Evolution of wound management throughout history

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Background
Wound management practices have evolved significantly over the course of human history. From the early remedies of the Neanderthals in 60,000 B.C. to the sophisticated techniques of contemporary medicine, the treatment of wounds has undergone various phases of evolution. This paper delves into the intricate history of wound management, spanning from ancient civilizations to the modern era.
Beginning with the significance of wound classification, the study traces the development of wound management practices in different historical periods. It highlights the role of various civilizations, such as the Sumerians and the ancient Egyptians, in the early advancements of wound care. The document extensively covers the contributions of key figures like Hippocrates and Galen, who made significant strides in the understanding and treatment of wounds.
The paper also emphasizes the critical transition from traditional and empirical wound care to a more scientific approach, as demonstrated by the works of Joseph Lister and Louis Pasteur. It discusses pivotal moments in the timeline, such as the advent of antiseptics and the recognition of the role of microorganisms in wound infections. Furthermore, it underlines the contemporary efforts to integrate advanced technologies, such as artificial intelligence, into wound management for early identification of non-healing wounds.
Overall, the paper reflects on the profound historical context of wound care and the persistent advancements that continue to shape contemporary medical practices, emphasizing the importance of understanding the historical trajectory for the effective treatment of wounds in modern medicine.

Keywords: Wounds, history of wound management, wound dressings.

The topic of wound management has been as old as human history. The Neanderthal man in 60,000 B.C. used herbs for burns, and the Smith papyrus talks about dressings dating back to 5000 B.C. (1,2)

A wound is defined as any disruption of normal anatomical and functional structures. There are multiple classifications for wounds, but the most important aspect in their classification is determining whether the wound is acute or chronic, based on the concepts of temporality and order.(1,2,3)

An acute wound is defined as one that follows an orderly healing process within an appropriate time, restoring its anatomical and functional integrity. (2)

On the other hand, a chronic wound is one that does not follow a normal healing process and will not adequately restore its anatomical and functional integrity. (3,4,5)

We define healing as a cascade directed by numerous feedback and regulatory processes driven by signals from the wound tissue itself, the wound microenvironment, as well as the interventions where the tissue is subjected to therapy. (5)

According to different bibliographies, we can divide the healing process into three or four phases, which are as follows:

1. Hemostasis phase, occurring immediately after the injury for seconds to minutes, damages the vascular wall, exposing the extracellular matrix, and continues with platelet aggregation and degranulation, culminating in a fibrin clot. (5,6)
2. Inflammatory phase, which occurs seconds after hemostasis, is divided into the vascular reaction and the cellular reaction. The former causes vasodilation, increasing flow and hydrostatic pressure, leading to intravascular fluid escape, resulting in redness and swelling. In the latter, extravasation and leukocytosis occur, forming a scab. Neutrophils are the first cells to arrive, peaking between 24 and 48 hours, functioning in phagocytosis and

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Figure 1. Goddes Gula

chemotaxis, followed by macrophages and finally T lymphocytes.(6)

3. The proliferation phase is the third or, according to some literature, the second phase since the hemostasis and inflammatory phases are combined as one. This phase occurs between days four and twelve, with important cells being fibroblasts and endothelial cells. Fibroblasts are primarily responsible for synthesizing and remodeling the matrix, while endothelial cells play a crucial role in angiogenesis. (6)

The last phase is maturation and remodeling, which lasts between 6 months and 2 years according to various bibliographies. It is characterized by collagen reorganization with a balance between collagenolysis and collagen synthesis. Tensile strength continues to increase for several more months but never equals the pre-injury tension.

There are three different ways of healing based on the form and time of occurrence: Healing by primary intention, which is ideal for any surgeon. Tissues heal by primary approximation, characterized by no local secretion, no separation of wound edges, minimal edema, and minimal scar formation. (6.7)

Healing by secondary intention refers to when the wound is not promptly closed as instructed by the surgeon. This usually happens in dirty wounds, and the healing process is more prolonged and complicated. (7,8)

Figure 2. Papire of Smith.

The wound heals from the deep layers and edges, forming granulation tissue containing myofibroblasts that help in wound contraction. This process is slow and generally leaves a non-aesthetic scar. (8)

Healing by tertiary intention is a safe method for repairing highly traumatized tissues or highly contaminated wounds. A thorough cleaning of the wound is performed, and closure is deferred for three to seven days after the wound's production, evaluating its evolution, thus ensuring subsequent closure without complications.(8)

The aim of this essay is to discuss wound management throughout history, as well as innovations and new therapeutic approaches to various types of wounds that may arise. (8,9)

History of wound management

The man has shared his life since the very beginning with wounds and has not managed to escape their repercussions. Therefore, their care has varied immensely over the years, as wound management has been observed from prehistoric times to the modern age. (1,2)

From prehistoric times until 3000 B.C., the only information we have about the life and illnesses of human beings from those eras is based on archaeology. (1,2,3)

During this period of history, there is a lack of written information. There are remains with bone fractures and dislocations, but there is no evidence of wound treatments. It is undeniable that wounds have been present since the beginning of humanity; therefore, they have been the oldest field of surgery. (1)

The main drawback of the lack of written information is that since wounds are injuries that affect the soft tissues of the body, they do not leave traces on bone surfaces, which are the main material that paleontologists work with, thus hindering the study of wound management during this era of humanity.(2,3)

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Figure 3. Galeno de Pergamo

There is evidence of infectious processes such as osteomyelitis, which may have resulted from the chronicity of wounds.

During these times, women were the bearers of recipes for wound management and were in charge of the healing process. Initially, these practices were based on the direct observation of animals and their various significant actions for well-being, such as licking wounds or consuming specific plant products.(1,4)

These were applied in the form of bandages on the wounds, including leaves, stem fibers, barks, resins, and even soil and animal excrement. This practice continued for several centuries in various civilizations.(2,3,4)

In the final period of this era, the figure of the shaman, who was a priestly healer, began to emerge. Documented from this era, the shaman is depicted adorned with feathers and was responsible for preparing medicinal remedies. They were also entrusted with the incorporation of the wound healing process. During this time, the environment was characterized by a magical-religious component derived from the spiritual beliefs of that era. (5,6)

During ancient times, while most descriptions point to the Egyptians as pioneers in medicine, especially in the art of wound healing, it is important to note that the ancient Mesopotamian culture of the

Figure 4. Image of the treatise "Practiva chirurgiae"

Sumerians, the creators of writing, were the first to transmit and evolve knowledge in the field of medical arts, albeit with certain limitations primarily dictated by the moral and religious beliefs of that era.(5,6)

The gods of that period influenced all aspects of daily life, including health, in a similar manner.(6)

The goddess Gula, (Figure 1) also known as Ninkarrak and Ninisinna, was the one who presided over health and healing, aided by her consort Pabilsag and their children Damu and Ninazu, as well as their daughter Gunurra. This goddess was the main deity of healing and health, known as the "great physician of the black-headed people," as the Sumerians were called. The intertwined staff with snakes, an international symbol of health, did not originate with her but with her son Ninazu, who was associated with snakes, healings, and the underworld. (7,8)

The relationship between religion and health during this era indicated that wounds that did not heal, persistent infections, sepsis, and death were directly related as punitive consequences, seen as divine punishment for the misdeeds of the affected individuals.(7)

The antiseptics of that time were made from a mixture of honey, alcohol, and myrrh. (1)

It is described in ancient texts that during that era, the ancient culture in the treatment of all wounds consisted of three critical steps, which were: washing, applying plaster, and bandaging the wound. (1,2)

What is even more surprising is that the Sumerians recognized the use of clean water for washing wounds and ensuring that the hands of the physician were also properly clean, which prevented the appearance of infections and accelerated the wound healing process. (3,4,5)

Hands and wounds were cleaned with a kind of mixture of beer with hot water. (2)

There are documents describing the preparation of poultices, as well as the use of certain medications that were used for wounds. As amazing as

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Figure 5. Guy de Chauliac.

it may seem, the principles of TIMES began to be described approximately 4200 years ago.(8,9,10)

The maximum exponent was the Smith Papyrus (Figure 2), which was considered the first specialized book for the management of wounds. It describes the types of injuries and provides an overview of the exploration, diagnosis, likelihood of success, and the management to follow. (1,2,3)

Some of the treatments described in this papyrus included suturing the wound, placing fresh meat on it during the first day, resting until it healed, and performing daily treatments using lard, honey, and flax fibers.(8,9)

Wound suturing is also an ancient practice; stone needles have been found that could have been used as suturing instruments for wounds. (10,11,12)

The Masai tribe in Africa used a sharp thorn from an acacia branch, which was inserted into the edges of the wound and tied together with a braided plant fiber thread. (10,11)

Tribes in India and South America used termite or beetle mandibles to join the edges of wounds, comparing this method to the principles of the current technique of suturing with staples. (1,2)

In the year 1250 B.C., during the reign of Ramses II, an inscription appeared on a stone, which is the first written document about the work of nurses. It can be read how a group of women was given the obligation to work in the construction of the temples of the Valley of the Kings, to dedicate themselves to the care of sick members of their family. (1,2,3)

Figure 6. Ambroise Paré.

Some activities such as circumcision or embalming were carried out by priests, while tasks such as feeding, hygiene, and the application of basic remedies were assigned to servants or slaves, always supervised by the lady of the house. (2,4,6)

In 500 B.C., Greek natural philosophy began, which conditioned medicine toward the rationalization of health phenomena.

Religion, empiricism, and magic were replaced by observation and reason, leading to a theoretical development of medicine, which today we could call scientific medicine.(1,5,6)

This period achieved the consolidation of rational thought, the "logos" versus the "mythos" or mythical thinking.

The ultimate representative of this period of history and the creator of rational empirical medicine was the Greek physician Hippocrates, who founded a school and whose legacy is considered a masterpiece to this day. (1,4,7)

Hemostatic bandages were described by Chrysippus of Cnidos, as well as other non-invasive methods in the management of traumatic injuries. It was common to wash wounds with beer, hot water, and honey, and then cover them with gauze impregnated with herbal plasters and fat. (1)

Galeno of Pergamon (120-201 A.D.) (Figure 3) was a physician, surgeon, and philosopher of the Roman Empire who gained extensive experience with wounds through the treatments he performed on

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Figure 7. Dominique Jean Larrey

gladiators. It is important to remember that autopsies were prohibited by law during that era. (1,4,6)

Galeno took advantage of these brutal events to record different soft tissues, anatomical structures, and even visceral organs. (1)

Some of Homer's epics describe wounds and their treatments. In relation to treatments, there is a passage in the Iliad where a warrior heals another in the following way: "With a knife he removed the sharp tip of the arrow from the hip, washed and cleaned the wound with warm water, and applied an ointment to soothe it." (1,9)

In the same work, we can ascertain the high mortality caused by weapon wounds during that era, describing a mortality rate of 100% for sword wounds, followed by spears at 80%, slings at 67%, and arrows at 50%. (2,4)

In one of the aphorisms of Hippocrates regarding wound management, he states: "What medicines do not cure, iron cures. What iron does not cure, fire cures. But what fire does not cure, that must be considered incurable." (1,9,12)

His teachings speak of the wound being moistened exclusively with wine and recommend that new wounds, lacerations, or those from weapons, should form pus as soon as possible, as both the wounds and their surroundings will then become less inflamed. However, this pus should not accumulate at the wound's opening; it should be able to drain the excess. If this does not happen, the wound should be treated with a remedy that is not too strong, so as not

Figure 8. Luis Pasteur

to excessively dry the wound and avoid triggering fever with shivering and cramps. (13,14)

During the Middle Ages, the interest in the study of classical world medical science, especially Greek medicine, continued. Medicine was practiced in monasteries, managed by priests, monks, and clerics who lacked any medical knowledge. The method they mainly used for treating diseases was bloodletting, accompanied by the corresponding prayers, asking God for the patient's recovery. (1,9,10).

During the 12th century, a center of medical studies appeared in southern Italy, known as the School of Salerno. There, wounds were treated with egg white mixed with rose oil and brandy. According to the teachings of Galen, they considered suppuration as a normal and necessary phase of healing. (1,2,4)

The first treatise of this era on surgery was "Practiva chirurgiae" by Ruggero Frugardi (1170) (Figure 4), who was a prominent figure in the School of Salerno and was in charge of treating wounds. (1,9.13).

Guy de Chauliac, in his work "Chirúrgica Magna" in the year 1363 (Figure 5), was the first to observe wounds caused by firearms, first used in the Battle of Crécy in 1346. He also described how the perfect surgeon's kit should contain five ointments: basil to ripen pus, apostles for purification, gold to promote tissue growth, white for healing, and dialethea to induce sweating. Along with these, there should be five tools: tongs, probes, a blade, lancets, and needles. (14,15)

In the Renaissance, the renewed knowledge of anatomy quickly influenced medicine. Religious wars provided a large number of patients for military surgeons. Physicians had obtained the right to supervise barber surgeons, elevating them to the same level as barbers while belittling them. (1,5,7)

At the beginning of the 16th century, Juan de Vigo affirmed the caustic and toxic nature of many

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Figure 9. Joseph Lister

wounds caused by firearms. He proposed the use of hot iron and boiling oil on the injury, followed by the application of aromatic plasters or Egyptian ointment. Surgery saw significant development thanks to Ambroise Paré (1510-1590) (Figure 6), titled the "Father of Modern Surgery," who also served as the first surgeon of the chamber to King Charles IX of France. He used egg yolk, rose oil, and turpentine, finding that his patients experienced less pain and inflammation. He concluded that he would no longer cauterize the wounded. (1,10,13).

During the Romanticism period, the following approach was emphasized for infected wounds: drainage and removal of extravasated blood with the application of liquids. The use of cold water dressings was supported, and wounds were irrigated with calcium chloride. The modernization of warfare with the regulated incorporation of firearms and the development of military hospitals on the battlefield provided an ideal setting for the exploration and treatment of a large number of wounded. (1,10,14,15).
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In the modern era, wars were a fundamental driving force for the development of surgical empiricism. French surgery, influenced by its conflicts, was enriched by the presence of important

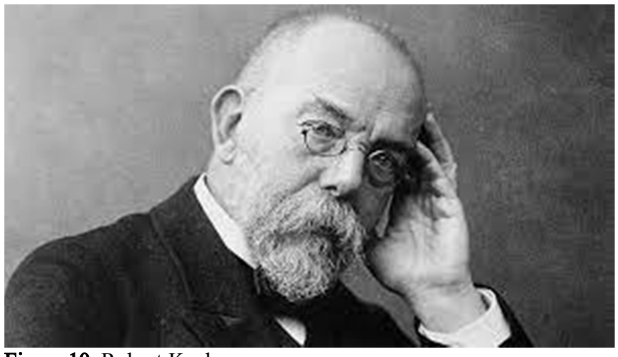

Figure 10. Robert Koch

surgeons, among whom Dominique Jean Larrey (1766-1842) (Figure 7) stands out. Among his many achievements was the creation of the first corps of ambulance attendants, as well as observations on thoracic wounds through proper cleaning and suturing, which increased survival. This era saw a new conception of military surgery that radically surpassed its traditional image. In addition to wound treatment and care for the sick, the new surgery included the organization of the transport of the wounded and their medical assistance on the battlefield, the technical training of personnel, and even the adoption of preventive measures based on epidemiological studies. (1,10,15)

Between 1860 and the mid-19th century, half of the patients admitted to surgery died from infections. Erysipelas, gangrene, and purulent edema were the predominant causes. Louis Pasteur (1822-1895) (Figure 8) demonstrated that fermentation was due to the presence of microorganisms carried on dust particles floating in the air, which adhered to solid bodies and multiplied in liquid media. He proved that it was possible to eliminate these microorganisms through heat. By 1865, Pasteur's work had become known to Joseph Lister. (1,10,12)

Joseph Lister (1827-1912) (Figure 9) aimed to prevent any agents from entering wounds, thus he used phenol. However, it was not until Lemaire's work between 1860 and 1863 that its effectiveness was demonstrated. (1,9,15)

Robert Koch in 1978 (Figure 10) published his work, in which he urged surgeons to consider preventing the entry of microorganisms rather than waiting for disinfection once the wound was already contaminated. (1,11,12)

George Winter in 1962 (Figure 11) determined that maintaining a moist environment in wounds resulted in better healing compared to those exposed to air. Moisture is maintained by occluding and retaining wound fluids in place, thereby preventing dehydration and desiccation with an interface between the environment and the wound. (1,11,13,14)

This led to the first controversy in the medical field, which was the impression that occlusive healing

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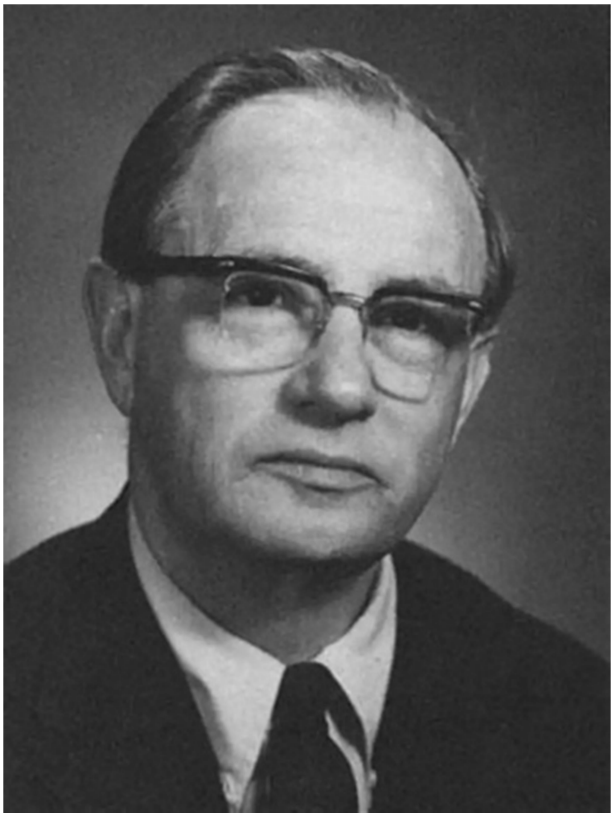

Figure 11. George Winter

caused infection due to lack of drainage. However, Winter scientifically proved that wounds covered with a polymeric film epithelialized almost twice as fast as wounds exposed to air, confirming that the creation of a moist and controlled environment improved collagen synthesis, cell proliferation, and angiogenesis, known as moist wound healing.(14,15)

Regarding the contemporary age, an important fact about chronic wounds globally considered was the significant increase in life expectancy over the last 60 years from an average of 57 to 75 years, creating not just a complex wound but a more complex wound due to increased malnutrition, chronic degenerative diseases, polypharmacy, senility, disintegrated social nuclei, and lack of family attachment, resulting in chronic, severe, and challenging wounds that require a deeper study of the patient, as well as professional practice and experience for optimal care. (1,10)

TIMES was initiated in 2003 for the optimization and primarily the creation of an optimal wound bed, and in 2013, DOMINATE was created, adding a more holistic vision to this previous ideology, incorporating a nutritional, metabolic, pharmacological, and psychosocial approach with great acceptance. (5,6,7,8)

With the advances in electron microscopy and a better understanding of biomolecular processes, the comprehension of the biofilm or biocap and its relation to wound chronicity were added to these tools. Similarly, the boost in sciences such as immunology and infectiology supported the understanding of the microbiota and its both eutrophic and pathological states. (9,10,11)

The evolution of reconstructive techniques and the creation of both synthetic and autologous soft, bony, and even visceral tissues have enabled the effective treatment of large defects that were considered fatal 20 years ago, and incredibly, in many cases, with acceptable aesthetic results. (12,13)

Currently, there are multiple efforts to integrate artificial intelligence as a guiding tool for decision-making regarding treatment by identifying early the patients at risk of non-healing. (11,12,13)

Conclusion

The world of wounds, as we have seen, is as vast and ancient as the very history of humanity. Wounds have accompanied us since the beginning of human history, and just as humans have evolved, so too has the management of wounds. As we have seen throughout history, there have been many occasions of significant progress and, at other times, some setbacks. It is of utmost importance for our medical community, which seeks specialization in the management of patients with wounds, to understand from the most basic definitions of what wounds are, their pathophysiology, the physiology of the normal healing process, the classifications, and types of wounds that we may encounter. It is also crucial to understand the extensive history that encompasses the management of wounds from the beginnings of civilizations to the present day.

Conflicts of interests

There are no conflicts of interest.

References

1. Andrades P. Curación avanzada de heridas, Rev. Chilena de Cirugía. 2004; 56: 396-403.
2. Lazaurus GS. Definitions and guidelimnes for assessment of wounds and evaluation of healing, Arch Dermatol. 1998; 25: 433-41.
3. Krizek TJ, Harries RH, Robson MC. Biology of tissue injury and reapir. En: Georgiade GS (ed). Plastic, Maxilofacial and Reconstructive Surgery. 3er ed. Williams and Wilkins, 1997; 3-9.
4. Rohrich R, Robinson J. Wound Healing. Select Read Plast Surg. 1999; 9: 1-39.
5. Nwometh BC, Yager DR, Cohen K: Physiology of the chronic wound. Cl Plast Surg 1998; 25: 341.
6. Robson M: Cytokine manipulation of the wound. Cl Plast Surg 2003; 30: 57-65.
7. Castellanos D. Manejo de heridas, Cirujano General. 2014; 2: 112-120.
8. Yager DR, Nwometh BC: The proteolytic environ- ment of chronic wounds. Wound Repair Regen 1999; 7: 433-41.

DOI 10.5281/zenodo.10032418

9. Vranckx JJ, Slama J, Preuss S, et al: Wet wound healing. Plast Reconstr Surg 2002; 110: 1680.
10. Heggers JP: Defining infection in chronic wounds: does it matter?. J Wound Care 1998; 7: 389.
11. Salem C. Heridas. Conceptos generales, Cirugía. 2000; 14: 90-99.
12. López J. La evolución en el manejo de heridas y su importancia en la historia de la humanidad, Cirugía Plástica. 2021; 31: 116-123.
13. Mengarelli R. Evolución del tratamiento de las heridas a lo largo de la historia, CicatrizAR. 2016; 3: 27-30.
14. Martinez F. El cuidado de las heridas: Evolución histórica, GEROKOMOS/HELCOS (1999) Vol. 10 pp. 182-192.
15. Ladin D. Understanding wound dressings. Cl Plast Surg 1998; 25: 433-41

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