Abstract: Health care-associated infections (HCAIs) are infections acquired through contact with any aspect of health care. They can cause minor complications or serious disability or death, and can involve a wide variety of resistant or emergent organisms. Surgical site infections make up approximately one-fifth of HCAIs, and at least 5% of patients undergoing open surgery develop an SSI. Surgical site infections are probably the most preventable HCAI but have received the least attention; although that is changing with increased surveillance and public awareness of published data of individual specialty and hospital incidence rates. Surgical site infection continues to be a complication of surgical care. These infections span a continuum of severity with some being quite innocent and easy to manage, while others are life-threatening. Considerable evidence provides direction in the prevention of SSI (eg, systemic antibiotic prophylaxis) but many preventive strategies need better definition, with additional clinical studies. When SSI occurs, the clinician needs to quickly recognize it and tailor management to the specific needs of the patient. In general, drainage, debridement, and specific antibiotics for the putative pathogen are the hallmarks of management.

Key words: surgical site infection, treatment, prophylaxis

Health care-associated infections (HCAIs) are infections that are acquired through contact with any aspect of health care. They can cause minor complications or serious disability or death, and can involve a wide variety of resistant or emergent organisms. Examples of HCAIs include respiratory tract infections such as hospital- and ventilator-associated pneumonias complicated by Gram-negative, nonfermenting bacilli that are resistant to almost all classes of antibiotics; and urinary tract infections caused by microorganisms resistant to the quinolones and increased by the presence of a catheter, mostly involving coliforms that can produce extended spectrum beta-lactamases (and, more worrying, metallo-beta-lactamases, such as the newly described New Delhi-metallo-beta-lactamase 1 [NDM-1], making bacteria resistant to a wide range of beta-lactam antibiotics, including all...
Infections involving prosthetic materials, as diverse as hip replacement or vascular grafts, are caused mainly by multiple-resistant coagulase negative \textit{staphylococci}; bacteraemias and complicated skin and soft tissue infections are associated with highly virulent meticillin sensitive \textit{Staphylococcus aureus} (MSSA) or meticillin resistant \textit{Staphylococcus aureus} (MRSA) strains; and emergence of \textit{Clostridium difficile} is the underlying cause of antibiotic related colitis. Among HCAIs, surgical site infection (SSI) is of greatest recent concern. Surgical site infections can be caused by many organisms which may be antibiotic resistant. Patients who develop HCAIs usually have related treatments or underlying contributory illnesses, but the misuse of antibiotics is a key factor in all cases. All HCAIs can be prevented or reduced by attention to known risk factors. The cost of HCAIs to health care is large, and has prompted many initiatives associated with extensive international media and political campaigns.

The bacteria involved in SSIs include those carried by the patients themselves (endogenous flora), and those that may be introduced in the operating room (exogenous flora). Native colonization (the source of infection), is determined through the type of surgery (eg, coliforms and anaerobes in colorectal surgery), although \textit{staphylococci} predominates overall from the bacterial reservoir in skin. Gram-positive pathogens from airborne microbes and the surgical team (due to glove punctures during surgical procedures or from suboptimal sterilization of instruments) may be infrequent sources of contamination of the surgical site. Opportunistic and resistant organisms may be cultured from infections after selected operations (eg, prosthetic surgery). All patients are at risk of acquiring resistant organisms, particularly if they have an underlying debilitating illness, poor compliance with accepted prevention guidelines, or they have health care-associated exposure (ie, prior hospitalization or admission to a chronic care facility) that colonizes them with unusually resistant bacteria.

Surgical site infections make up approximately a fifth of the HCAIs in the United Kingdom, and at least 5% of patients undergoing open surgery in the UK develop an SSI. Surgical site infections are probably the most preventable HCAI but have received the least attention; although that is changing with increased surveillance and public awareness of published data of individual specialty and hospital incidence rates. Surgical site infections are associated with more than one-third of postoperative related deaths ranging from relatively trivial, short-lived, wound discharge (eg, after open hernia surgery) to being life threatening (eg, mediastinitis and sternal wound infection). In between, HCAIs contribute to scars which may be cosmetically unacceptable to the patient, cause pain, require prolonged length of hospital stay with the incurred expenses, and result in poor emotional well-being for the patient.

### Surgical Site Infection

**Definitions.** Many surgeons are unaware of their SSI rate because of nonexisting or suboptimal surveillance and inconsistent definitions. The first realistic survey of SSI was not sensitive, as only the presence of pus was used for the identification of SSI. Wounds are now categorized into clean (no viscus opened), clean-contaminated (viscus opened, minimal spillage), contaminated (viscus opened with spillage or presence of inflammatory disease), and dirty (pus or perforation present or incision made through an abscess). This categorization was based on a theoretical division of potential for SSI development. It is flawed by the failure to include patient risk and the use of prosthetic materials, which may dramatically impact the risk for SSI in procedures within the clean category. Furthermore, because of the constant introduction of new operative techniques, particularly endoscopic procedures and the rise of natural orifice transluminal endoscopic surgery (NOTES) this categorization is becoming increasingly blurred and may not be applicable.

It is critical that standard definitions are used to allow studies to be comparable. Analysis of outcomes and comparison between studies requires exact definitions of patients’ characteristics and their risk stratification, based on comorbid medical conditions. In addition to demographic details, clinical manifestations of SSI vary epidemiologically depending on the onset of infection. The Centers for Disease Control and Prevention (CDC) is the most widely used and comprehensive definition (Table 1). This system only gives categorical data which does not reflect the severity of an SSI. In brief, SSIs are categorized at 3 levels: superficial incisional, in the skin or subcutaneous tissues; deep incisional involving fascia or muscle; and deep/organ space, involving, for example, the pleura after lung surgery or the liver after hepatic resection. Most SSIs fall into the superficial group and the less common deep/organ space infections are the most serious or life threatening. The categories are open to interpretation and may depend on the attending physician’s diagnosis. By contrast, the ASEPSIS scoring method
Leaper et al.

Table 1. Summary of CDC definition of SSI.

<table>
<thead>
<tr>
<th>Superficial Incisional SSI</th>
<th>Deep Incisional SSI</th>
<th>Organ/Space SSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection occurs within 30 days after the operation; infection involves only the skin or subcutaneous tissue; and at least 1 of the following:</td>
<td>Infection occurs within 30 days of operation or within 1 year if an implant is present; infection involves deep soft tissues (eg, fascia and/or muscle) of the incision; and at least 1 of the following:</td>
<td>Infection occurs within 30 days of operation or within 1 year if an implant is present; infection involves anatomic structures not opened or manipulated by the operation; and at least 1 of the following:</td>
</tr>
<tr>
<td>o purulent drainage (culture documentation not required); o organisms isolated from fluid/tissue of superficial incision; o at least 1 sign of inflammation (eg, pain or tenderness, induration, erythema, local warmth of the wound); o wound is deliberately opened by the surgeon; or o surgeon or attending physician declares the wound infected.</td>
<td>o purulent drainage from the deep incision but without organ/space involvement; o fascial dehiscence or fascia is deliberately separated by the surgeon due to signs of inflammation; o deep abscess is identified by direct examination, during reoperation, by histopathology, or by radiologic examination; or o surgeon or attending declares deep incisional infection is present.</td>
<td>o purulent drainage from a drain placed by a stab wound into the organ/space; o organisms isolated from organ/space by aseptic culturing technique; o identification of abscess in the organ/space by direct examination, during reoperation, or by histopathological or radiological examination; or o diagnosis of organ/space SSI by surgeon or attending physician.</td>
</tr>
</tbody>
</table>

A wound is not considered a superficial site infection if there is:

- a stitch abscess present;
- infection of episiotomy or circumcision site;
- infection of a burn wound; or
- incisional SSI that extends into the fascia or muscle.


for postoperative wound infections gives interval data but, despite its simplicity, has only been used in research trials. In today’s world of same-day surgery and fast-track postoperative recovery ASEPSIS is less easy to use and its validity may be questioned.

Surveillance, incidence, and cost. Surveillance is equally critical to standard definitions. The CDC definition requires surveillance for infection be undertaken for 30 days for infection in soft tissues and up to a year for orthopedic and vascular prosthetic surgery. Again, the uptake of same-day surgery and fast-track postoperative recovery has affected the accuracy of surveillance figures, which were largely based on inpatient data. Postdischarge surveillance must now be included since the majority of SSIs have a mean time to presentation of 8-10 days and are not apparent until after the patient has left the hospital. Ideally, surveillance should include a trained, blinded observer using agreed-upon definitions rather than surrogate automated methods. Accurate surveillance, including postdischarge data, can inform and influence practice by allowing valid comparisons. In some countries, SSI surveillance is becoming mandatory. The methodology used has to be pragmatic and mostly depends on assessment at discharge, or telephone and questionnaire follow-up, but in research trials individual follow-up by direct observation is required for accuracy. Some areas of surgery have a low incidence of SSI, such as laparoscopic/endoscopic surgery.

There have been several predictive indices for SSI. The Study on the Efficacy of Nosocomial Infection Control (SENIC) included contaminated wound, diagnosis at discharge, duration of surgery, and abdominal surgery; and...
the National Nosocomial Infections Surveillance index included contaminated wound, the American Society of Anesthesiologists Physical Status classification system grade, and duration of surgery. They have been compared\textsuperscript{28,29} and both were found capable of predicting SSI.

Apart from the unrecorded indirect costs related to loss of productivity, reduced quality of life, and litigation, the actual cost of an SSI can involve additional inpatient treatment and procedures that can run into many thousands of pounds.\textsuperscript{30} The morbidity and mortality rates which follow sternal infection after cardiac surgery are just one example.\textsuperscript{31} There is a paucity of prospective cost-benefit analysis of the SSI, but retrospective analyses clearly identify that the economic costs of SSI are substantial.\textsuperscript{32}

**Prevention of Surgical Site Infection**

*Level I evidence.* Many national and international guidelines present the best available evidence for the prevention of SSI. In the United Kingdom, for example, there are 2: from the National Institute for Health and Clinical Excellence (NICE)\textsuperscript{33} and the Scottish Intercollegiate Guideline Network (SIGN).\textsuperscript{34} In the United States, similar quality improvement programs include the Surgical Care Improvement Project (SCIP)\textsuperscript{35} and the National Surgical Quality Improvement Program (NSQIP).\textsuperscript{36,37} The principal recommendations have been collated into a care bundle by the Department of Health of the United Kingdom.\textsuperscript{38} The concept of using this best evidence should summata the effects of the interventions, but success depends on the quality of compliance. The longer-term follow-up of NICE, SCIP, and NSQIP and their respective degree of compliance, will determine how effective they are.

The effectiveness of these national guidelines and performance measures to improve the rates of SSI remains to be seen. Three recent studies have demonstrated no improvement in SSI rates despite national efforts in the US to enforce compliance with SCIP measures.\textsuperscript{39,41} Hospitals with high rates of compliance do not have better SSI rates than those with less compliance. It is important to emphasize that SSI rates are influenced by multiple clinical variables and not only those articulated by national agencies. The recommendations by NICE and SCIP are clinically valid, but issues such as poor surgical technique and suboptimal compliance, along with the many other variables that influence SSI, will negate the benefits that should be seen. Clinicians and government policy makers must understand the complexity of SSI as a clinical outcome; recommendations focused upon a limited number of practices are only a starting point in prevention and, by themselves, may not influence overall outcomes.\textsuperscript{42}

Common to all of the guidelines and performance measures is the level I evidence supporting the rational use of antibiotic prophylaxis and the avoidance of razors for hair removal. Considerable level I evidence shows antibiotic prophylaxis significantly reduces SSI after clean prosthetic, clean-contaminated, and contaminated operations.\textsuperscript{53-56} Prophylaxis should be initiated within the immediate preincisional period of time (< 60 minutes before incision) and the antibiotic that is chosen should cover the organisms that are likely to be encountered. The selected antibiotic may depend on local resistance patterns, and guidance of a local formulary may be necessary. Usually a single-dose of antibiotic at, or immediately before, the induction of anesthesia is sufficient. Dirty operations, where infection already exits, will need a longer course of antibiotics that acts both as therapy and prophylaxis.

During the past 3 decades, prevention of SSI has relied almost entirely on the availability of effective perioperative antibiotic prophylaxis due to its high level of evidence. For the same reason, antibiotic prophylaxis has also been used for treatment of infections after clinical presentation. For example, in vascular surgery, 10 randomized controlled trials (RCTs) have been undertaken comparing systemic antibiotics vs placebo, and a systematic review and meta-analysis\textsuperscript{45} demonstrated a consistent benefit in reduction of SSI in 1297 patients relative risk (RR fixed, 0.25; (95% CI, 0.17 to 0.38; $P = 0.0001$). Although no single study demonstrated a statistically significant reduction in early vascular graft infection, the pooled results of these 10 RCTs appeared homogeneous with a reduction in early graft infection evident on meta-analysis (RR fixed, 0.31; 95% CI, 0.11 to 0.85; $P = 0.02$). There are, however, 2 aspects of these results which need to be highlighted. First, 6 of the 10 RCTs included a case-mix of patients with both prosthetic and vein grafts. If the results of the prophylactic effect of antibiotics are stratified by the type of graft, the RR for wound infection with prosthetic graft is nonsignificant at 0.51 (95% CI, 0.24 - 1.11). The administration of prophylactic antibiotics yielded a significant benefit only for patients with vein grafts ($RR = 0.13; 95\% CI, 0.04 - 0.41$). Therefore, in vascular surgery, evidence for the prophylactic effect of systemic antibiotics exists only for patients with vein grafts, who are at lower risk of infection, compared to patients receiving prosthetic material. Second, the meta-analysis is based on 10 studies that compared the effect of systemic antibiotics with placebo, conducted in the early to mid-1980s.

Resistance of *Staphylococcus aureus* (the most fre-
quent bacterial organism to cause vascular infections) to methicillin was first noted clinically in 1961. In the US, methicillin-resistant *Staphylococcus aureus* (MRSA) only emerged in the period 1975 to 1981 in tertiary care centers. The percentage of major US acute care hospitals reporting greater or equal to 50 MRSA cases per year increased from 18% in 1987 to 32% in 1989. Therefore, the result of meta-analyses of RCTs chiefly investigating the beta-lactam antibiotics which demonstrated efficacy of antibiotic prophylaxis need to be noted with caution today, as MRSA already has become the most frequent cause of skin and soft tissue infections presenting to emergency departments in the US. Although speculative, it remains questionable if a meta-analysis of these RCTs would yield significance again if conducted with the current rigor and epidemiologic situation.

The studies which give evidence that the use of razors to remove hair preoperatively cause infection are primarily from 30 years ago, but most guidelines suggest that if hair has to be removed, it should be done with a disposable clipper head, close to the time of surgery. These studies are robust enough to give level I evidence. The damage caused to skin by shaving too long before surgery encourages the growth of organisms, which increase the risk of SSI.

Also common in the guidelines and performance measures are methods to optimize the physiology of the host at the time of the operations; that is, avoidance of hypothermia, adequate glycemic control, and supplemental oxygen administration. The clinical value of avoiding perioperative hypothermia was first realized more than 15 years ago and there has since been many adequate RCTs confirming the relevance of warming in the prevention of SSI, which led to a NICE guideline. The pathophysiological benefit has also been well examined.

From the analysis of secondary outcomes in clinical trials, it has been suggested that patients who have diabetes and whose blood sugar is out of control are more at risk of SSI. This is supported by experimental evidence that many physiological mechanisms are impaired by hyperglycemia. Most guidelines suggest blood glucose should be tightly controlled in patients with diabetes. However, it has been convincingly shown that following cardiac surgery, even in patients without diabetes, poor glucose control is associated with poor wound healing, as well as SSI in sternal wounds and in leg wounds after harvest of saphenous vein. The maintenance of blood glucose has been adopted as standard practice in cardiac surgery and it is unlikely that RCTs will be undertaken to further prove this point. However, glycemic control in other fields of major surgery remains unproven, and tight glycemic control in patients without diabetes remains an area to be explored with RCTs. This may be especially true in trauma patients and patients with major surgical interventions, where hyperglycemia is part of the normal metabolic response to trauma and major surgical stress.

Intraoperative and immediate postoperative use of supplemental oxygen in the prevention of SSI discussed in

<table>
<thead>
<tr>
<th>Table 2. Factors implicated in a higher risk of surgical site infection.*</th>
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<tbody>
<tr>
<td><strong>i. Patient factors</strong></td>
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<tr>
<td>age sex obesity smoking</td>
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<tr>
<td>immunosuppression</td>
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<tr>
<td>steroids, cancer, anticancer therapy (chemo and radio-</td>
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<tr>
<td>therapy), HIV</td>
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<tr>
<td>nutritional indices</td>
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<tr>
<td>metabolic factors</td>
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<tr>
<td>diabetes mellitus, hepatorenal failure, serum albumin,</td>
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<tr>
<td>haemoglobin</td>
</tr>
<tr>
<td><strong>ii. Preoperative factors</strong></td>
</tr>
<tr>
<td>nasal decontamination</td>
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<tr>
<td>mechanical bowel preparation</td>
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<tr>
<td>skin preparation (surgical teams' hands patients' skin)</td>
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<tr>
<td><strong>iii. Operative factors</strong></td>
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<tr>
<td>previous surgery</td>
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<tr>
<td>antiseptic-impregnated incise drapes</td>
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<tr>
<td>length and complexity of operation</td>
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<tr>
<td>operating surgeon</td>
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<tr>
<td>blood loss</td>
</tr>
<tr>
<td>antimicrobial sutures</td>
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<tr>
<td>diathermy</td>
</tr>
<tr>
<td><strong>iv. Postoperative factors</strong></td>
</tr>
<tr>
<td>antiseptic lavage of wounds and cavities</td>
</tr>
<tr>
<td>antimicrobial dressings</td>
</tr>
<tr>
<td>supplemental oxygen in recovery</td>
</tr>
<tr>
<td><strong>v. Other factors observed but with varying levels of evidence</strong></td>
</tr>
<tr>
<td>theatre environment</td>
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<tr>
<td>preoperative showering</td>
</tr>
<tr>
<td>theatre wear</td>
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<tr>
<td>minimising movement in the OR</td>
</tr>
<tr>
<td>banning of jewellery and nail polish</td>
</tr>
<tr>
<td>drapes and gowns</td>
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<tr>
<td>wound drainage</td>
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</table>

*The relevance of many of these factors needs revisiting with adequate trial design.

this review because of the conflict in the results of RCTs. Considerable experimental evidence supports the use of supplemental oxygen to prevent incisional infection. Two RCTs have demonstrated significant reductions in SSI by the use of intraoperative and immediately postoperative oxygen supplementation (FiO₂= 0.8). A single RCT has demonstrated an increase in SSI rates with supplemental oxygen. While the theoretical arguments to support supplemental oxygen are abundant, additional studies appear to be warranted before guidelines or performance measures can be applied for the prevention of SSI.

Other evidence and risk factors. Many guidelines and reviews have listed other factors (Table 2) that can influence the incidence of SSI but most are of level II evidence base at best. Many are anecdotal, others have been identified by logistic regression analysis in trials and audit of SSI; and others by meta-analysis (Table 1).

Many of these reports suggest that being male or being elderly is associated with an increased risk of SSI, although 1 cohort study found a decreasing risk after 65 years. Obesity is also cited in studies as being an important, independent risk factor. In addition, many patient-related factors, including smoking, have a strongly supportive experimental base which has not been proven conclusively in clinical trials. This also applies to immunosuppressive, nutritional, and metabolic factors outside the scope of this article. Serum albumin is an example of a factor often ascribed significance for being an independent clinical risk factor, but it has not been clearly defined as such in prospective trials. A low value is associated with uncertain causation and may not reflect nutritional deficiencies in the developed world. However, experimental data shows it is a strong marker of poor healing; but in clinical practice, the serum albumin value is usually related to confounding factors associated with severe systemic illness, such as cancer cachexia or sepsis.

Skin preparation is routine prior to surgery but there has been little clear evidence demonstrating which antiseptic preparation is the best. Chlorhexidine has been a popular skin preparation, but in a concentration of 2% in combination with 70% isopropanol it has been shown to significantly reduce superficial and deep SSIs. The use of topical antiseptics for preparation of the surgical team’s hands, and as a preoperative wash for patients, has a good evidence base which deserves recognition. In view of the continued rise of antibiotic resistance, the use of antiseptic dressings and prophylactic antiseptic lavage for wounds and cavities bears reconsideration in future clinical trials, as well as reconsideration as a treatment for established SSIs.

Intraoperative factors that might relate to the incidence of SSI are traditionally observed and operating room discipline is long established, with a reluctance to change protocol without clear evidence. Operating room environment control has to be placed in this category. Some of these factors do have basis and are included in the risk factor prediction indices. The NICE guideline, having reviewed the old trials of antiseptic impregnated drapes, recommended they be used as nonimpregnated drapes, as there clearly was an increased risk of SSI associated with their use. By contrast, the guideline could not recommend, for example, the use of diathermy to reduce the risk of SSI. Evidence that the use of antimicrobial sutures can reduce SSIs is increasing; this has been found in clean, prosthetic, abdominal and thoracic surgery, and a meta-analysis has now been published which shows a level I evidence-base of the efficacy of antimicrobial sutures for the prevention of SSI. Again, we are sec-
ing the return of antiseptics as a first line treatment of managing SSI.

Many of the remaining factors listed in Table 1 have been challenges, although many of them are part of the traditional lore of clinical surgery. Guidelines continue to support gowns and drapes, appropriate use of surgical gloves, and reduction of movement in the operating room. Some have advocated the banning of jewelry and nail polish, but the evidence to support these policies are lacking. Preoperative showering and the value of wound drains are areas with supportive opinions but need additional research to validate their application.

Other strategies used in infection prevention, such as maximal sterile barrier precautions; routine change of surgical gloves before graft implant; performing surgical procedures in HEPA filtered, turbulence-free, laminar air-flow, ventilated operation rooms; implementation of perioperative surgical check lists; or the choice and concentration of pre-operative skin antiseptics and how they should be used, have not been studied in depth and indicate areas for future research.

Treatment of Established Surgical Infection and SSIs

Essential to treating surgical infection, and superficial and deep SSIs, is to open the area of infection and to drain pus. With deep SSI, this may require opening and draining the entire incision, while superficial SSI may only require a limited area of drainage. Fibrous debris is removed and any remaining sutures or staples in the area of infection should also be removed. The open wound commonly needs specific wound care to allow healing by secondary intention, although delayed primary or secondary closure may be feasible in selected cases. The open wound is managed with interactive moist dressings and wound desiccation should be avoided. The use of topical antimicrobial therapy is largely chosen by physician preference and remains an area for additional comparative investigations of alternative agents. The concerns that antiseptics may induce bacterial resistance to themselves, or even to antibiotics, with the risks of transmission, are unfounded. This is either because their mode of action is not suitable for bacteria to develop resistance, or because the clinically used high concentrations of antiseptics (which often surpass the required minimum inhibitory concentrations by 500 to 1,000 fold), are still able to rapidly kill off pathogens even if they have developed a decreased susceptibility against the applied antiseptic.74

Topical negative pressure wound management may be desirable in specific cases, but most superficial and deep SSIs do not require antibiotics when drainage and debridement is prompt. Antibiotics are warranted when local cellulitis or wound necrosis is present (Table 3). For staphylococcal SSI, microbiological culture and sensitivities may be needed to direct antibiotic coverage for MSSA or MRSA. With community-associated MRSA, clindamycin, trimethoprim/sulfamethoxazole, or doxycycline may be sufficient. Clinicians are advised to beware the clindamycin-sensitive but erythromycin-resistant MRSA since many of these organisms develop induced resistance to clindamycin during therapy. For conventional health care-associated MRSA, the use of vancomycin, linezolid, or daptomycin may be appropriate. Gram-negative infections need culture guidance, and when infections follow colonic procedures, the coverage of enteric anaerobic species, with use of metronidazole for example, is necessary.

The organ/space infection may require more aggressive measures. When there is necrotizing infection and separation of the fascia, debridement is essential. Debridement of these infections can be extensive with considerable loss of fascia and associated muscle. Invasive necrotizing infections within the surgical incision have become an increasing problem with the community-associated MRSA pathogens.75 Polymicrobial necrotizing infections will be seen following gastrointestinal contamination of the surgical site. Inadequate debridement leads to additional debridement and increased fascia and muscle loss. Temporary absorbable meshes may be required for abdominal wounds when there is loss of fascia. High rates of ventral hernia are seen following the scenario of necrotizing infection and absorbable meshes in the abdominal wall.

Intra-abdominal abscesses may require percutaneous drainage procedures. Management of the source of the organ/space infection, such as a leaking intestinal suture line, may require surgical management to control the source of continued contamination. Infected prostheses generally require removal, although these infections of vascular grafts,

<table>
<thead>
<tr>
<th>Table 3. Indications for antibiotics in surgical practice for treating surgical site infection.</th>
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<tbody>
<tr>
<td>• Cellulitis</td>
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<tr>
<td>• Lymphangitis</td>
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<tr>
<td>• Bacteremia</td>
</tr>
<tr>
<td>• Systemic inflammatory response and multiple organ dysfunction syndromes</td>
</tr>
<tr>
<td>• Definite pathogens (eg, beta-hemolytic streptococcus)</td>
</tr>
<tr>
<td>• Large numbers of organisms (eg, critical colonisation local infection)</td>
</tr>
<tr>
<td>• Poor host defenses (eg, immunosuppression, diabetes)</td>
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</table>

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heart valves, and prosthetic joints pose special problems. Antibiotics are almost always required for organ/space infections, the specific choice of which must be guided by culture and sensitivity data. Organ/space SSI pathogens are often staphylococcal but these infections are commonly associated with resistant organisms from the hospital environment. Antibiotic therapy again must be driven by specific culture and sensitivity data.

**Microbiological Diagnosis**

Microbiological investigations may support the diagnosis of SSI and surgical infections, provided specimens are obtained appropriately. Thereby, microorganisms that are potentially causative for infection are yielded, and not colonized flora, which have no relevance for a suspected infection. Optimal results are achieved from specimens obtained directly from the infection site. Such material may include explanted grafts, extra- or intra-operatively obtained tissue biopsies from the infected area, and material aspirated from peri-graft fluid collection. Indirectly obtained material, such as blood cultures, may also yield important information. However, blood cultures may often be negative, particularly in late-onset infection, but are more frequently positive in early-onset infection.

Specimens may be processed using a number of techniques such as direct streaking swabs on agar plates, broth culture, homogenization of tissue specimens with serial dilution techniques, and sonication of the specimen to enhance the recovery of biofilm-forming organisms from graft or infected material. The report of processed microbiological specimens is decisive for a valuable evaluation of therapy and clinical results. The demonstration of specimens' relevance from the pre-, intra- and postoperative phases is considered most valuable, if feasible and possible. Relevant preoperative samples include blood cultures taken from central and peripheral venous catheters or direct vein puncture, wound specimens, drainage fluid, nose and throat swabs in the case of MRSA colonization, and urinary samples. In any case, all responsible microorganisms should be classified according to their type (eg, Gram-positive or -negative, fungi, etc.) and specific therapy antibiograms offered for highly virulent microorganisms (eg, *Pseudomonas aeruginosa*). Careful assessment is needed for microorganisms isolated from overlying wounds or sinuses, as such microorganisms may represent colonizing flora, (eg, MRSA), and may be wrongly interpreted as causative agents. Relevant intraoperative samples are standard specimens obtained from the surgical site, the peri-graft fluid/pus, or explanted prosthetic material. Worth noting is that a considerable number of specimens may be negative. A negative microbiological report, however, does not exclude an infection. Finally, relevant postoperative samples are blood cultures, drainage fluid, and wound specimens (eg, those usually taken when there is delayed wound healing). The development of polymerase chain reaction methodologies that will provide unique bacterial species and sensitivity signatures may greatly enhance the diagnosis of infection and will reduce the number of circumstances where microbiological evaluation of wound and blood cultures are negative, but clinical infection appears to be present.

**Conclusion**

Surgical site infection continues to be a complication of surgical care. These infections span a continuum of severity with some being easy to manage while others are life-threatening. Considerable evidence provides direction in the prevention of SSI such as systemic antibiotic prophylaxis, but many preventive strategies need better definition, with additional clinical studies. When SSI occurs, the clinician needs to be able to quickly recognize it and tailor management to the needs of the patient. In general, drainage, debridement, and specific antibiotics for the putative pathogen are the hallmarks of management.

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