



Surgical site infections (minor, major, SIRS, MODS), Disinfection & Sterilization

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Wound infection

- It is **defined** as the invasion of organisms through tissues following a breakdown of local and systemic host defenses, leading to cellulitis, lymphangitis, abscess and bacteremia.
- Infection of most surgical wounds is referred as **superficial surgical site infection** (SSSI).
- Other categories include;
 - **Deep SSI** (infection in deeper musculofascial layers),
 - **Organ space infection** (eg pelvic abscess).

Risk factors

- Malnutrition (obesity, weight loss)
- Metabolic disease (diabetes, uremia, jaundice)
- Immunosuppression (cancer, AIDS, steroids, chemotherapy and radiotherapy)
- Colonisation and translocation in GIT
- Poor perfusion (systemic shock or local ischemia)
- Foreign body material
- Poor surgical technique (dead space, hematoma)

Factors determining microorganism growth

- Host response
- Virulence and inoculum of infective agent
- Vascularity and health of tissue being invaded (including local ischemia as well as systemic shock)
- Presence of dead or foreign tissue
- Presence of antibiotics during the 'decisive period'

Classification of sources of infection

- **Primary**

- acquired from a community or
- endogenous source (eg after perforated peptic ulcer)

- **Secondary or exogenous (HAI)**

- acquired from the operating theatre (eg inadequate air filtration) or the ward (eg poor hand-washing) or
- from contamination at or after surgery (eg anastomotic leak)

Major wound infections

- A major SSI is defined as a wound that either discharges significant quantities of pus spontaneously or needs a secondary procedure to drain it.
- The patient may have systemic signs such as tachycardia, pyrexia and a raised white count (SIRS).



Minor wound infections

- It may discharge pus or infected serous fluid but should not be associated with excessive discomfort, systemic signs or delay in return home.



Southampton wound grading system

Grade	Appearance
• 0	Normal healing
• I	Normal healing with mild bruising or erythema
• Ia	Some bruising
• Ib	Considerable bruising
• Ic	Mild erythema
• II	Erythema plus other signs of inflammation
• IIa	At one point
• IIb	Around sutures
• IIc	Along wound
• IId	Around wound
• III	Clear or hemoserous discharge
• IIIa	At one point only (< 2 cm)
• IIIb	Along wound (> 2 cm)
• IIIc	Large volume
• IIId	Prolonged (> 3 days)
• IV	Pus discharge
• IVa	At one point only (< 2 cm)
• IVb	Along wound (> 2 cm)
• V	Deep or severe wound infection with or without tissue breakdown hematoma requiring aspiration

ASEPSIS wound score

Criterion	Points
• Additional treatment	
• Antibiotics for wound infection	10
• Drainage of pus under local anesthesia	5
• Debridement of wound under general anesthesia	10
• Serous discharge*	Daily 0–5
• Erythema*	Daily 0–5
• Purulent exudate*	Daily 0–10
• Separation of deep tissues*	Daily 0–10
• Isolation of bacteria from wound	10
• Stay > 14 days as result of wound infection	5
• *Scored for 5 of the first 7 days only,	
• the remainder being scored if present in the first 2 months.	

Abscess

- An abscess presents all the **clinical features** of acute inflammation:
 - rubor (redness), dolor (pain), calor (heat), tumor (swelling) & functio laesa (loss of function).
- They usually **follow**;
 - a puncture wound of some kind
 - surgery, or
 - metastatic in all tissues following bacteremia.
- **Pyogenic organisms**, esp. *Staphylococcus aureus*, cause tissue necrosis and suppuration.
 - **Pus** is composed of dead and dying WBCs that release damaging cytokines, oxygen free radicals and other molecules.
 - It is surrounded by an **acute inflammatory response** and a pyogenic membrane composed of a fibrinous exudate.
 - **Granulation tissue** (macrophages, angiogenesis and fibroblasts) forms later around the suppurative process and leads to collagen deposition.

Course

- If it is not drained or resorbed completely, a **chronic abscess** may result.
 - Persistent chronic abscess may lead to sinus or fistula formation.
 - There is tissue sequestration and later calcification.
 - Common organisms are Mycobacterium and Actinomyces.
- If it is partly sterilized with antibiotics, an **antibioma** may form.
- If they **spread**, they usually track along planes of least resistance and point towards the skin.
- It may **discharge** spontaneously by tracking to a surface, but may need drainage through a surgical incision.

Treatment

- **Drainage with curettage**

- Surgical decompression and curettage of abscess must be adequate.
- Healing by secondary intention is encouraged
- Primary closure can be used, but delayed primary or secondary suture is safest once granulation tissue is mature and the wound is clean.

- **Image guided aspiration**

- Ultrasonography, CT, MRI and isotope scans are all useful and may allow guided aspiration without the need for surgical intervention.

- **Antibiotics only**

- if the abscess is not localised (e.g. evidence of cellulitis)

Cellulitis and lymphangitis

- **Cellulitis** is the non-suppurative invasive infection of tissues.
 - There is **poor localization, with cardinal signs of inflammation**.
 - It is usually located at the point of injury and spreading to surrounding tissue.
 - Spreading infection is typically caused by organisms such as β -hemolytic streptococci (Fig1), staphylococci (Fig2) and *C. perfringens*.
 - Tissue destruction, gangrene and ulceration may follow, which are caused by release of proteases.
 - **Systemic signs (toxemia)** are common: SIRS, fever and rigors.
 - These follow the release of organisms, exotoxins and cytokines.
 - However, blood cultures are often negative.



- **Lymphangitis** is part of a similar process and presents as painful **red streaks** in affected lymphatics.
 - often accompanied by **painful lymph nodes** in the related drainage area.



Bacteremia and sepsis

- **Bacteremia** is unusual following superficial SSIs but common after anastomotic breakdown (deep space SSI).
 - It is usually transient and can follow procedures undertaken through infected tissues (eg instrumentation in infected bile or urine).
 - In cases of implanted prosthesis, it can cause infection of the prosthesis.
- **Sepsis** accompanied by MODS may follow anastomotic breakdown.
 - Aerobic Gram-negative bacilli are mainly responsible, but Staph aureus and fungi may be involved, esp. after the use of broad-spectrum antibiotics.

Definitions of infected states

- **SSI** is an infected wound or deep organ space
- **SIRS** is the body's systemic response to an infected wound
- **MODS** is the effect that the infection produces systemically
- **MSOF** is the end-stage of uncontrolled MODS

SIRS & MODS

- **Sepsis** is defined as the systemic manifestation of SIRS, with a documented infection.
 - its signs and symptoms are also caused by multiple trauma, burns or pancreatitis without infection.
- Serious infection, eg peritonitis, may lead to SIRS through the release of **lipopolysaccharide endotoxin** from the walls of dying Gram-negative bacilli (mainly E coli) or other bacteria or fungi.

- **SIRS**

Characterized by the presence of 2 of the followings:

- **hyperthermia** ($>38^{\circ}\text{C}$, 100.4 F) or **hypothermia** ($< 36^{\circ}\text{C}$, 96.8 F)
- **tachycardia** ($>90\text{min}^{-1}$, no β -blockers) or **tachypnea** ($> 20\text{ min}^{-1}$)
- **white cell count** $>12 \times 10^9\text{l}^{-1}$ or $<4 \times 10^9\text{l}^{-1}$

- **Sepsis** is SIRS with a documented infection

- **Severe sepsis** or sepsis syndrome (**MODS**) is sepsis with evidence of one or more organ failures

- respiratory (acute respiratory distress syndrome),
- cardiovascular (septic shock follows compromise of cardiac function and fall in peripheral vascular resistance),
- renal (usually acute tubular necrosis),
- hepatic,
- blood coagulation systems or
- central nervous system

- Septic manifestations and multiple organ dysfunction syndrome (**MODS**) are mediated by the release of **cytokines** eg IL-6, TNF α and other substances released from polymorphonuclear and phagocytic cells.
- In its most severe form, MODS may progress into multiple system organ failure (**MSOF**). In this state, the body's resistance to infection is reduced.

Treatment of surgical infection

- Now that patients are discharged more quickly after surgery and many procedures are performed as day cases, **many SSIs are missed** by the surgical team unless they undertake a prolonged and carefully audited follow-up with primary care doctors.
- Suppurative wound infections take 7–10 days to develop, and even cellulitis around wounds caused by invasive organisms (such as the β -hemolytic *Streptococcus*) takes 3–4 days to develop.

Treatment of surgical infection

- Major surgical infections with systemic signs, evidence of spreading infection, cellulitis or bacteremia need treatment with **appropriate antibiotics**.
 - empirical initially
 - best based on culture and sensitivities
- If an infected wound is under tension, or there is clear evidence of suppuration, sutures or clips need to be removed, with curettage if necessary, to **allow pus to drain adequately**.
- In severely contaminated wounds, such as an incision made for drainage of an abscess, **leave the skin open**.
 - Delayed primary or secondary suture can be undertaken when the wound is clean and granulating (Figs).



Skin layers left open to granulate after laparotomy for faecal peritonitis. The wound is clean and ready for closure.



Secondary closure of wound.

- If bacteremia is suspected, but results are negative,
 - then repeat **blood culture** is required.
- A rapid report can be based on **Gram stain**.
- Aerobic and anaerobic **culture on conventional media** allows sensitivities to be assessed.
- Many **dressings** are now available.
 - **Polymeric films** are used as incision drapes and also to cover sutured wounds.
 - **Agents that help debride** open infected wounds and absorb excessive exudate or encourage epithelialisation and the formation of granulation tissue are available.
 - Dressings containing **silver or povidone iodine** antiseptics

Surgical dressings

- **Debriding agents (Benoxyl–benzoic acid)**
 - Used only in necrotic sloughing skin ulcers.
 - Provide acidic environment.
- **Enzymatic agents (Varidase–streptokinase/streptodornase)**
 - Activate fibrinolysis and liquefy pus on chronic skin ulcers
- **Bead dressings (Debrisan, Iodosorb)**
 - Remove bacteria and excess moisture by capillary action in deep granulating wounds.
 - Antimicrobials
- **Polymeric films (Opsite, Tegaderm)**
 - Primary adhesive transparent dressing for sutured wounds or donor sites
- **Foams (Silastic elastomer)**
 - can be shaped to fit deep cavities and granulating wounds.
 - Absorbent and non-adherent

- **Hydrogels (Geliperm)**
 - Maintain moist environment.
 - Polymers can absorb exudate
 - Semi-permeable, allow gas exchange
- **Hydrocolloids (Comfeel)**
 - Promote epithelialisation and granulation tissue.
 - Maintain moisture without gaseous exchange across them
- **Fibrous polymers (Kaltostat)**
 - Absorptive alginate dressings.
 - They can be used to pack deep wounds
- **Biological membranes (Porcine skin, amnion)**
 - Used for superficial chronic skin ulcers.
- **Simple Gauzes**
 - Simple absorptive dressings to absorb exudate.

Preoperative preparation

- **Short preoperative hospital stay** lowers the risk of acquiring MRSA, multiply resistant coagulase-negative staphylococci (MRCNS) and other organisms.
- Medical staff should always **wash** their **hands** between patients.
- **Staff with open, infected skin lesions** should not enter the operating theatres.
- **Antiseptic baths** (usually chlorhexidine) can be used.
- **Preoperative shaving** should be avoided except for aesthetic reasons or to prevent adherence of dressings.
 - If it is to be undertaken, it should be undertaken immediately before surgery as the SSI rate after clean wound surgery may be doubled if it is performed the night before, because minor skin injury enhances superficial bacterial colonisation.

Scrubbing and skin preparation

- **For the first operation** of the day, aqueous antiseptics should be used, and the scrub should include the nails.
 - **Subsequent scrubbing** should merely involve washing to the elbows, as repeated extensive scrubbing releases more organisms than it removes.
- One application of an alcoholic antiseptic is adequate for **skin preparation** of the operative site. This leads to a more than 95% reduction in bacterial count.
- Numbers of **staff in the theatre** and movement in and out of theatre should be kept to a minimum.
- Careful and regular surveillance is needed to ensure the quality of theatre **ventilation, instrument sterilisation** and aseptic technique.
- **Operator skills are important**
 - gentle manipulation and dissection of tissues
 - dead spaces and hematomas should be avoided
 - use of diathermy kept to a minimum.
- Perioperative **avoidance of hypothermia and supplemental oxygen** during recovery can significantly reduce the rate of SSIs.

Antiseptics commonly used in general surgical practice

Name	Presentation	Uses	Comments
Chlorhexidine (Hibiscrub)	Alcoholic 0.5% Aqueous 4%	Skin preparation Skin preparation. Surgical scrub in dilute solutions in open wounds	Has cumulative effect. Effective against Gram-positive organisms and relatively stable in the presence of pus and body fluids
 Povidone-iodine (Betadine)	Alcoholic 10% Aqueous 7.5%	Skin preparation Skin preparation. Surgical scrub in dilute solutions in open wounds	Safe, fast-acting, broad spectrum. Some sporicidal activity. Anti-fungal Iodine is not free but combined with polyvinylpyrrolidone (povidone)
 Cetrimide (Savlon)	Aqueous	Hand-washing Instrument and surface cleaning	<i>Pseudomonas</i> spp. may grow in stored contaminated solutions. Ammonium compounds have good detergent action (surface-active agent)
Alcohols	70% ethyl, isopropyl	Skin preparation	Should be reserved for use as disinfectants
Hypochlorites	Aqueous preparations  (Eusol, Milton, Chloramine T)	Instrument and surface cleaning (debriding agent in open wounds?)	Toxic to tissues
Hexachlorophane	Aqueous bisphenol	Skin preparation Hand-washing	Has action against Gram-negative organisms

SSI rates relating to wound contamination

Type of surgery	Infection rate (%)	Rate before prophylaxis
Clean (no viscus opened)	1–2	The same
Clean-contaminated (viscus opened, minimal spillage)	< 10	Gastric surgery up to 30% Biliary surgery up to 20%
Contaminated (open viscus with spillage or inflammatory disease)	15–20	Variable but up to 60%
Dirty (pus or perforation, or incision through an abscess)	< 40	Up to 60% or more

Disinfection

It refers to the process which kills or removes pathogenic micro-organisms, with the exception of bacterial spores.

Classification

- **Low**

- Reduces overall number of vegetative micro-organisms but does not destroy tubercle bacilli or bacterial spores.
- **Application:** Environmental surfaces.

- **Intermediate**

- Kills tubercle bacilli, most viruses & some fungi but only some spores.
- **Application:** Horizontal surfaces, floors.

- **High**

- Kills most forms of microbial life, including tubercle bacilli, but not some spores.
- **Application:** Flexible endoscopes.

Methods Of Disinfection

- ***Low-temperature steam***
 - Method: Exposure to dry saturated steam at 73°C for 20 minutes at subatmospheric pressure.
 - Application: Disinfection of heavily contaminated instruments.
- ***Boiling water***
 - Method: Exposure to soft water at 100°C for 5 minutes at normal pressure.
- ***Formaldehyde***
 - Method: Exposure to circulating formaldehyde gas in an airtight cabinet at 50°C.
- ***Glutaraldehyde***
 - Method: A 2% solution is effective against most bacteria & viruses including hepatitis B & C & HIV; degree of disinfection is proportional to duration of immersion.
 - Application: Disinfection of flexible endoscopes.
 - Disadvantages: Allergic reactions.

Sterilization

It refers to the process which destroys all forms of microbial life, including bacteria, viruses, spores & fungi.

Methods Of Sterilization

- ***Sterilization by steam***

- Vegetative bacteria including M tuberculosis, & viruses eg HBV, HCV & HIV, & heat-resistant spores including those of C tetani & C perfringens, are killed.
- Combination of pressure, temperature & time with the moist heat is important:
 - Temperature of 134°C at 30 lb/in (2 kPa) for 3 minutes.
 - Temperature of 121°C at 15 lb/in (1 kPa) for 15 minutes.
- Prepacked materials & instruments are processed thru an autoclave that incorporates a prevacuum cycle necessary to extract air.
- **Monitoring**: Steam penetration test (Bowie-Dick test) & chemical indicators (Browne's tubes or impregnated tapes) are used to ensure the efficiency of the process.

- ***Sterilization by ethylene oxide***

- It is a highly penetrative non-corrosive gas that has a broad-spectrum cidal action.
- It is **used** to sterilize heat- & moisture-sensitive materials, including electrical equipment.

- ***Sterilization by hot air***

- This is **used** to treat solid non-aqueous liquids & grease/ointments & to process closed (airtight) containers.
- Lack of corrosion may be important, esp. with instruments with fine cutting edges (eg ophthalmic instruments).

- ***Sterilization by low-temperature steam & formaldehyde***

- This **uses** a combination of dry, saturated steam & formaldehyde, with the main advantage being that sterilization is achieved at a low temperature (73°C).
- It is **suitable** for heat-sensitive materials & equipment with integral plastic components.

- ***Sterilization by irradiation***

- It **employs** gamma rays or accelerated electrons; dose in excess of 25 kGy is used.
- It is an industrial process & is esp. **appropriate** to the sterilization of large batches of similar products such as syringes, catheters & IV cannulas.

- ***Sterilization by peracetic acid (STERIS)***

- This **involves** liquid chemical immersion, which denatures protein, destroys cell membranes by disrupting sulphur & sulphydryl bonds, inactivates catalase & oxidizes enzymes involved in the cell membrane transport process.
 - System includes a table-top microprocessor working at 50-56°C for 12 minutes, with constant fluid circulating during the sterilizing & rinsing cycles, & is esp. suitable for flexible endoscopes.
- It is esp. efficient **against** spores but also against bacteria, mycobacteria, viruses, yeasts & fungi.



A 53 year old woman develops a swinging pyrexia five days after an eventful cholecystectomy. On examination the wound appears inflamed, and there is oozing of pus from the upper end. Gram stain of the pus reveals Gram-positive cocci in cluster, with pus cells present

- **What is the wound grade?**
- **What is the likely organism?**
- **What antibiotic is likely to be helpful?**
- **What other intervention may be necessary?**



A 70 year old man who is awaiting surgery for an enlarged prostate is admitted from home having been found collapsed by neighbours. He is confused and unable to give a history. Examination reveals only mild suprapubic tenderness, other systems are clear. He is pyrexial and hypotensive.

- What is the likely diagnosis?
- What is the likely organism?
- What other intervention might be necessary?

The End!