WOUND INFECTION

Anatomy

- Two additional features of skin anatomy that affect the repair of injuries are cleavage lines and wrinkles.
- Lines of cleavage are also known as Langer's lines.
- These lines are formed by the collagen bundles that lie parallel in the dermis.
- An incision or repair along these lines lessens disruption of collagen bundles and decreases new collagen formation and therefore causes less scarring.
- Wrinkle lines are not always consistent with Langer's lines.
- If a laceration is not in an area of apparent wrinkling, following the basic outline of Langer's lines results in the best repair.

Definition

- A wound is a breach (damage) in a normal tissue (May be superficial or deep) resulting accidentally or of planned surgery.
- Wound healing is the summation of a number of processes which follow injury including coagulation, inflammation, matrix synthesis and deposition, angiogenesis, fibroplasia, epithelialisation, contraction, remodelling and scar maturation
- Where wound edges are apposed healing proceeds rapidly to closure; this is known as **healing by first intention or primary healing**
- Where the wound edges are apart, such as when there has been tissue loss, the same biological processes occur, but rapid closure is not possible.
- Angiogenesis and fibroblast proliferation result in the formation of granulation tissue.
- In human regeneration is limited to epithelium and the liver; most tissues heal by repair resulting in scarring.
- This contract to reduce wound area and allows epithelialisation across its surface to achieve wound closure.
- This is known as **healing by second intention**
- This process is slower, the contraction involved may cause contracture and functional restriction, and the resultant healed surface is a thin layer of epithelium on scar tissue that may not prove durable in the long term.

- In general, healing by second intention will give a worse aesthetic outcome.
- It is because of the poor functional and aesthetic results of healing by second intention that surgical endeavour is usually directed towards achieving primary wound healing.

Epidemiology

- A survey sponsored by the World Health Organization demonstrated a prevalence of nosocomial infections varying from 3-21%, with wound infections accounting for 5-34% of the total.

Etiology

- All surgical wounds are contaminated by microbes, but in most cases, infection does not develop because innate host defenses are quite efficient in the elimination of contaminants.
- A complex interplay between host, microbial, and surgical factors ultimately determines the prevention or establishment of a wound infection.

Microbiology:

- Microbial factors that influence the establishment of a wound infection are the bacterial inoculum, virulence, and the effect of the microenvironment.
- When these microbial factors are conducive, impaired host defenses set the stage for enacting the chain of events that produce wound infection
- Most Surgical site infections (SSIs) are contaminated by the patient's own endogenous flora, which are present on the skin, mucous membranes, or hollow viscera
- The usual pathogens on skin and mucosal surfaces are gram-positive cocci (notably staphylococci); however, gram-negative aerobes and anaerobic bacteria contaminate skin in the groin/perineal areas.
- The contaminating pathogens in gastrointestinal surgery are the multitude of intrinsic bowel flora, which include gram-negative bacilli (e.g. *Escherichia coli*) and gram-positive microbes, including enterococci and anaerobic organisms
- Gram-positive organisms, particularly staphylococci and streptococci, account for most exogenous flora involved in SSIs.

- Sources of such pathogens include surgical/hospital personnel and intraoperative circumstances, including surgical instruments, articles brought into the operative field, and the operating room air
- The most common group of bacteria responsible for SSIs are *Staphylococcus aureus*.

Host Systemic factors:

- Advanced age
- Malnutrition
- Hypovolemia
- Poor tissue perfusion
- Obesity
- Diabetes
- Steroids and other immunosuppressants
- Smoking
- Alcoholism
- Chronic renal failure
- Poor physical condition
- Previous radiotherapy

Wound characteristics:

- Nonviable tissue in wound
- Hematoma
- Foreign material, including drains and sutures
- Dead space
- Poor skin preparation, including shaving
- Preexistent sepsis (local or distant)

Operative characteristics:

- Include poor surgical technique
- Lengthy operation (>2 h)
- Intraoperative contamination, including infected theater staff and instruments and inadequate theater ventilation
- Prolonged preoperative stay in the hospital
- Hypothermia
- Pain
- Blood transfusion

- Tissue perfusion
- concentration of inspired oxygen

The type of procedure is a risk factor

- Certain procedures are associated with a higher risk of wound contamination than others.
- Surgical wounds have been classified as clean, clean-contaminated, contaminated, and dirty-infected

Classification	Description	Infective Risk (%)
Clean (Class I)	Uninfected operative wound No acute inflammation Closed primarily Respiratory, gastrointestinal, biliary, and urinary tracts not entered No break in aseptic technique Closed drainage used if necessary	<2
Clean-contaminated (Class II)	Elective entry into respiratory, biliary, gastrointestinal, urinary tracts and with minimal spillage No evidence of infection or major break in aseptic technique Example: appendectomy	<10
Contaminated (Class III)	Nonpurulent inflammation present Gross spillage from gastrointestinal tract Penetrating traumatic wounds <4 hours Major break in aseptic technique	About 20
Dirty-infected (Class IV)	Purulent inflammation present Preoperative perforation of viscera Penetrating traumatic wounds >4 hours	About 40

Pathophysiology

- Wound healing is a continuum of complex interrelated biological processes at the molecular level
- Healing is divided into the following phases for descriptive purposes: inflammatory phase, proliferative phase, and maturation phase

Phase One: Inflammatory Phase

- The inflammatory phase commences as soon as tissue integrity is disrupted by injury; this begins the coagulation cascade to limit bleeding.
- Platelets are the first of the cellular components that aggregate to the wound, and, as a result of their degranulation (platelet reaction), they release several cytokines (or paracrine growth factors).
- These cytokines include platelet derived growth factor (PDGF), insulinlike growth factor-1 (IGF-1), epidermal growth factor (EGF), and fibroblast growth factor (FGF).
- Serotonin is also released, which, together with histamine (released by mast cells), induces a reversible opening of the junctions between the endothelial cells, allowing the passage of neutrophils and monocytes (which become macrophages) to the site of injury
- The substrate, or inflammatory, phase occurs during the first 5 to 6 days after injury.
- Leukocytes, histamines, prostaglandins, and fibrinogen, delivered to the injury site via blood and lymphatic channels, attempt to neutralize bacteria and foreign material.
- This large cellular movement to the injury site is induced by cytokines secreted by the platelets (chemotaxis) and by further chemotactic cytokines secreted by the macrophages themselves once at the site of injury.
- These include transforming growth factor alpha (TGF-alpha) and transforming growth factor beta (TGF-beta).
- Consequently, an inflammatory exudate that contains red blood cells, neutrophils, macrophages, and plasma proteins, including coagulation cascade proteins and fibrin strands, fills the wound in a matter of hours.
- Macrophages not only scavenge but they also are central to the wound healing process because of their cytokine secretion

Phase Two: Proliferative phase

- The fibroblastic, or collagen, phase occupies days 6 though 20 after injury.

- Fibroblasts enter the wound rapidly and begin collagen synthesis, which binds the wound together
- The proliferative phase begins as the cells that migrate to the site of injury, such as fibroblasts, epithelial cells, and vascular endothelial cells, start to proliferate and the cellularity of the wound increases.
- The cytokines involved in this phase include FGFs, particularly FGF-2 (previously known as basic FGF), which stimulates angiogenesis and epithelial cell and fibroblast proliferation.
- The marginal basal cells at the edge of the wound migrate across the wound, and, within 48 hours, the entire wound is epithelialized.
- In the depth of the wound, the number of inflammatory cells decreases with the increase in stromal cells, such as fibroblasts and endothelial cells, which, in turn, continue to secrete cytokines.
- Cellular proliferation continues with the formation of extracellular matrix proteins, including collagen and new capillaries (angiogenesis).
- This process is variable in length and may last several weeks

Phase Three: Maturation (Remodeling) Phase

- The wound continues to undergo remodeling for 18 to 24 months, during which time collagen synthesis continues and retraction occurs.
- Normally during this time the scar becomes softer and less conspicuous.
- The prominent color of the scar gradually fades, resulting in a hue consistent with the surrounding skin.
- In the maturation phase, the dominant feature is collagen.
- The dense bundle of fibers, characteristic of collagen, is the predominant constituent of the scar.
- Wound contraction occurs to some degree in primary closed wounds but is a pronounced feature in wounds left to close by secondary intention.
- The cells responsible for wound contraction are called myofibroblasts, which resemble fibroblasts but have cytoplasmic actin filaments responsible for contraction
- The wound continuously undergoes remodeling to try to achieve a state similar to that prior to injury.
- The wound has 70-80% of its original tensile strength at 3-4 months postoperative

Pathology

Wound contamination

- The presence of non-replicating bacteria in the wound.
- All chronic wounds are contaminated by bacteria.
- Contaminants come from the indigenous microflora and/or the environment

Wound colonization

- The presence of replicating bacteria adherent to the wound in the absence of injury to the host.
- Most of the following organisms are normal skin flora.

Wound infection

- The presence of replicating bacteria within a wound that cause host injury.

Classification

- The most useful classification of wounds from a practical point of view is that of Rank and Wakefield into tidy and untidy wounds;

Tidy wounds

- Tidy wounds are inflicted by sharp instruments and contain no devitalised tissue; such wounds can be closed primarily with the expectation of quiet primary healing.
- Examples are surgical incisions, cuts from glass and knife wounds.
- Skin wounds will usually be single and clean cut.
- Tendons, arteries and nerves will commonly be injured in tidy wounds, but repair of these structures is usually possible
- Fractures are uncommon in tidy wounds.

Untidy wounds

- Untidy wounds result from crushing, tearing, avulsion, vascular injury or burns, and contain devitalised tissue
- Skin wounds will often be multiple and irregular.
- Tendons, arteries and nerves may be exposed, and might be injured in continuity, but will usually not be divided.

Fractures are common and may be multifragmentary.

- Such wounds must not be closed primarily; if they are closed wound healing is unlikely to occur without complications.
- At best there may be wound dehiscence, infection and delayed healing, at worst gas gangrene and death may result.
- The correct management of untidy wounds is wound excision, by this is meant excision of all devitalised tissue to create a tidy wound.

Once the untidy wound has been converted to a tidy wound by the process of wound excision it can be safely closed (or allowed to heal by second intention).

Types

Early acute wound
Long-term chronic wounds

Clinical features

History

Definitions of surgical site infection

Superficial incisional SSI:

Infection involves only skin and subcutaneous tissue of incision.

Deep incisional SSI:

Infection involves deep tissues, such as fascial and muscle layers.
This also includes infection involving both superficial and deep incision sites and organ/space SSI draining through incision.

Organ/space SSI:

Infection involves any part of the anatomy in organs and spaces other than the incision, which was opened or manipulated during operation.

Physical

According to a report by the NNIS program, surgical site infections are defined as follows:

Superficial incisional SSI

Occurs within 30 days after the operation
Involves only the skin or subcutaneous tissue
At least 1 of the following:
- Purulent drainage is present (culture documentation not required).
- Organisms are isolated from fluid/tissue of the superficial incision.
- At least 1 sign of inflammation (eg, pain or tenderness, induration, erythema, local warmth of the wound) is present.
- The wound is deliberately opened by the surgeon.
- The surgeon or clinician declares the wound infected.
- Note: A wound is not considered a superficial incisional SSI if a stitch abscess is present; if the infection is at an episiotomy, a circumcision site, or a burn wound; or if the SSI extends into fascia or muscle.

Deep incisional SSI

Occurs within 30 days of the operation or within 1 year if an implant is present
Involves deep soft tissues (e.g. fascia and/or muscle) of the incision
At least 1 of the following:
- Purulent drainage is present from the deep incision but without organ/space involvement.
- Fascial dehiscence or fascia is deliberately separated by the surgeon because of signs of inflammation.
- A deep abscess is identified by direct examination or during reoperation, by histopathology, or by radiologic examination.
- The surgeon or clinician declares that a deep incisional infection is present.

Organ/space SSI

Occurs within 30 days of the operation or within 1 year if an implant is present
Involves anatomical structures not opened or manipulated during the operation
At least 1 of the following:

Purulent drainage is present from a drain placed by a stab wound into the organ/space.
Organisms are isolated from the organ/space by aseptic culturing technique.
An abscess in the organ/space is identified by direct examination, during reoperation, or by histopathologic or radiologic examination.
A diagnosis of organ/space SSI is made by the surgeon or clinician.

Investigations

Laboratory

Staining methods: The simplest, and usually the quickest, method involves obtaining a Gram stain for infective organisms.
Staining for fungal elements can be obtained at the same time
Culture techniques: Most laboratories routinely will culture for both aerobic and anaerobic organisms.
Fungal cultures can be requested.
Isolation of single colonies allows further growth and identification of the specific organism.
Sensitivity testing then follows mainly for aerobic organisms

Imaging

Ultrasonography can be applied to the infected wound area to assess whether any collection needs drainage.

Treatment

Medical care

General agreement exists that prophylactic antibiotics are indicated for clean-contaminated and contaminated wounds
Antibiotics for dirty wounds are part of the treatment because infection is established already
Criteria for the use of systemic preventive antibiotics in surgical procedures are as follows:
Systemic preventive antibiotics should be used in the following cases:
A high risk of infection is associated with the procedure (e.g. colon resection).

Consequences of infection are unusually severe (e.g. total joint replacement).
The patient has a high NNIS risk index.

The antibiotic should be administered preoperatively but as close to the time of the incision as is clinically practical.

Antibiotics should be administered before induction of anesthesia in most situations.

The antibiotic selected should have activity against the pathogens likely to be encountered in the procedure.

Postoperative administration of preventive systemic antibiotics beyond 24 hours has not been demonstrated to reduce the risk of SSIs.

Surgical care

Treatment is individualized to the patient, the wound, and the nature of the infection

Preoperatively, attention should be paid to factors like optimization of patient status, proper asepsis, and surgical site preparation.

Intraoperatively, adherence to good basic surgical principles of minimal and fine tissue dissection, proper selection of suture materials, and proper wound closure is important

If a SSI sets in, the treatment often involves opening the wound, evacuating pus, and cleansing the wound.

The deeper tissues are inspected for integrity and for a deep space infection or source. Dressing changes allow the tissues to granulate, and the wound heals by secondary intention over several weeks.

Early/delayed closure of infected wounds is often associated with relapse of infection and wound dehiscence

The goals of primary closure are to stop bleeding, prevent infection, preserve function, and restore appearance.

Newer concepts in the prevention of SSIs

Blood glucose

Evidence shows that the close regulation of blood sugar may be a major determinant of wound morbidity.

Body temperature

There is now a prospective randomized study that demonstrates that failure to maintain intraoperative core body temperature within 1-1.5°C of normal increases the SSI rate by a factor of 2.

Oxygenation

The fresh, hemostatic surgical incision is a hypoxic, ischemic environment.
Maintaining or increasing oxygen delivery to the wound by increasing the inspired oxygen concentration administered to the patient perioperatively has also been shown to reduce the incidence of SSIs.
It is presumed that increased oxygen availability is a positive host factor, perhaps via enhanced production of oxidant products that facilitate phagocytic eradication of microbes