1971-1976. *Int J Fertil.* 1979;24(1):13-20.

29 Litynski G. Kurt Semm and the fight against skepticism: endoscopic hemostasis, laparoscopic appendectomy, and Semm's impact on the "laparoscopic revolution." *JSLS.* 1998;2:309-313.

30 Semm K. Endoscopic appendectomy. *Endoscopy*. 1983;15(2):59-64.

31 Litynski GS. Endoscopic surgery: The history, the pioneers. *World J Surg.* 1999;23(8):745-753.

32 Mouret P. How I developed laparoscopic cholecystectomy. *Ann Acad Med Singapore.* 1996;25(5):744-747.

33 Gow JG. Harold Hopkins and optical systems for urology–an appreciation. *Urology*. 1998;52(1):152-157.

34 Hecht J. *City of Light: The Story of Fiber Optics*. New York: Oxford University Press, 2004.

35 Fossum ER. Camera-on-a-chip: Technology transfer from Saturn to your cell phone. *Technology Innovation*. 2013; 15(3):197-209.

36 Pier A, Götz F, Bacher C. Laparoscopic appendectomy in 625 cases: From innovation to routine. *Surg Laparosc Endosc.* 1991;1(1):8-13.

37 Dubois F, Icard P, Berthelot G, et al. Coelioscopic cholecystectomy. Preliminary report of 36 cases. *Ann Surg*. 1990;211(1):60-62.

Legends

1 Bozzini's Lichleiter. Diagram from Bozzini P. Lichleither, eine Erfindung zur Anchauung innerer Theile und Krankheiten nebst der Abbildung. *Journal der practischen Arzneykunde und Wundarzneykunst* (Berlin). 1806;24:107-124.

2 Desomeaux's *l'endoscopie*. Illustration from Reference 2.

3 Harold Hopkins. Photo courtesy Karl Storz Endoscopy (UK).

4 Hopkins rod lens system. Figure courtesy Karl Storz Endoscopy (UK). Top: cross section of a scope with glass lenses placed at intervals, separated by air-filled spaces. Bottom: Hopkins rod lens system, with solid glass rods separated by lens-shaped intervals of air.

Bulletin of the Surgical History Group

Papers from the 2017 Poster Competition

CLINICAL CONGRESS 2017 | SAN DIEGO, CA

SURGICAL
HISTORY GROUP

AMERICAN COLLEGE OF SURGEONS
Inspiring Quality:
Highest Standards, Better Outcomes

100+years