

A Review in the View on Wounds

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ABSTRACT:

Whatever the etiology of wounds, some heal without difficulties, however in chronic wound the ultimate goal in wounds healing are to control symptoms and prevent complication like infection. The latter occurs when microorganisms of different kinds grow within damaged skin. The sign and symptoms vary according to wounds type, severity of infection and immune system, generally simple wound infection can be treated at home. However medical attention should be needed in severe wounds infection. Clinical and laboratory examination play an important role in diagnosis wounds infection. Different kinds of wounds managements are required as antibiotics, antiseptics, depressing and debridement. Hemostasis, inflammation, proliferation, and remodeling are the main four stages involves in wounds healing.

The aims of this review are highlight the types of wounds, the microorganisms involved, causes and management, and the effective preventive procedures of wound infection.

keywords: Antimicrobial treatment, Biofilm, Wounds infection.

مقال مراجعه في منظر على الجروح

الخلاصة

مهما كانت مسببات الجروح فبعضها يشفى دون صعوبات. ولكن في حالة الجرح المزمن فإن الهدف النهائي من التئام الجروح هو السيطرة على الأعراض ومنع حدوث مضاعفات مثل العدوى. يحدث هذا الأخير عندما تنمو الكائنات الحية الدقيقة من أنواع مختلفة داخل الجلد التالف. تختلف العلامات والأعراض وفقاً لنوع الجروح وشدة العدوى والجهاز المناعي، ويمكن عمومًا علاج عدوى الجرح البسيطة في المنزل. ومع ذلك، يجب أن تكون هناك حاجة إلى عناية طبية في حالات الإصابة بالجروح الشديدة. يلعب الفحص السريري والمختبري دورًا مهمًا في تشخيص عدوى الجروح. هناك حاجة إلى أنواع مختلفة من علاجات الجروح مثل المضادات الحيوية، المطهرات، الضمادات، وتنظيف الجروح. الإرقاء والالتهاب والتكاثر وإعادة التشكيل هي المراحل الأربع الرئيسية التي تنطوي على التئام الجروح.

الهدف من مقالة مراجعة هذه إلى تسليط الضوء على أنواع الجروح، والكائنات الحية الدقيقة المعنية، والأسباب وطرق لعلاج، والإجراءات الوقائية الفعالة لعدوى الجرح

الكلمات المفتاحية: علاج مضاد للميكروبات، الاغشية الحيوية، عدوى الجروح.

INTRODUCTION:

In our environment, where we live every surface harbor a microorganism usually the skin prevents the entry to tissue, however subcutaneous tissues act as an ideal

environment for microbial growth, hosts immune system can effectively limit bacterial proliferation whenever there is any breach in dermal barrier. However, in situations where

there is high bacterial load or when the immune response is compromised by trauma or other co-morbidities bacteria might establish themselves within the wound tissue with subsequent impact on the healing process (1).

It is well known that the skin is the body's first line of defense. In terms of physiology, the normal skin protected by acid film which represent a physiological barrier that regulates pH of the skins. In addition, such layer maintains skin a normal flora helps to prevent pathogens from entering the body. Pathogenic microorganisms often displace some of the normal flora and colonize the skin in certain locations, but in most cases and due to the mentioned defense, this does not lead to infection and does not stimulate the immune response (2).

Wound infection occurs when a pathogenic microorganisms colonize the broken skin with subsequent invasion of the underlying tissues with localized defector excavation of the skin. In addition, the such invasion stimulates the immune response causing

Classification of wounds:

A-According to integrity of skin (5).

1-Open wound: open wounds can be subclassified into:

-Incised wound: wound results from objects as knife or glass with narrow, sharp edges, it has regular clear cut borders, wound of this type is usually clean with sometimes minimal debridement.

-Lacerated wound: caused by saws and fan blades with narrow dull irregular wound edges with crushing which extends a limited distance, such type of wound usually required moderate debridement.

-Perforating wound: as gunshot wounds.

inflammation then tissue damage, such complication may result in slowing of the healing process. Some types of infection resolve on their own, while other infections if left untreated, can become more severe and require medical intervention (3).

Although bacteria are the most common cause of wound infection, but fungi and protozoa can also play role in developing secondary infections especially in immunocompromised patients. In fact, polymicrobial infection can be seen in chronic wound infection (2).

Generally the detection of bacteria in wound exudate, by direct microscopical and macroscopical cultural examination, provide an evidenc of wound infection however, treatment with antibiotic may interfere with bacteriological studies (4).

The aims of this review are to highlights on the types of wounds, the microorganisms involved, causes and management, and the effective preventive procedures of wound infection.

-Abrasions: superficial wound which heals by epitheliazation.

-Penetrated wound: nails is the most common cause, which there is a small opening but very deep.

-Avulsion: the most severe type of injury, which involve separation of tissues. A degloving injury is a special type of avulsion. In this type debridement is complex, and often grafts are require to repair.

2-Closed wound (6), (7)

-Hematoma: a collecting of blood under the skin caused by a damage to the blood vessel, usually hematoma follow pus formation.

-Contusions: known as bruise trauma it is the main cause of tissue damage without breaking skin, there is

bleeding that end with skin discoloration.

-Crush injury: characterized by a vicious circle of ischemia, hypoxia, oedema, and disturbed microcirculation.

B-According to wound hygiene (8)

-Class I/Clean: no inflammation is encountered as in closed wound or closed with drainage as in respiratory, alimentary, and genital incisional wound.

-Class II/Clean Contaminated: operative wound infection as in biliary tract, appendix, vagina and oropharynx are included in this category.

-Class III/Contaminated: surgical site infection.

-Class IV/Dirty-Infected: old traumatic wounds, perforated viscera,

Follow these steps to help keep wounds from getting infection (9).

- Wash the wound with soap and water.
- Use the appropriate antibiotic ointment.
- Cover wounds with dressing.
- Keep the wound clean and dry.
- Clean the hands before and after caring the wound.
- Change the dressing daily.

The following steps are taken by hospitals to prevent surgical site infections (10), (11).

•Hand washing: by using antiseptic soap, surgeon and operating room staff wash their hands and arms.

•Clean skin. by using antiseptic solution for cleaning the site of incision.

•Sterile clothing and drapes. medical uniforms are wearied.

•Clean air: air filter and positive pressure airflow are used in operating room

• Antibiotics use: a proper type of antibiotics are used according to type of surgery and patient condition.

which suggest that the organisms caused post-operative infection are already present in the operative field before the operation.

C-According to wound depth (6).

-Superficial wounds: only the epidermis is affected without bleeding and usually heals within few days.

-Partial-thickness wounds: part of dermis and epidermis is affected with bleeding. It can take several days to several weeks to heal by epithelialization, such as 2nd degree burn.

-Full-thickness wounds: involves the epidermis, dermis, and deeper tissue. It takes longer time to heal, such as 3rd degree burn.

•Controlled blood sugar levels: should be watched to ensure the blood sugar level within a normal range.

•Controlled body temperature: low body temperature prevent oxygen from reaching the wound and thus decrease the chance of healing, on the other hand high body temperature act as a sign of wound infection.

• Hair removal: before the operation the hair at the site of surgery should be removed to prevents germs to entering the wound.

•Wound care: wound should be covered with a dressing for 1- 2 day, while open wounds are packed with gauze and dressing.

How to prevent surgical site infections (12)

• Take a shower with antiseptic soap the night before or the day of your operation.

• If you smoke: smoke should be quitted before and after surgery.

• Antibiotics: proper antibiotic prescribed by the physician.

• Hands of the healthcare workers must always clean their hands by rinsing with alcohol or by washing with antiseptic soap and water.

• Healthy foods must be eaten after surgery with suitable caring the incision as directed by the doctor or nurse.

Complication and risk factors of wound infection.

Both local and \ or systemic complication of wound infection prevent wound healing, the former is usually associated with pain, discomfort, while the later include a varying degree of cellulitis, osteomyelitis, and septicemia (13).

The risk factors of wound infection can include the following (14):

Dressing: improper dressing such as using a low-quality medical adhesive which may dislodge because of excess moisture or physical activity; thus, it is highly recommended so it is very important to use a good quality care product (14).

Medical tape: nurse may use the same roll of tape for many patients, create a chance to introduce the microbes to the wound area, this due to the fact that microbes can survive on the hospital and medical surfaces as tapes, accordingly nurses should take steps to reduce the chance of cross-contamination among patients (15).

Advanced age: the chance of wound infection is increased three times in elderly patients above 60 years old in comparison to the general population, this is due to compromised the immune system in elderly patients, thus for such age patient regular assessment is required for their dressings (16).

Smoking: more than 4000 chemical substances found in tobacco which have a negative effect on healing of wound, basically 2–3 g of nicotine and 20–30 mL of CO₂ found in each cigarette, smoking of tobacco have an effect on hemostasis, inflammation and even reduce tissue oxygenation, thus risk of wound infection is

doubled in smokers, accordingly patient advised to stop smoking for 6–8 weeks before the operation to eliminate the risk of complications (17).

Diabetes: patients with diabetes are more susceptible to infection, this usually due to dysfunctional natural killer cells. The risk factor of wound infection in diabetic patient four times higher than that in non-diabetic patients. In some cases, hyperglycemia induced after surgery due to the stress of surgery and anesthesia which antagonize endocrine responses to insulin (18).

Stages in wound infection with sign and symptoms (19, 20, 21)

- 1- Contamination: presence of microorganisms in the skin of the wound without influencing immune responses. These stages occur without sign and symptoms.
- 2- Colonization: microorganisms start to multiply without triggering immune responses, this stage occurs without sign and symptoms.
- 3- Local infection: in this stage the microorganisms will move deep in wound tissue, with initiation of the immune responses, while the infection will be limited to wound area biofilm may present. Sign and symptoms include (hypergranulation, bleeding tissues, tissue breakdown, pain, malodor, and resultant delay in healing process).
- 4- Spreading infection: the microorganism spread from wound to the surrounding tissues such as muscle, and bone. Systemic sign and symptoms occur in these stages such as erythema, lymphangitis, with lymph node enlargement, wound tissue breakdown, with patient deterioration.
- 5- Systemic infection: microorganisms spread thorough vascular and lymphatic system to the whole body, severe systemic sign and symptoms such as sepsis, systemic

inflammatory responses, septic shock, multiple organ failure, and death.

Wound examination

Wound examination had two important steps (22)

a- Clinical examination

Pain, exudate, swelling, redness, warmth and tenderness are the most common clinical sign and symptoms that suggest the possibility of wound infection.

b- Laboratory examination includes.

- Complete blood count (CBC)
- Erythrocyte sedimentation rate (ESR)
- C- reactive protein (CRP)
- Bacteriology (Gram stain, culture and sensitivity)
- Imaging include
 - Plain x-rays
 - Computed tomography scan (CT scan)
 - Magnetic resonance imaging (MRI)
 - Bone scan

Wound management

A good care of wound are require to management wound and its environment to improve host defense and response especially in patient with high risk factor of getting wound infection (19,23).

Antimicrobial therapy (24)

1-Antibiotics

A-Systemic antibiotic therapy

Systemic antibiotic is prescribed to patients when local intervention fail to control the wound infection, especially indicated when there is a sign of systemic tissue infection, the most commonly used systemic antibiotics are beta-lactamsas cephalosporins, amoxicillin,

vancomycin clindamycin, and macrolides as (erythromycin, and azithromycin) (25).

Systemic antibiotic (24, 25)

- A- Antibiotics: choice of antibiotics depends on susceptibility test and the availability of the antibiotics.
- B- Patient: e.g., allergies, potential interactions with current medication, co-morbidities, and ability to take the treatment.
- C- Guidelines for the treatment of infection in specific wound types.
- D- Administration: intravenous antibiotics are used in life-threatening infections.
- E- Wound: systemic antibiotic choice depends on site and type of wounds.
- F- Local prescribing policy.

B-Topical antibiotics (23, 26).

A low dose of antibiotics usually found in topical antibiotics formulations, they are prescribed in some cases of infected wound, as infection under supervision of experienced clinicians, examples of topical antibiotics are topical metronidazole gel and mupirocin for the treatment of malodor infecting wounds, silver sulphadiazine for the treatment of burns and wounds.

C-Antibiotic prophylaxis

Prophylaxis is recommended in patients, at high risk of infection, to reduce the chance of getting infection of surgical incision and traumatic wound (23).

2-Antiseptics

Chemical substances that are used to kill or inhibit microorganisms' growth on living tissues. It usually has multi targets within microbial cell and broader spectrum of activity against bacteria, fungi, viruses, and protozoan with low level of resistance than antibiotic. (27,28).

Indications for antiseptics

Antiseptics have been indicated to reduce or prevent infection at highly risk patients as in

immunocompromised patients, in sacral wound, sever burn, and in patients with unhealed wound due to systemic factors like diabetes (29).

Table 1. Types of antiseptics with its formulations (30,31, 29).

Type of antiseptic	Formulation
Acetic acid	solution
Chlorhexidine	Solution, powder, impregnated dressing
Honey	Direct application, impregnated dressing
Hydrogen peroxide	Solution, cream
Iodine	PVP, solution, cream, ointment, spray, ointment, impregnated dressing, paste, powder.
Potassium permanganate	Solution, and tablets
Polyhexamethyl biguanide	Solution , and impregnated dressing
Silver	Silver sulfadazine found as cream, and impregnated dressing Ionic silver impregnated dressing, and nanocrystalin silver
Sodium hypochlorite	Solution
Triclosan	Solution, and impregnated dressing

3-Wound dressing and debridement

Debridement types

The choice of debridement depends on: patients wound, age of patients, health and risk for complications (32).

A-Biological debridement

A selective debridement by using maggots or larva in therapy as live medical devices. The sterilized maggots are placed on the wound surface within a net pouch, and fixed by an absorbent dressing, the most commonly used maggot larva of species *Luciliasericata* (33,34).

B-Autolytic debridement

Enzymes and natural fluids used to soften necrotic tissue with a moisture retaining dressing ointment or gel which typically changed once a day. Enzymes source are from plants, animals, or bacteria (35,36).

C-Mechanical debridement

Includes removal of the unhealthy tissues with a moving force. Mechanical debridement types include hydrotherapy, wet-to-dry dressing, and monofilament debridement pads (37).

D- Surgical sharp debridement

Type of debridement use when unhealthy tissue is removed by cutting it off. The cut in this debridement doesn't extend to surrounding healthy tissue (38,39).

Wound dressing

Wound healing started when there is a good environment for healing dressings and topical agents are important which play a role, that lowering or removing wound bacteria, and protecting the wound from contamination (40).

Some examples of wound dressings are:

A-Gauze dressings

Cotton, with multiple shapes and sizes, can be used for one-time in cleaning wounds. It is useful for protection from infection and exudate management, and reduce bacterial invasion (41,42).

B-Foam dressings

Polyurethane is use to produce a foam, composed of single or multiple layer, they are available impregnated with charcoal with a waterproof backing foams which are indicated for a wide range of wound infection. (43,40).

C-Transparent dressings

Polymer materials used in this type of dressing as polyester, and acrylic adhesive agents, it is supported with flexible lattice

pad, they are permeable to pass oxygen and water vapor through, while preventing germ from passing through. (44, 42).

D-Hydrocolloid dressings

Adhesives with polymers held in a fine suspension on a backing of polyurethane film or foam. Hydrocolloids are indicated in the management of superficial leg ulcers, burns, and donor sites (45).

E-Alginate dressings

Calcium or calcium/sodium salts of alginic acid obtained from seaweed, primarily the genus *Laminaria*, alginates are used in, leg ulcers, cavity wounds, and pressure wounds. (46, 40).

Table 2. Types of microorganisms that can cause wound infection (47,48).

Bacterial classification	Bacteria
Gram positive cocci	<i>Streptococcus pyogenes</i> <i>Enterococcus faecalis</i> <i>Staphylococcus aureus</i> / MRSA
Gram negative aerobic rods	<i>Pseudomonas aeruginosa</i>
Gram negative facultative rods	<i>Enterobacter</i> spp. <i>Eschresichia coli</i> <i>Klebsiella</i> spp. <i>Proteus</i> spp.
Anaerobic	<i>Bacteroides</i> spp. <i>Clostridium</i> spp.
Fungi	<i>Aspergillus</i> spp., and <i>Candida</i> spp.

Bacterial biofilm

Tissue formed by bacteria which adhered to chronic wound and fused with extracellular matrix that called bacterial biofilm (BBF), such biofilm is composed of bacteria and their products, BBF can be found in pressure ulcer, diabetic foot ulcer, and other chronic wounds (49,50).

Identification biofilm in wounds (51,23)

The presence of fibrin, necrosis, and slimy surfaces on wounds which indicated the

presence of biofilm, so that samples for laboratory examination was indicated in these cases because different types of wounds appear to be healthy by visual examination. Microbiological examination showed the presence of microorganisms in wound sample and need further examination for the presence of biofilm. However, biofilm was impossible to examine by naked eye which require further identification the sign and symptoms with laboratory and clinical examination.

Criteria indicative of patient's biofilm formation (52).

1. Failure of antibiotic treatment
2. Delay healing when antibiotic cessation
3. Increase in forming the exudate
4. Inflammation
5. Erythema
6. Granulation
7. Sign and symptoms of infection

Prevention

Appropriate strategies were required to prevent wound infections and to facilitate healing. Proper care of the wound bed, edge and wound skin, is essential to preventing infection, the role of biofilms should also be considered, this could be due to fact that formation a biofilm meaning a transition from colonization to infection, thus delayed in wound healing. Finding a way to minimize the formation of biofilms may prove to be a key step in preventing the transition from colonization to infection. In fact, wound care strategy key to target biofilm formation by removing debridement from wound bed with antimicrobial agents use, insufficient treatment of debridement caused delayed of wound healing most attempts acts to preventing wound infections have today focused on the use of silver as an adjunct (53,54).

Debridement of infected wounds requires proper care in order to make them heal faster, management of dead space cavities is very important this due to fact that this cavity can fill up with exudate and provide a good environment to growth and multiplication of microorganisms (55).

What are the four stages of wound healing (54).

1-Hemostasis

A first phase starts when the skin is broken and stops when blood loss is controlled. The most immediate reaction to vascular injury occurs at the level of the vessel itself that

reflexively vasoconstrictions when damaged. However, means of hemostasis involve initiation of the coagulation cascade and the formation of a platelet plug, the time required depends on the wound size and intrinsic factors associated with the patient's health (56).

2-Inflammation

A second phase, which lasts from 3 to 5 days and is defined by the presence of neutrophils which plays an important role of body's innate immune response, neutrophils their action are critical but nonspecific, they act by releasing cytokines and chemokines within the wound bed, leading to free radical production and creating an unfriendly environment for both pathogens, as well as body's own tissue-healing cells (57). Neutrophils also release the enzymes collagenase and elastase into the wound bed to break down the remaining extracellular matrix in preparation for subsequent wound-healing stages to prevent pathogens from establishing foci and removing the detritus of an injured wound bed (extracellular matrix, dead pathogens, and native cells). Neutrophils will generally persist until most of the bacteria and necrotic tissue are removed (58).

3-Proliferation

A third phase when macrophage play an important role by consuming bacteria and nonviable material, and release enzymes to breakdown the existing extracellular matrix. However, macrophages, which are more sophisticated and multidimensional than neutrophils in their overall function, they can be considered the orchestrators of wound healing. The release of growth factors and cytokines leads to the migration of keratinocytes and fibroblasts into the wound bed to initiate re epithelialization and granulation tissue formation, respectively (57).

Three steps in the proliferative phase include

A- Re-epithelialization

The first step begins after 24 hours of post injury, when an area of skin is broken, the loss of contact inhibition that occurs between epidermal cells stimulates replication and migration into the wound bed, this migration is coordinated by macrophages (59).

B- Granulation Tissue Formation

The second step can begin after 3 days of post injury and is visually the hallmark of the proliferative phase, the wound bed begins to take on a shiny, reddish-pink, cobblestone appearance, macroscopically each red cobblestone represents a burgeoning new capillary, and the shiny texture is imparted by the loose extracellular matrix, which is produced by fibroblasts (60).

C-Wound Contraction

When a wound is mature enough, the third step has been appeared fibroblasts are signaled to alter their gene expression, the synthesis of actin filaments is up regulated, and the fibroblast transforms into a myofibroblast, which link up across the wound bed and over time pull the wound closed (54,61,62).

4-Remodeling

The final and longest wound healing phase, frequently lasts more than 2 years, it is largely mediated by fibroblasts and consists primarily of collagen deposition along the lines of stress, remodeling is a dynamic process and increases the tensile strength of the wound where it needs (63,64, 65).

CONCLUSION

Bacteria may enter and multiply inside any wounds with resultant wound infection, thus wound cleaning is considered the best way to prevent infections. However, severe wound infections require medical attention. Choosing the most appropriate antimicrobial product to manage wound infection can be challenging. Antimicrobial products are expensive and sometimes inappropriately used, clinical examination must be aided microbiological analysis in order to ensure that effective results can be provided in as short time duration.

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