A Brief History of Wound Care

George Broughton II, M.D., Ph.D., COL., M.C., U.S.A.
Jeffrey E. Janis, M.D.
Christopher E. Attinger, M.D.

Dallas, Texas; and Washington, D.C.

Summary: Since the caveman, man has been tending to his wounds. Wound care evolved from magical incantations, potions, and ointments, to a systematic text of wound care and surgery from Hippocrates and Celsus. These advances were lost after the fall of the Roman Empire. In Europe, the Middle Ages were a regression of wound care back to potions and charms. It wasn't until the time of large armies using muskets and cannons that surgical wound care emerged again. This article will briefly highlight major milestones in wound care. (*Plast. Reconstr. Surg.* 117 (Suppl.): 6S, 2006.)

The class of wound and its shape are also important. For a contused wound is worse than one simply incised, hence it is better to be wounded by a sharp weapon than by a blunt one. A wound is worse also if a piece is cut out, or if the flesh is cut away in one part and hanging free in another. A curved wound is worst, a straight linear one safest; hence a wound is more or less serious, according as it approximates to the former or to the latter shape. Again, both age and constitution and mode of life and the season have also some influence; for a boy or young adult heals more readily than does an old man; one who is strong than a weak man; a man who is not too thin or too fat than one who is either of these; one of sound habit than of unsound; one who takes exercise than a sluggard; one who is sober and temperate than one addicted to wine and venery. And the most opportune time for healing is the spring, or at any rate when the weather is neither cold nor hot, for wounds are harmed by excessive heat and excessive cold, but most of all by variations of these; hence autumn is the most pernicious season.

—A. Cornelius Celsus, Book V, *De Medicina*, early first century A.D.

SURGICAL TREATMENT

Ancient Egyptian physicians' treatment for open wounds is documented in papyruses (Fig. 1) dating back to 1400 BC. They would apply a paste of honey, grease, and lint into open wounds to remove skin and pus to encourage wound healing.[1] The Hippocratic Collection discusses the ancient (400 BC) Greek practice of surgical drainage of pus with a piece of tin pipe placed into the abscess cavity—a practice lost with the ancient Greek civilization.[2] The syringe was invented by a Greek barber in 280 BC and was noted to be good for injecting liquids and sucking pus out of wounds. The Greek's name for the syringe is pyúlkos, latinized as pyulcus, the "pus-puller."[2] The syringe's usefulness was forgotten until nearly 2000 years later.

It was customary through the Middle Ages to allow the wound to "rot a bit."[1] Wounds became infected with either a manageable *Staphylococcus* species or gangrene, which resulted in certain death. Wounds infected with *Staphylococcus* resulted in "laudable pus" and was evidence of the body's effort to heal itself; the patient was likely to survive. Napoleon's surgeon, Dominique Jean Larrey (1766–1842), wrote extensively on the necessity for early amputation for any limb injured that cannot be saved. Hospital gangrene was frequently seen in untreated wounds and was almost universally fatal. Larrey reasoned that an early amputation would obviate this danger by creating a relatively clean viable wound.[3] This belief was held by most (but not all) through the American Civil War. Thirty percent of gunshot and fragment wounds to the extremities resulted in amputation. It wasn't until 1865, when Dr. Joseph Lister (1827–1912) first demonstrated the use of an antiseptic in surgery and his treatment of wounds with dressings soaked in carbolic acid, that germ theory and infection were being understood. Textbooks on wound care in the 1880s stressed the importance of skin cleansing, removal of foreign matter, bone splinters, and irrigation with carbolic acid. Carl Reyher (1846–1890), a Russian military surgeon, added further instructions. He recommended adding a

From the Department of Plastic Surgery, Nancy L & Perry Bass Advanced Wound Healing Laboratory, University of Texas Southwestern Medical Center; and The Georgetown Limb Center, Georgetown University Medical Center.
Received for publication February 1, 2006; revised March 5, 2006.
The opinions or assertions contained herein are the private views of the author (G.B.) and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

DOI: 10.1097/01.prs.0000225429.76355.dd

Fig. 1. A page of the Ebers Papyrus. It was written around 1700 BC but most of the information is based on texts written around 2640 BC— Imhoteps time. The papyrus discusses mainly wounds and how to treat them, and there is surprisingly little about diseases. Placed on sale by Mustafa Agha in 1862, the papyrus was purchased by Edwin Smith. Upon his death in 1906, his daughter donated the papyrus in its entirety to the New York Historical Society. Photograph courtesy of The History of Medicine Division of the National Library of Medicine, National Institute of Health.

more extensive mechanical wound cleansing which he termed *débridement*. He demonstrated a significant reduction in mortality in patients he treated during the Russo-Turkish war.[3]

Many credit French surgeons of the eighteenth and early nineteenth centuries particularly French surgeon Pierre Joseph Desault (1744–1795), for the modern concept of débridement. These early surgeons believed that inflammation or injury could, on occasion, produce constriction of soft tissues confined by fascia, tendons, or aponeuroses by *augmentation de volume,* or a rise in pressure. Such constriction, termed *etranglement,* might result in gangrene if left unattended. For this reason, débridement (Fr. *debrider,* to unbridle) was used: an incision was made through investing fascia to unbridle, or release, the underlying expanding tissue. Bleeding reflected viable tissue and was considered a favorable sign. Less encouraging was the release of putrid or watery fluid, indicating gangrene. Often, such débridement would drain pus from deep muscle abscesses, particularly in wounded areas.[3] Reyher should be credited with first describing the modern notion of débridement. However, full credit for the modern practice of débridement belongs to Belgian Army surgeon Antoine Depage (1862–1925). World

War I resulted in new types of wounds from high-velocity bullet and shrapnel injuries concurrently with contamination from the battlefield. Depage was not satisfied with simple débridement, or wound exploration. In the course of his débridement of soldiers injured during World War I, it was important not only to eliminate foreign bodies but also to remove contaminated tissue and contused, necrotic flesh. He feared this environment was fertile ground for the growth of pathogens, particularly the spore-forming anaerobes responsible for many cases of gangrene gazeuse (gas gangrene). He would use wound brushings as guidance for the timing of secondary wound closure. Depage was keen and kept up to date on bacteriology. Alexander Fleming was doing many of his bacteriologic studies in the research laboratories of Depage's military hospital at La Panne and identified *Bacillus aerogenes capsulatus (Clostridium perfringens, Clostridium welchii), Clostridium tetani, streptococci, and staphylococci.*[3]

HEMOSTASIS

Ancient healers did not understand the concept of hemostasis. Minor bleeding was controlled by stuffing some kind of "material" into the wound and bandaging it. Wounds that caused any major bleeding meant the inflicted would die from hemorrhage. The notion of a tourniquet did not appear until men were wounding each other with guns.[2]

The Smith Papyrus from Ancient Egypt does not mention any method to control bleeding. The Eber Papyrus (1500 BC) contains the first recorded instructions for hemostasis. The document instructs the reader that before a "cyst" is cut, the knife "should be heated in fire, the bleeding is not great."[2] The papyrus also suggests that if a vessel "bleeds a lot, you must burn it with fire."[2]

The Ancient Greeks had a vague notion about hemostasis. Hippocrates never mentioned tying off or clamping a bleeding blood vessel. In Homer's *Iliad* the only attempt mentioned to control bleeding was to recite a charm over the wound. Nonsurgical treatment for bleeding is discussed in the Hippocratic Collection. A carpenter, who cut his foot with an ax and was pale and "bleeding a lot," was treated by elevating the injured leg and applying a towel dipped in cold water around the wound while a second towel dipped in warm water was poured around the patient's head (the idea was to draw blood away from the foot and up into the head).[2] A plug of wool moistened with the sap of a fig tree (which was believed to stop bleeding—it does not; it was well known at that time that sap from a fig tree will cause milk to curdle) was placed into the wound and then covered by a bandaged soaked in red wine and dripping. This treatment is recorded as working. After this surprisingly "modern" approach to hemostasis, the physician must then tie a band around the patient's knee and slit a vein around the ankle to make him bleed. The Hippocratic triad for treating disease and injury was starving, purging, and bleeding. The Greek physicians understood that "hemorrhage kills, but bleeding helps."[2] The tourniquet is mentioned once in the Hippocratic Collection, with a warning that if left on too long, gangrene will result. Its practical use never caught on and the notion of a tourniquet did not reappear until approximately 50 AD when a Roman writer, Scribonius Largus, mentioned it only to ridicule it (see below). The tourniquet remained dormant until Etienne J. Morel, a French Army surgeon, reintroduced it in 1674.[2]

Cornelius Celsus was the first to put into writing our current practice of hemostasis. He practiced in Rome during the time of Tiberius (14-37AD) and authored *De medicina.* He wrote, "When a man has been wounded who can be saved, there are in the first place two things to be kept in mind: that he should not die from hemorrhage or inflammation."[2] About bleeding he wrote:

"If we are afraid of hemorrhage which can be judged both from the position and size of the wound and from the force of the flowing blood, the wound is to be filled with dry lint, and over that a sponge applied, squeezed out of cold water, and pressed down by the hand. If the bleeding is not checked thus, the lint must be changed several times, and if it is not effective when dry, it is to be soaked in vinegar. . . But if even these are powerless against the profuse bleeding, the veins that are pouring out blood are to be seized, and round the wounded spot they are to be tied in two places, and cut across in between, so that each end may retract on itself, and yet have its orifices closed."[2]

Galen (130–200 AD), court physician to Roman emperor Marcus Aurelius and a gladiatorial surgeon, is most notable for his anatomical dissections (Galen's nerve). He wrote that hemorrhage should be treated in one of four ways—applying direct pressure with a finger, twisting the cut end with a hook, grasping the cut end and tying it off, or applying styptics (an example of his mixture was frankincense, aloe, and egg white mixed to a consistency of honey with a "pinch" of clippings added from the fur of a hare).[2] Marcus

Aurelius sent a mission of merchants from Rome to China and brought back silk, which Galen used to tie off bleeding vessels. Galen did not write on the use of a tourniquet (but he certainly must have known about it). He may have been influenced by the writings of Scribonius Largus, court physician to the Roman emperor Claudius, who wrote:

"One should sponge the wound with water or vinegar and prevent the limb from being constricted [*by a tourniquet*], which most doctors do, not realizing that by compressing the muscle they force more blood out of the wound. . .. In the same way, if you tie a rope around a skin bag and tighten it, if that bag has a leak, it will of course squirt out its contents."[2]

After Galen, little is written about wound care and medicine. Europe was cloaked in the Dark Ages. It wasn't until 1545, when Ambroise Paré substituted egg yolk and turpentine for boiling oil and re-introduced the ligature of arteries in lieu of cauterization during amputation, that wound care advanced.

Ambroise Paré was the official royal surgeon for kings Henry II, Francis II, Charles IX, and Henry III. He was born in 1510 and died in 1590. He was apprenticed to a barber at an early age, became barber-surgeon at the Hôtel-Dieu, Paris, surgeon in the army of Francis I (1536–1538), re-enlisted on the reopening of hostilities (1542–1544), and in 1545 began the study of anatomy at Paris under François-Jacques Dubois. He was appointed field surgeon by Marshal Rohan and (1552) became surgeon to King Henry II. In 1563, after the siege of Rouen, he became first surgeon and chamberlain to King Charles IX. The prevailing thought at the time was that gunshot wounds were poisoned by powder and had to be cauterized with a red-hot iron or hot oil. On one occasion, after a battle, Paré, not having sufficient oil, substituted egg yolk and turpentine and bandaged the wounds, and observed that the healing was better under this treatment. His observations, published in 1545, gave the impetus to a rational reform of the whole system of dealing with wounds, and did away with the theory of poisoned gunshot wounds, despite the fact that the Italians Alfonso Ferri (1552) and Giovanni Francesco Rota (1555) obstinately defended the old view. Vascular ligation was revived by Paré for amputations. A surgeon during this era had about 30 seconds to amputate the limb and 3 minutes to complete the operation. Working without anesthesia and a tourniquet, this was too little time for a surgeon (other than Paré) to complete the surgery and is why many, such as Guillemeau, Paré's student, again abandoned this method for direct cautery. It wasn't until later with the reintroduction of the tourniquet in 1674 by Etienne J. Morel, also a French Army surgeon, during the Siège of Besançon, that ligation would have more widespread use.[4]

Paré also invented upper and lower extremity prostheses, showing remarkable knowledge of basic prosthetic function. "Le Petit Lorrain" was a hand operated by springs and catches for a French army captain, which he used in battle. He also invented an above-knee prosthesis which was a kneeling peg leg and foot prosthesis. It had a fixed equinas position, adjustable harness, knee lock control, and other engineering features used today.[4]

BIOLOGICAL DÉBRIDEMENT

One of the first written reports of maggot therapy is credited to Ambroise Paré. He noted the beneficial effects of maggots in the wounds of soldiers in 1557.[5] In 1829, Baron D. J. Larrey, while serving as a military surgeon for Napoleon's armies, observed that maggots only attacked necrotic tissue and promoted healing of wounds.[6] During the Civil War, Confederate surgeons Joseph Jones and J. F. Zacharias began using maggots to treat wounds. Zacharias noted that "in a single day [maggots] would clean a wound much better than any agents we had at our command. . . I am sure I saved many lives by their use."[7,6]

The first scientific studies of maggots' medicinal uses were conducted by Dr. W.S. Baer.[6–9] Baer began an extensive study of the blowfly after having treated two soldiers during World War I. He commented that although the soldiers had lain unattended for 7 days on a battlefield, their compound fractures and abdominal wounds, which were infested with thousands of maggots, contained healthy granulation tissue. During this preantibiotic era, the mortality rate from such types of wounds was close to 75 percent. During the 1920s and 1930s, Baer reported the successful treatment of osteomyelitis and chronic leg ulcers in over 90 patients by using maggots.

DRESSING THE WOUND

The concept of keeping a wound clean and bandaged has been known for a very long time. Recorded wound care goes back to 2100 BC, when "three healing gestures" were chiseled into the famous Sumerian clay tablet: washing the wound with beer and hot water, making plasters (mixtures of herbs, ointments, and oils), and bandaging the wound.[2,10] Ancient salves are very bacteri-

ocidal. A mixture of one-third honey and two-thirds grease (butter) decreased a 10^5 count of *Staphylococcus* and *Escherichia coli* to less than 10^2 within 24 hours.[2] The Bible mentions wound care: "He went to him and bandaged his wounds, pouring on oil and wine. Then he put the man on his own donkey, took him to an inn and took care of him." (Luke, 10:34). Homer's *The Odyssey* (800 BC) tells about the treatment given to Ulysses' injured leg from a wild boar: "With bandage firm, Ulysses' knee they bound."[10] In Homer's *The Iliad*, bandaging is only mentioned twice. One episode describes how Agenor's hand was pierced by a spear and was bandaged with a sling, *sphendóne*, of wool. Four hundred years later, Hippocrates mentions a sphendóne for bandaging. The sphendóne must have looked like a woman's hair band because both had the same name.[2] Ancient Greek physicians took great pride in their bandaging skill and created elaborate dressings. The Hippocratic Collection warned its readers that some physicians turned bandaging into a "foolish parade of manual skill" and to "leave aside theatrical bandages that serve no purpose; this is miserable and fit for charlatans, and often hurts the patient. Indeed the patient is seeking not ornaments, but help."[2] Ancient Greek physicians would cover their patients' wounds with a variety of salves diluted in wine and made from combinations of salts (copper acetate, copper oxide, lead oxide), vinegar, nuts, flowers, grease, and fragrance (myrrh or frankincense—both bacteriocidal as well as fragrant). Wine (which has an alcohol content of 9.8%) is more bacteriocidal than 10% alcohol. Wine's antiseptic components are the pigments malvoside and oenoside, which become activated during fermentation and kill vibrio cholera in 0.5 to 10 minutes, *E. coli* in 25 to 60 minutes and *Escherichia typhi* in 5 to 240 minutes (red wine is faster than white).[2] During the time of Christ, Roman physicians used similar antiseptics as the Greeks. Cornelius Celsus, a Roman physician and author of *De medicina,* ("On Medicine"), an eight-volume work, lists 34 plasters and ointments. All but five contain large doses of lead and copper salts, and those five were meant to produce pus.[2]

In 1891, Johnson and Johnson was the first company to mass produce sterile surgical dressings by sterilizing cotton and gauze with dry heat and then by steam and pressure. The founder of the company, Robert Wood Johnson, heard Dr. (Sir) Joseph Lister speak in 1876 about his antiseptic methods (operating in a fog of carbolic acid) and antiseptic dressings. Lister is credited as developing the first antiseptic dressing in 1867 by soaking lint and gauze in carbolic acid (phenol). Tulle gras, a nonadherent dressing for wounds, was composed of wide-mesh curtain net cut into squares and impregnated with soft paraffin (98 parts), balsam of Peru (one part), and olive oil (one part). It was developed and used mostly in France but gained worldwide popularity during World War I. [11]

As late as the nineteenth century, aseptic surgery was not routine practice. Sterilization of instruments began in the 1880s, as did the wearing of gowns, masks, and gloves. Dr. William Halsted (professor of surgery, Johns Hopkins University, United States, 1852–1922) introduced rubber gloves to his scrub nurse (and future wife) because she was developing skin irritation from the chemicals used to disinfect instruments. The routine use of surgical gloves was introduced by Halsted's student Joseph Bloodgood. Halstead also advocated the use of silver foil dressings for wounds. The antibacterial property of silver was "re-discovered" in the mid- to late 1800s (the Romans were using silver nitrate and other metal filings on wounds). These dressings were used extensively until just after World War II, and were listed in the *Physician's Desk Reference* until 1955. World War II brought renewed demand for first aid products and surgical dressings. The "Rymplecloth" gauze, a purified, whitened, bleached gauze, was developed. It would later become known as the popular Kerlix sponges and bandages. Fine mesh gauze, with its modest absorption but minimally adherent surface, was introduced in 1944. In 1954, Telfa, a nonadherent bandage, was introduced.[12] Today, dozens of dressings impregnated with anything ranging from Vaseline to genetically engineered growth factors are available.

HYPERBARIC OXYGEN

Oxygen therapy has its roots dating back to 1662 with the construction of a pressurized room, or 'domicillium' as it was called, by an English physician named Henshaw. The room was pressurized by bellows raising the air pressure a few pounds per square inch above ambient pressure. This, claimed Henshaw, was good for most afflictions of the lungs and bowels. Junod treated pulmonary diseases in 1834 by placing patients in a chamber with 2 to 4 atmospheres of pressure. Dr. Orval Cunningham constructed the largest hyperbaric chamber in 1928. It was five stories high and 64 feet in diameter with multiple floors, each holding 12 beds. Cunningham never recorded his therapies, and the American Medical Association con-

demned his treatments in 1942 for a lack of scientific proof.[13]

WOUND PHYSIOLOGY

In 1908, Ilya Metchnikoff (1845-1916) won the Nobel Prize for his discovery of phagocytosis and the theory that the purpose of inflammation was to bring phagocytic cells to the injured area to engulf bacteria.[14] F. J. Lang of Chicago published in 1926 that macrophages arose from transformed tissue and migrating monocytes. He also described that injured endothelial cells will elongate and differentiate into wound "fibroblasts" (what he was describing, but did not know it, was angiogenesis).[15,16] Cytokines and growth factors were first described about 50 years ago. In the 1950s, endogenous pyrogen (which we know as interleukin-1), nerve growth factor, and interferon were described.[17] In 1952, Rita Levi-Montalcini (1909-) termed a molecule that was capable of stimulating growth and differentiation of developing nerve cells nerve growth factor.[18] She collaborated with Stanley Cohen (1922-) to further describe it. Stanley Cohen also described epidermal growth factor in 1959. In 1986, both Drs. Levi-Montalcini and Cohen won the Nobel Prize for their work in growth factors.[19] In the 1960s, immunologists described a mediator produced by lymphocytes that affects many immune functions; they called them lymphokines. In the early 1970s, the actions of tumor necrosis factor were described. In the 1980s, clinical trials with monoclonal antibodies against interleukin-2 receptors to prevent T-cell proliferation and as treatment for graft-versus-host disease were underway. In the later part of the 1980s through the 1990s, identification and characterization of inflammatory mediators took off with the identification dozens of interleukins, cytokines, chemokines, growth factors, and more.[17]

CONCLUSIONS

A brief overview of the Western history of wound care has been presented. Some modern practices of wound care were in use millennia ago only to fade and reemerge as "new" thousands of years later. The reader is encouraged to read *The Helping Hand* [2] for an excellent and detailed overview of wound care (and medical) history.

M. le Comte Ringrave died, who was shot in the shoulder, like the King of Navarre before Rouen. M. de Bassompierre, colonel of twelve hundred horse, was wounded by a similar shot, in the same place, as M. de Mansfeld: whom I dressed, and God healed.

—Voyage of the Battle of Moncontour, 1569
Ambroise Paré (1510–1590), French military surgeon

George Broughton II, M.D., Ph.D., COL., M.C., U.S.A.
Department of Plastic Surgery
The University of Texas Southwestern Medical Center
5323 Harry Hines Boulevard
Dallas, Texas 75390-9132
george.broughton@us.army.mil

REFERENCES

1. Henry, G., and Garner W. Inflammatory mediators in wound healing. *Surg. Clin. North Am.* 83: 483, 2003.
2. Majno, G. ***The Healing Hand: Man and Wound in the Ancient World.*** Cambridge: Harvard University Press, 1975. P. 570.
3. Helling, T., and McNabney, W. The role of amputation in the management of battlefield casualties: A history of two millennia. *J. Trauma* 49: 930, 2000.
4. Hamby W. B. ***Ambroise Paré, Surgeon of the Renaissance.*** St. Louis: W. H. Green, 1967. P. 251.
5. Sherman, R. A., and Pechter, E. A. Maggot therapy: A review of the therapeutic applications of fly larvae in human medicine, especially for treating osteomyelitis. *Med. Vet. Entomol.* 2: 225, 1988.
6. Thomas, S., Jones, M., Shutler, S., et al. Wound care: All you need to know about maggots. *Nurs. Times* 92: 63, 1996.
7. Thomas, S., Jones, M., Shutler, S., et al. Using larvae in modern wound management. *J. Wound Care* 5: 60, 1996.
8. Pechter, E. A., and Sherman, R. A. Maggot therapy: The surgical metamorphosis. *Plast. Reconstr. Surg.* 72: 567, 1983.
9. Krajacic, A. Consider using maggots. *Todays Surg. Nurse* 20: 28, 1998.
10. Lionelli, G. T., and Lawrence, W T. Wound dressings. *Surg. Clin. North Am.* 83: 617, 2003.
11. Johnson, S. *Early Years: Our History.* Available at http://www.jnj.com/our_company/history/history_section_1.htm, 2005.
12. Beiersdorf, I. About Us: History. Available at http://ww.curadusa.com/about_us/about_history.asp, 2005.
13. Bill, T. J., Hoard, M. A., and Gampper, T. J. Applications of hyperbaric oxygen in otolaryngology head and neck surgery: Facial cutaneous flaps. *Otolaryngol. Clin. North Am.* 34: 753, 2001.
14. Tauber, A. Metchnikoff and the phagocytosis theory. *Nature Reviews Mol. Cell Biol.* 4: 897, 2003.
15. Lang, F. J.. Role of endothelium in the production of polyblasts (mononuclear wandering cells) in inflammation. 1926. *Arch. Pathol. Lab. Med.* 125: 44, 2001.
16. Lingen, M. Role of leukocytes and endothelial cells in the development of angiogenesis in inflammation and wound healing. *Arch. Path. Lab. Med.* 125: 67, 2001.
17. Vilcek, J., and Feldman M. Historical review: Cytokines as therapeutics and targets of therapeutics. *Trends Pharm Sci.* 25: 201, 2004.
18. Aloe, L., and Levi-Montalcini R. A brief biographic view of past and present studies on nerve growth factor. *Microscopy Res. Tech.* 45: 207, 1999.
19. Stanley Cohen: Autobiography. Available at http://www.nobel.se/medicine/laureates/1986/cohen-autobio.html: Nobel Prize eMuseum Web Site, 1986.