

An overview of surgical site infections: aetiology, incidence and risk factors

Abstract

Infection has always been a feature of human life and sepsis in modern surgery continues to be a significant problem for healthcare practitioners across the globe. This paper describes the factors that influence surgical wound healing and the risk of surgical site infection.

Keywords: Surgical site infection (SSI); sepsis; healthcare associated infections (HAIs); wound care; infection control.

Key points

1. Surgical site infections (SSIs) are a real risk associated with any surgical procedure and represent a significant burden in terms of patient morbidity and mortality, and cost to health services around the world.
2. A multitude of risk factors influence the development of SSIs and awareness of these will help to promote effective preventive strategies.
3. Assessment tools such as the Centers for Disease Control definitions, ASEPSIS and the Southampton Wound Assessment Scale are needed to accurately identify and classify SSIs.

INTRODUCTION

Until the middle of the 19th century, when Ignaz Semmelweis and Joseph Lister became the pioneers of infection control by introducing antiseptic surgery, most wounds became infected. In cases of deep or extensive infection this resulted in a mortality rate of 70–80%¹. Since then a number of significant developments, particularly in the field of microbiology, have made surgery safer. However, the overall incidence of healthcare associated infections (HAIs) remains high and represents a substantial burden of disease.

In 1992, the US Centers for Disease Control (CDC) revised its definition of ‘wound infection’, creating the definition ‘surgical site infection’ (SSI)² to prevent confusion between the infection of a surgical incision and the infection of a traumatic wound. Most SSIs are superficial, but even so they contribute greatly to the morbidity and mortality associated with surgery.^{3,4} Estimating the cost of SSIs has proved to be difficult but many studies agree that additional bed occupancy is the most significant factor. A review of the incidence and economic burden of SSIs in Europe estimated that the mean length of extended stay attributable to SSIs was 9.8 days, at an average cost per day of €325.⁴

HEALING BY PRIMARY INTENTION

Surgical wounds may heal by primary intention, delayed primary intention or by secondary intention. Most heal by primary intention, where the wound edges are brought together (apposed) and then held in place by mechanical means (adhesive strips, staples or sutures), allowing the wound time to heal and develop enough strength to withstand stress without support. The goal of surgery is to achieve healing by such means with minimal oedema, no serous discharge or infection, without separation of the wound edges and with minimal scar formation. On occasion, surgical incisions are allowed to heal by delayed primary intention where non-viable tissue is removed and the wound is initially left open. Wound edges are brought together at about 4–6 days, before granulation tissue is visible.⁵ This method is often used after traumatic injury or dirty surgery. ►



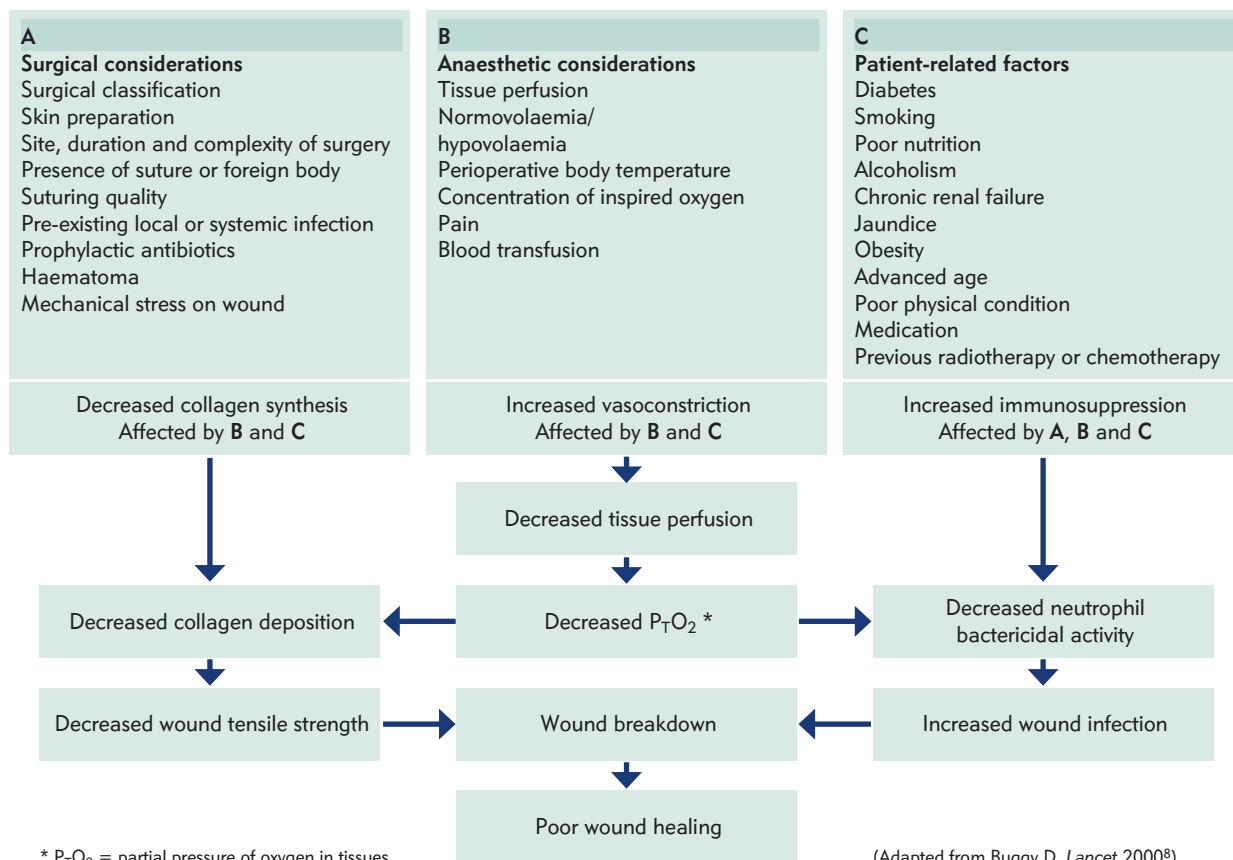
Finn Gottrup
MD, DMSci

Professor of Surgery,
University of Southern
Denmark, The Univer-
sity Center of Wound
Healing, Department of
Plastic Surgery, Odense
Hospital, Denmark
finn.gottrup@
ouh.fyns-amt.dk

Andrew Melling
RN, BSc
Research Fellow –
Nursing, Professorial Unit
of Surgery, University
Hospital of North Tees,
Stockton-on-Tees, UK
andymelling@
btinternet.com

Dirk A. Hollander
MD
Surgeon, Trauma Sur-
geon, Surgical Center,
Bethanien Hospital,
Frankfurt, Germany
dhollander@ukaachen.de

Figure 1: Factors that affect surgical wound healing



HEALING BY SECONDARY INTENTION

Healing by secondary intention happens when the wound is left open, because of the presence of infection, excessive trauma or skin loss, and the wound edges come together naturally by means of granulation and contraction.⁶

Experimentally as well as clinically it has been shown that a delay in wound closure of four to five days increases the tensile strength of the wound as well as resistance to infection. The overall rate of SSIs in traumatic war wounds using delayed principles was 3-4%, compared with more than 20% after primary closure.⁷ In civilian practice, delayed healing has been used successfully in cases of severe incisional abscesses, mainly after laparotomy.

Another benefit of delayed closure is the cosmetic result after healing. The appearance of a wound after a delay of four to five days is comparable to that of primary closure. A wider scar follows late closure (after 10-14 days), although this is cosmetically much better than the result obtained after the healing of an open granulating wound.

FACTORS INFLUENCING SSIS

Many factors influence surgical wound healing and determine the potential for, and the incidence of, infection⁸ (Figure 1). The level of bacterial burden is the most significant risk factor,^{9,10,11} but modern surgical techniques and the use of prophylactic antibiotics have reduced this risk.

Table 1: Classification of operative wounds based on degree of microbial contamination

Classification	Criteria
Clean	Elective, not emergency, non-traumatic, primarily closed; no acute inflammation; no break in technique; respiratory, gastrointestinal, biliary and genitourinary tracts not entered.
Clean-contaminated	Urgent or emergency case that is otherwise clean; elective opening of respiratory, gastrointestinal, biliary or genitourinary tract with minimal spillage (e.g. appendectomy) not encountering infected urine or bile; minor technique break.
Contaminated	Non-purulent inflammation; gross spillage from gastrointestinal tract; entry into biliary or genitourinary tract in the presence of infected bile or urine; major break in technique; penetrating trauma <4 hours old; chronic open wounds to be grafted or covered.
Dirty	Purulent inflammation (e.g. abscess); pre-operative perforation of respiratory, gastrointestinal, biliary or genitourinary tract; penetrating trauma >4 hours old.

(Adapted from Berard F, Gandon J, Ann Surg 1964⁹)

Table 2: Incidence of SSIs following closure/delayed closure of an infected wound

Opening and re-closure times	Reinfection rate
Opening and re-closure at once	50%
Opening and re-closure after two days	20%
Opening and re-closure after four days	5%
Opening and re-closure after nine days	10%

Note: all wounds were closed under antibiotic cover.

(Adapted from Gottrup, F. Wound healing and principles of wound closure. In: Holstrøm H, Drzewieck KT (Eds). *The Scandinavian Handbook of Plastic Surgery*. Malmoe: Studentlitteraturen, 2005 (In press).)

Table 3: Summary of the definitions of superficial and deep SSIs

<p>Superficial incisional surgical site infections Superficial incisional surgical site infections must meet the following two criteria²:</p> <ul style="list-style-type: none"> ■ occur within 30 days of procedure ■ involve only the skin or subcutaneous tissue around the incision. <p><i>Plus</i> At least one of the following criteria:</p> <ul style="list-style-type: none"> ■ purulent drainage from the incision ■ organisms isolated from an aseptically obtained culture of fluid or tissue from the incision ■ at least one of the following signs or symptoms of infection – pain or tenderness, localised swelling, redness or heat – and the incision is deliberately opened by a surgeon, unless the culture is negative ■ diagnosis of superficial incisional SSI by a surgeon or attending physician. <p>The following are not considered superficial SSIs:</p> <ul style="list-style-type: none"> ■ stitch abscesses (minimal inflammation and discharge confined to the points of suture penetration) ■ infection of an episiotomy or neonatal circumcision site ■ infected burn wounds ■ incisional SSIs that extend into the fascial and muscle layers (see deep SSIs). <p>Deep incisional surgical site infections Deep incisional surgical site infections must meet the following three criteria²:</p> <ul style="list-style-type: none"> ■ occur within 30 days of procedure (or one year in the case of implants) ■ are related to the procedure ■ involve deep soft tissues, such as the fascia and muscles. <p><i>Plus</i> At least one of the following criteria:</p> <ul style="list-style-type: none"> ■ purulent drainage from the incision but not from the organ/space of the surgical site ■ a deep incision spontaneously dehisces or is deliberately opened by a surgeon when the patient has at least one of following signs or symptoms – fever (>38°C), localised pain or tenderness – unless the culture is negative ■ an abscess or other evidence of infection involving the incision is found on direct examination or by histopathologic or radiological examination ■ diagnosis of a deep incisional SSI by a surgeon or attending physician.

(Adapted from Horan et al⁸)

A system of classification for operative wounds that is based on the degree of microbial contamination was developed by the US National Research Council group in 1964.⁹ Four wound classes with an increasing risk of SSIs were described: clean, clean-contaminated, contaminated and dirty (Table 1). The simplicity of this system of classification has resulted in it being widely used to predict the rate of infection after surgery.

RATES OF INFECTION

Infection rates in the four surgical classifications (clean, clean-contaminated, contaminated and dirty wounds) have been published in many studies but most literature refers to the work of Cruse and Foord as a benchmark for infection rates.^{10,11} Before the routine use of prophylactic antibiotics infection rates were 1-2% or less for clean wounds, 6-9% for clean-contaminated wounds, 13-20% for contaminated wounds and about 40% for dirty wounds.^{10,11} Since the introduction of routine prophylactic antibiotic use, infection rates in the most contaminated groups have reduced drastically. Infection rates in US National nosocomial infection surveillance (NNIS) system hospitals were reported to be: clean 2.1%, clean-contaminated 3.3%, contaminated 6.4% and dirty 7.1%.¹² There is, however, considerable variation in each class according to the type of surgery being performed.¹³

PREVENTIVE TECHNIQUES

The surgical technique used can affect the infection rate in various ways, for example in relation to skin preparation, shaving and wound closure.

Skin preparation: The skin is colonised by various types of bacteria, but up to 50% of these are *Staphylococcus aureus*.¹⁴ In analyses of contamination rates after cholecystectomy, the main source of wound contamination was found to be the skin of the patient.¹⁵ For this reason, preoperative preparation should be performed. Evidence has shown that the use of a preoperative wash containing chlorhexidine decreases the bacterial count on skin by 80-90%, resulting in a decrease in preoperative wound contamination.¹⁶ The effect on SSI incidence has, however, been more difficult to demonstrate and it is possible that prolonged washing releases organisms from deeper layers of the skin.

Shaving: It is now recognised that shaving damages the skin and that the risk of infection increases with the length of time between shaving and surgery.¹⁰ In one study, if the patient had been shaved more than two hours before surgery the clean wound infection rate was found to be 2.3%.¹¹ However, if patients had not been shaved but their body hair had been clipped the rate was 1.7%, and ▶

Figure 2: ASEPSIS wound scoring system

ASEPSIS wound score						
Wound characteristic	0	Proportion of wound affected				
		<20	20-39	40-59	60-79	>80
Serous exudate	0	1	2	3	4	5
Erythema	0	1	2	3	4	5
Purulent exudate	0	2	4	6	8	10
Separation of deep tissues	0	2	4	6	8	10

Points are scored for daily wound inspection.

Criterion	Points
Additional treatment:	
Antibiotics	10
Drainage of pus under local anaesthesia	5
Debridement of wound (general anaesthesia)	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	10
Stay as inpatient prolonged over 14 days	5

* Given score only on five of seven days. Highest weekly score used

Category of infection: total score 0-10 = satisfactory healing; 11-20 = disturbance of healing; 20-30 = minor wound infection; 31-40 = moderate wound infection; >40 = severe wound infection.

(Adapted from Wilson AP et al, *Lancet* 1986²⁰).
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if they had not been shaved or clipped the rate dropped to 0.9%.¹¹ If shaving is essential, it should be performed as close to the time of surgery as possible.

Wound closure: The healing of closed surgical wounds depends on many factors, one of the most complex of which is the influence of technique and expertise.⁷ The incidence of SSIs in relation to the different types of closure techniques used is shown in Table 2.

Once wounding has occurred, the surgeon has control over several factors concerning the wound itself that may reduce susceptibility to infection. The duration of surgery is one factor that influences the wound infection rate. Procedures that take longer than two hours are associated with higher infection rates.^{17,18} This may be related to desiccation or maceration of the wound edges, an increase in the number of bacteria that accumulate within the wound, and decreased temperature and hypovolaemia leading to peripheral vasoconstriction and therefore poorly perfused skin. Fewer bacteria are required to produce an infection in the presence of necrotic tissue, foreign bodies, haematomas, seromas and poor tissue perfusion.

Although infection cannot occur without any bacterial burden or contamination, the presence of bacteria in a wound does not inevitably result in an infection. Many different factors determine the potential for and incidence of infection (Figure 1).

Figure 3: Southampton wound scoring system

Southampton scoring system	
Grade	Appearance
0	Normal healing
I Normal healing with mild bruising or erythema:	
A	Some bruising
B	Considerable bruising
C	Mild erythema
II Erythema plus other signs of inflammation	
A	At one point
B	Around sutures
C	Along wound
D	Around wound
III Clear or haemoserous discharge:	
A	At one point only (<2cm)
B	Along wound (>2cm)
C	Large volume
D	Prolonged (>3 days)
Major complication	
IV Pus:	
A	At one point only (<2cm)
B	Along wound (>2cm)
V Deep or severe wound infection with or without tissue breakdown; haematoma requiring aspiration	

The wound grading system used was simplified for the use of analysis. By using the worst wound score recorded and information about any treatment instituted either in hospital or the community, wounds were regarded in four categories: (A) normal healing; (B) minor complication; (C) wound infection-wounds graded IV or V or wounds treated with antibiotics after discharge from hospital, irrespective of the wound grading given to them by the nurse; and (D) major haematoma-wound or scrotal haematomas requiring aspiration or evacuation.

(Adapted from Bailey IS et al, *BMJ* 1992²¹)

IDENTIFYING SURGICAL SITE INFECTIONS

The most widely recognised definition of infection, which is used throughout the USA and Europe, is that devised by Horan and colleagues and adopted by the CDC². This splits surgical site infections into three groups – superficial and deep incisional SSIs and organ-space SSIs – depending on the site and the extent of infection. The definitions of superficial and deep infections are summarised in Table 3. The CDC definition states that only infections occurring within 30 days of surgery (or within a year in the case of implants) should be classified as SSIs.

Wound infections have been subdivided according to the following clinically related subgroups:¹⁹

Aetiology: in a *primary infection*, the wound is the primary site of infection, whereas a *secondary infection* arises following a complication that is not directly related to the wound;

Time: an *early infection* presents within 30 days of a surgical procedure, whereas an infection is described as *intermediate* if it occurs between one and three months afterwards and *late* if it presents more than three months after surgery;

Severity: a wound infection is described as *minor* if there is discharge without cellulitis or deep tissue destruction, and *major* if the discharge of pus is associated with tissue breakdown, partial or total dehiscence of the deep fascial layers of the wound, or if systemic illness is present.

WOUND ASSESSMENT

No validated universal system is designed specifically to aid the assessment and management of surgical wounds. The most commonly used, the CDC definition, employs stringent criteria to classify infection. Several other wound scoring systems exist and two of the best are ASEPSIS (Figure 2) and the Southampton Wound Assessment Scale (Figure 3). These enable surgical wound healing to be graded according to specific criteria, usually giving a numerical value, and therefore provide a more objective assessment of the wound.^{20,21}

The ASEPSIS system was devised to assess wounds resulting from cardiothoracic surgery, while the Southampton scale was designed for use in the postoperative

assessment of hernia wounds. The Southampton system is much simpler than the ASEPSIS system, with wounds being categorised according to any complications and their extent.²¹ Both systems, however, have been developed for use following specific types of surgery and this may limit their usefulness.

CONCLUSION

In spite of the use of prophylactic antibiotics, SSIs are still a real risk of surgery and represent a substantial burden of disease for both patients and health care services in terms of morbidity, mortality and economic cost. Changes in definition have focused attention on infection of the surgical incision, and factors associated with SSIs are now being studied with a view to limiting the risk of infection.

Research has shown that surgical techniques, skin preparation and the timing and method of wound closure are significant factors that can influence the incidence of subsequent infection. Antibiotic prophylaxis has also had a positive impact after certain types of surgery. Many other factors have been identified as having an effect on the potential for infection and healthcare professionals should consider these before, during and after surgery. ■

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