Wound Healing Process, Phases of Wound Healing and Risk Factors: A Review

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Abstract: Wound healing is a complex process in which the skin (or another organ) repairs itself after injury. Various cells and biological molecules work together in this process to repair the damaged tissue. The first step in wound healing is for the body to stop the bleeding. This is done by clotting factors in the blood coming into contact with damaged endothelial cells lining the blood vessels. Once bleeding has stopped, repair cells called fibroblasts migrate into the area to start synthesizing collagen fibers and other materials needed to rebuild the tissue. At the same time, new blood vessels begin to form, and inflammatory cells help clear away debris. As collagen is laid down and cross-linked, a temporary scaffold is formed that will eventually be replaced by permanent scar tissue. The rate of wound healing varies depending on many factors, including age, nutrition, immune status, and chronic health conditions.

Keywords: Wound Healing, Wound healing Process, Wound healing Risk Factor, Phases of Wound Healing

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INTRODUCTION

When an object pierces the skin, it creates a wound. The depth of the wound depends on the object that caused it. A shallow wound may only damage the outer layer of skin, while a deep wound can penetrate to the bone [1]. A wound can significantly impact a person's life, depending on its severity. A minor wound may heal quickly and cause little

inconvenience, while a more serious one may take weeks or months to recover from and require hospitalization. Sometimes, a wound can lead to permanent disability or even death [2].

Wound healing is a natural process wherein the skin or any other injured part of the body repairs itself. It is a complex process that involves various steps like inflammation, formation of new tissue, Etc [3]. The wound healing process can be divided into three phases: inflammatory, proliferative, and maturation. The inflammatory phase occurs immediately after injury and is characterized by the release of cytokines, growth factors, and enzymes that promote tissue repair [4]. The proliferative phase is characterized by cell proliferation and extracellular matrix synthesis. This phase lasts for approximately 2-3 weeks following injury. In the final stage of wound healing, maturation is characterized by remodeling of the extracellular matrix and collage [5].

Types of Wound

There are four types of wounds: incised, lacerated, punctured, and avulsion. Incised wounds are caused by a clean, sharp-edged object like a knife or razor [6]. Lacerations are ragged tears in the skin caused by a blunt force. Punctures are small, deep holes caused by something sharp, like a nail or needle. Avulsions occur when part of the body is torn away from the rest, usually by trauma [7].

Incised wound

Incised wound is caused by a sharp object, like a knife, slicing through the skin. It's a clean cut with well-defined edges. Incised wounds are deep cuts that go through all the layers of the skin [8].

Lacerated Wound

A lacerated wound is a deep cut or tearing of the skin. Lacerations can occur from sharp objects, such as knives or glass, or from blunt trauma, such as a punch or fall. Depending on the depth and location of the laceration, they can be quite painful and may require stitches or other medical treatment [9].

Punctured Wound

Punctured wound is a deep cut that penetrates the skin and underlying tissues. It is caused by a sharp object, such as a nail or knife. The most common type of punctured wound is a stab wound, which is usually inflicted with a sharp object, such as a knife [10].

Avulsion Wound

An avulsion wound is a type of traumatic injury that occurs when an external force tears a body part away from the rest of the body. This can occur when a limb is severed by an accident or when clothing or jewelry gets caught on something and pulls off the skin. Avulsion wounds are usually very painful and can result in significant blood loss [11].

Stages of Wound

Stages of wound healing are haemostasis, inflammation, proliferation and remodeling. Each stage is characterized by different events which lead to successful healing. Haemostasis occurs immediately after injury, where blood vessels constrict to stop bleeding. Inflammation occurs when repair cells and antibodies are attracted to the injury site [12].

Proliferation is when new tissue starts to form and remodeling is the final stage where tissues heal, and scarring may occur. Stages of wound healing are haemostasis, inflammation, proliferation and remodeling. Each stage is characterized by different events which lead to successful healing [13]. Haemostasis occurs immediately after injury, where blood vessels constrict to stop bleeding. Inflammation occurs when repair cells and antibodies are attracted to the injury site. Proliferation is when new tissue starts to form and remodeling is the final stage where tissues heal, and scarring may occur [14].

Stages of wound: Haemostasis, inflammation, proliferation and maturation

Haemostasis

Haemostasis is the body's natural mechanism for stopping bleeding. It involves three steps: vasoconstriction, platelet plug formation, and coagulation (clotting) [15]. Haemostasis can be disrupted by a number of factors, including blood vessel damage, platelet dysfunction, and abnormal clotting proteins. This can lead to excessive bleeding or hemorrhage [16].

Inflammation

Inflammation is the body's natural response to injury or infection. It is a protective mechanism that releases immune cells and mediators to clean up damaged tissue and kill pathogens [17]. However, when inflammation persists or occurs in excess, it can damage healthy tissue and lead to chronic diseases such as arthritis, heart disease, and cancer. Therefore, it is essential

to know the signs and symptoms of inflammation [18].

The inflammatory phase of wound healing is the first stage of the healing process. It begins with the release of inflammatory mediators and ends when the wound is covered with a new layer of tissue. Four main events characterize this phase [19].

(1) Vasoconstriction,

(2) Microvascular leakage,

(3) Neutrophil infiltration, and

(4) Macrophage infiltration.

These events lead to a fibrin clot that provides a scaffold for repair. Additionally, growth factors and cytokines are released during this phase which promotes cell proliferation and migration [20].

Proliferation

In the proliferation phase, cells called fibroblasts and endothelial cells migrate into the wound area. They secrete collagen and other proteins that form a network of strong fibers called granulation tissue [21]. This provides support for new blood vessels to grow into the area. The result is increased blood flow, which brings more oxygen and nutrients to the wound site. This phase typically lasts two to three weeks [22].

This is followed by the maturation phase, where cells grow and develop into their final form. The last stage is the death phase, where cells die off or are eliminated. The cell cycle is an ordered series of events that occur in a cell leading to its division and replication [23].

The cycle can be divided into four main phases: interphase (G1, S, and G2), mitosis (M), and cytokinesis. Interphase is itself further divided into three sub-phases: [21, 22]

1. G1 phase, during which the cell grows
2. S phase, during which DNA replication occurs
3. G2 phase, during which the cell prepares for mitosis

Mitosis is then followed by cytokinesis, during which the cytoplasm of the parent cell divides to form two daughter cells [24].

Maturation

The maturation phase of wound healing is marked by the gradual transformation of the wound from a raw and bloody surface to a healed and scarred one. This process can

take several weeks or even months, depending on the depth and severity of the wound [25]. During this time, new collagen fibers are laid down to replace the damaged ones, and the skin gradually regains strength and elasticity. Although complete healing may not be achieved until this phase is complete, most wounds will have significantly healed by this point [26].

Pathogenesis of Wound Healing

Pathogenesis of wound healing by secondary intention results from an inflammatory process. This process is initiated by cells in response to tissue injury and releases cytokines and growth factors that promote cell proliferation, extracellular matrix production, and angiogenesis [27]. The final step in wound healing by secondary intention is remodeling, characterized by collagen deposition and organization into parallel bundles. Remodeling takes place over weeks to months and results in tissue strength comparable to uninjured tissue [26].

Etiology of Wound Healing

Wound etiology is essential to consider when treating a patient with an ulcer. Ischemia, venous disease, and arterial insufficiency are the most common etiologies of wounds. The practitioner must also be aware of other potential causes, such as diabetes, trauma, infection, and neoplasm [27]. Treatment will vary depending on the underlying cause of the wound. For example, a wound caused by ischemia will require revascularization, while a wound caused by infection will require antibiotics. The practitioner must also take into account the patient's comorbidities and individual circumstances when formulating a treatment plan [28]. The importance of considering wound etiology cannot be understated. When treating patients with ulcers, it is crucial first to identify the underlying cause of the wound. Ischemia, venous disease, and arterial insufficiency are the most common etiologies of wounds; however, other potential causes such as diabetes, trauma, infection, and neoplasm must also [30].

Skin Structure

Skin structure and function are maintained by a complex communication network between the different cell types that make up the skin. This communication is essential for maintaining normal skin function and homeostasis [31]. The cells of the skin communicate through various mechanisms, including gap junctions, which allow for direct communication between adjacent

cells, and secreted mediators, which can diffuse long distances to reach target cells. These signals regulate a variety of processes in the skin, such as proliferation, differentiation, and apoptosis (cell death) [32].

The skin comprises three layers: the epidermis, dermis and subcutaneous tissue. The epidermis is the outermost layer and is made up of stratified squamous epithelium. This layer provides a barrier against the environment and prevents water loss [33]. The dermis is the middle layer and consists of connective tissue supporting the skin. It also contains blood vessels, nerves, hair follicles and sweat glands. The subcutaneous tissue is the innermost layer and consists of loose connective tissue and fat cells. This layer helps to insulate the body and provides shock absorption [34].

Treatment

Treatment of wound healing is an essential aspect of modern medicine. The process of wound healing is a natural process that occurs in the body to repair damaged tissue. However, certain medical interventions can help speed up the process and improve the overall outcome. Treatment options for wound healing include: [35]

Antibiotics

These are used to treat infections that can delay or prevent healing. Antibiotics for wound healing are essential to prevent infection and speed up healing. Many different types of antibiotics are available, and the best one for a particular wound may vary depending on the type of bacteria present [36]. Choosing an antibiotic that is effective against the specific type of bacteria causing the infection is important. In some cases, more than one type of antibiotic may be necessary to clear the infection completely [37].

Surgery

This may be necessary to remove dead tissue or close a wound. Surgery for wound healing is a medical procedure performed to repair damaged tissues. The goal of surgery is to promote healing and prevent infection. Many different types of surgical procedures can be used to treat wounds. The type of surgery that is performed will depend on the location and severity of the wound [38].

Skin grafts

This is a procedure where healthy skin is transplanted to an area of damaged skin. Skin grafts for wound healing are a standard

and effective treatment. The skin graft will take on the appearance of the surrounding skin, so it is essential to choose a donor site that will match the colour and texture of the recipient site [39]. There are two types of skin grafts: autografts and allografts. Autografts are taken from the patient's body, while allografts come from donors. Both types of skin grafts have their advantages and disadvantages [40].

Hyperbaric oxygen therapy

This treatment involves breathing 100% oxygen in a chamber at high pressure, which can promote healing by increasing the amount of oxygen available to tissues [41]. Hyperbaric oxygen therapy for wound healing is a medical treatment that entails breathing pure oxygen in a pressurized chamber. The high oxygen concentration under pressure enhances the body's ability to heal by promoting the growth of new blood vessels and skin tissue. Additionally, hyperbaric oxygen therapy can help reduce inflammation and fight infection. While typically used to treat slow healing wounds, hyperbaric oxygen therapy has also been effective in treating various conditions, such as chronic pain, stroke, and Alzheimer's disease [42].

Nutrition

Eating a well-balanced diet with adequate protein and calories can help support healing. Nutrition for wound healing includes adequate protein intake because wounds require increased amounts of specific amino acids to heal [43]. Furthermore, vitamin C is necessary for producing collagen, which is essential for wound healing. Vitamin A is also necessary for proper immune function, which is essential in order to fight infection and promote healing. Finally, zinc is required for the production of new tissue [44].

Risk factors

Risk factors for wound healing include age, comorbidities, medications, nutrition, and smoking. These factors can delay or prevent healing by affecting the cells and tissues involved in the repair process [45]. Age-related changes in cell function may contribute to impaired wound healing in the elderly. Comorbid conditions such as diabetes, obesity, and vascular disease can also lead to poor wound healing by reducing blood flow and oxygenation and causing inflammation [46].

Medications that suppress the immune system or affect clotting can also interfere

with healing. Poor nutrition can limit the availability of nutrients necessary for cell repair and growth. Smoking delays wound healing by constricting blood vessels and reducing oxygen levels in tissue. In order to promote wound healing, it is essential to address any underlying risk factors that may be present. This includes ensuring that the individual is receiving adequate nutrition, managing any comorbid conditions, and avoiding smoking [47].

Comorbid conditions

These common diseases include diabetes, hypertension, obesity, and poor nutrition. These conditions can lead to decreased blood flow to the wound site, which can delay healing. In addition, patients with comorbid conditions often have other health problems that complicate their care [48]. For example, obese patients may have difficulty moving around and risk developing pressure ulcers. Patients with diabetes may have poor circulation and are at risk for infection. Hypertensive patients may have trouble controlling their blood pressure, which can delay healing [49].

Medicine

Medications risk factors for wound healing include steroids, NSAIDs, diabetes, and cancer. Some medications can delay or prevent healing by inhibiting the inflammatory response crucial to wound repair [50]. In addition, certain medications can interfere with blood clotting, which is also necessary for proper healing. Diabetes and cancer can also impede the body's ability to heal wounds by causing problems with circulation and immunity [51].

Poor Nutrition

Poor nutrition can lead to poorer wound healing. To heal properly, the body needs certain nutrients, such as protein, vitamin C, and zinc. If a person does not have enough of these nutrients in their diet, they may have trouble healing from wounds. In some cases, poor nutrition can even delay the healing process. Therefore, people with wounds need to eat a well-rounded diet with all the necessary nutrients for healing [52].

Smoking

Smoking affects wound healing by decreasing the level of oxygen that gets to the wound. This is because when smoking, the carbon monoxide in cigarettes replaces some of the oxygen in red blood cells. This means that less oxygen is available to heal wounds. In addition, smoking also decreases the

production of collagen, which is an essential protein for wound healing [53].

Conclusion

Wound healing is a complex and dynamic process that begins immediately after an injury occurs. It is a continuous and coordinated sequence of events that leads to restoring functional tissue. The healing process is divided into three overlapping phases: inflammation, proliferation, and maturation. Each phase is characterized by different cellular events and interactions with the extracellular matrix.

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