Surgical wound infection

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Objective. To review the risk factors for surgical wound infection; the use of prophylactic antibiotics in the prevention of wound infection; and the benefits of wound surveillance programmes to reduce the rate of surgical wound infection.
Data sources. *Medline* literature search and review of published work on surgical wound infection, and the references cited in them.
Study selection. Critical studies containing supporting evidence were selected.
Data extraction. Data were extracted independently by multiple observers.
Data synthesis. Factors that affect the susceptibility of a wound to infection include a pre-existing illness, the duration of the operative procedure, wound contamination, three or more diagnoses at the time of discharge, and abdominal operations. Antibiotic prophylaxis can decrease postoperative morbidity, shorten hospital stay, and reduce overall costs attributable to infection; the choice of antibiotic depends on the wound class. Wound surveillance can also decrease wound infection rates.
Conclusion. Surgical wound infections are common and consume a considerable portion of health care finances. A reduction in the infection rate to a minimal level, however, can be achieved by the judicious use of antibiotic prophylaxis and the use of an organised system of wound surveillance and reporting.

HKMJ 1999;5:82-6

Key words: Postoperative complications; Risk factors; Surgical procedures, operative; Surgical wound infection

Introduction

Surgical wound infection is a common postoperative complication and causes significant postoperative morbidity and mortality, prolongs hospital stay, and adds between 10% and 20% to hospital costs. Although the total elimination of wound infection is not possible, a reduction in the infection rate to a minimal level could have significant benefits in terms of both patient comfort and medical resources used.[1]

Any purulent discharge from a closed surgical incision, together with signs of inflammation of the surrounding tissue should be considered as wound infection, irrespective of whether micro-organisms can be cultured. Infection can occur at an incision site within 30 days of an operation, but wounds that are closed and primarily healed are not considered infected. There are intermediate categories of wounds that may or may not be infected—namely, wounds that have a small amount of clear discharge. These wounds may be considered as ‘possibly’ or ‘probably’ infected. In 1992, the Surgical Wound Infection Task Force replaced the term ‘surgical wound infection’ with ‘surgical site infection’, to include infections of organs or spaces deep in the skin and soft tissues, such as peritoneum and bone. Surgical site infection is classified into superficial site infection and organ or space infection.[2]

Factors that affect the incidence of wound infection

There are many factors that are thought to affect the susceptibility of any wound to infection, some of which strongly predispose to wound infection. These factors include pre-existing illness, length of operation, wound class, and wound contamination. Other factors such as extremes of age, malignancy, metabolic diseases, malnutrition, immunosuppression, cigarette smoking, remote site infection, emergency procedures, and long duration of preoperative hospitalisation are not considered as independent risk factors for wound infections.[3]

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The effect of pre-existing illnesses on wound infection

In the Study on the Efficacy of Nosocomial Infection Control (SENIC) of 1970, 58 498 patients undergoing operations were monitored for the presence and progress of wound infection.[4] Stepwise multiple logistic regression techniques identified four independent risk factors: (1) procedures lasting more than 2 hours; (2) wound contamination; (3) three or more diagnoses at the time of discharge (excluding those related to surgical wound infections and their complications); and (4) abdominal operations.[4] The SENIC risk index—an assessment index that takes these four factors into account—was replaced by the American Society of Anesthesiologists (ASA) preoperative assessment score, which was validated in a large study involving 44 hospitals from 1987 to 1990.[5] The wound infection rate among patients in ASA class I or II was 1.9%, whereas among patients in class III to V was 4.3%.[5] Garibaldi et al[6] have since confirmed the independent predictive power of the ASA score in a prospective study of 1852 surgical patients in which the odds ratio of having a wound infection for ASA class III to V patients compared with Class I or II patients was 4.2. There are newer, more comprehensive measures of classifying patient physiological status, such as the Acute Physiologic Assessment and Chronic Health Evaluation (APACHE) II or III. Whether these measures give a more precise prediction of risk remains to be proven.

Duration of the operative procedure

The risk of wound infection has repeatedly been shown to be proportional to the duration of the operative procedure. Cruse and Foord[7,8] found that the rate of wound infection increased for longer procedures, roughly doubling with every hour of the procedure. Operations lasting 1 hour or less had a wound infection rate of 1.3%, whereas those lasting 3 hours or more had a rate close to 4.0%.[7,8] Haley et al[4] showed by using multivariate analysis that an operative time of more than 2 hours is the second greatest independent predictor of risk (wound contamination being the first). And by using a different index, Culver et al[5] found operative time to be one of three variables—along with wound class and ASA class—that independently predict infection.

Wound classification

The wound classification scheme proposed by the National Research Council continues to be useful.[9] The wound class has been shown to be independently predictive of wound infection in several large studies using multivariate analysis. In 1980, the Foothills Hospital study of 62 939 wounds generated a set of wound infection rates for the four wound classes: clean, 1.5%; clean contaminated, 7.7%; contaminated, 15.2%; and dirty 40%.[8] Culver et al[5] modified the SENIC risk index in 1991, but wound classification was the only risk factor that was unchanged from the original index. Garibaldi et al[6] also found surgical wound class (by stepwise logistic regression analysis) to be predictive of wound infection.

Wound contamination

Wound contamination, as shown by intra-operative culture, is associated with later wound infection. Whyte et al[10] showed that during cholecystectomy, the number and species of bacteria cultured from bile are predictive of wound contamination and later wound infection. Garibaldi et al[6] found that 30 or more colony-forming units (CFU) of bacteria cultured from a wound are predictive of wound infection, regardless of wound class. In addition, a prospective study of 190 colorectal surgery patients has shown that a concentration of 5 CFU per millilitre or higher of bacteria in the peritoneal fluid are predictive of wound infection; infection rates without and with contamination were 6.4% and 1.2%, respectively.[11]

Reducing the occurrence of wound infection

The judicious use of antibiotics and the use of an organised system of wound surveillance are the most effective means to reduce the wound infection rate.[12] Tissue level factors such as micro-environment and the presence of white cells and cellular products are important elements of the local immune response; thus, their manipulation may be useful in planning wound management strategies. Other procedures such as preoperative hair removal, use of adhesive drapes, and wound irrigation are of small benefit only.

Antibiotic prophylaxis

Burke[13] demonstrated the importance of the timely use of prophylactic antibiotics in surgery. Antibiotic prophylaxis can decrease postoperative morbidity, shorten hospital stay, and reduce overall costs attributable to infection.[1]

Choice of antibiotics

The wound classification scheme devised by the National Research Council serves as the basis for recommending antibiotic prophylaxis.[9] The least toxic and most effective antibiotic regimen should be chosen. Excellent guidelines regarding the selection and use of prophylactic antibiotics to treat surgical wounds have been published.[14,15]

Clean wounds

Wounds in which the risk of infection is less than 2%, generally do not require antibiotic prophylaxis. Common exceptions are procedures in which infection would be disastrous—for example, prosthesis placements, central nervous system operations, or cardiac procedures that use cardiopulmonary bypass. A first generation cephalosporin, such as cefazolin, is commonly used; if the patient is allergic to penicillin, vancomycin is a good alternative.

Clean contaminated wounds

Antibiotic prophylaxis to treat clean contaminated wounds reduces the risk of infection from 30% to 10%.[3] Head and neck, thoracic, biliary, gastroduodenal and genito-urinary procedures should receive appropriate antibiotics (ie cefazolin or cefuroxime). Patients undergoing colorectal operations should receive mechanical bowel preparation and oral antibiotics (eg neomycin or erythromycin). Most surgeons add a parenteral antibiotic (eg cefoxitin).

Contaminated, infected, or dirty wounds

Wounds that are known to be or expected to be infected or dirty, such as a ruptured viscus or traumatic wound, should be treated with preoperative antibiotics, which are usually continued in the postoperative period as active treatment. Both gram-negative aerobic and anaerobic organisms causing the contamination need to be eliminated. Cefoxitin or cefuroxime, in combination with metronidazole are usually used. The risk of infection is reduced from >60% to less than 40% by antibiotic prophylaxis.

Route and time of administration

For most surgical procedures, a single bolus of intravenous antibiotic at the time of induction of anaesthesia is considered adequate.[16] This dose enables a high plasma and tissue concentration to be attained rapidly. The rate of infection increases if prophylactic antibiotics are given more than 2 hours preoperatively, or postoperatively.[17] Oral and intramuscular routes of administration produce a lower peak plasma level. For colorectal operations, both intravenous and oral routes of prophylaxis administration are necessary. In certain orthopaedic procedures, local antibiotics are used—for example, bone cement that is impregnated with gentamicin is used in joint prosthesis implantations.[18]

Dosage of antibiotic

The dose of prophylactic antibiotics should not be smaller than the standard therapeutic dose of the drug. A single prophylactic dose is effective and preferred to multiple doses.[19] Consequently, treatment consists of a single dose given preoperatively and a certain number of postoperative doses for 24 hours to a few days. The definition of 'single dose' prophylaxis includes the administration of a second dose during surgery if the procedure lasts more than 2 to 3 hours and the plasma half-life of the drug is short.[19] The single dose approach has the advantage of low cost, less toxicity, and less chance of developing antibiotic resistance.

Limiting the use of antibiotic prophylaxis to the intra-operative period is one of the most significant changes in preventing infection and is dramatically different from the previously recommended 24- to 48-hour coverage.[20] Single-dose prophylaxis is effective in most surgical procedures, although its use during cardiac operations remains debatable. Additional, prolonged antibiotic prophylaxis while lines, tubes, and catheters are in situ is not necessary.[14]

The use of antibiotic prophylaxis is not a substitute for good infection control practices, proper patient preparation, good judgement, good technique, or an adequate operating environment. Inappropriate and indiscriminate use of prophylactic antibiotics may increase costs through unnecessary drug use, requisite laboratory monitoring, and the emergence of resistant organisms. The potential toxicity of antibiotics is also an important risk of antibiotic prophylaxis.

Wound surveillance

The rigorous surveillance and reporting of wound infection rates have been advocated as the best way to decrease wound infection rates. In a prospective study performed over a 10-year period, the clean wound infection rate was reduced from 2.6% to 0.6%.[8] Condon et al[21] studied 8227 wounds from 1976 to 1981 and also noted a reduction in the clean wound infection rate—from 3.5% to less than 1.0%. And close observation of 40 915 wounds over a 10-year period showed that the wound infection rate in each study year ranged from 1.8% to 2.8% and was significantly less than the infection rate of 4.2% in the index year.[12] In this study, the introduction of an aggressive surveillance programme led to a large saving in in-patient service costs over 9 years; the overall wound infection rate subsequently decreased from 4.2% to 2.5%.[12]

A prospective study of 1483 patients aged from 10 to 92 years compared two measures of patient risk for nosocomial infection—the SENIC index and NNIS (National Nosocomial Infection Surveillance) index. The NNIS index had a better reliability than the SENIC index for discriminating and predicting the risk of surgical site infection.[22]

The Surgical Wound Infection Task Force in the United States published a series of guidelines for wound surveillance in 1992. The following are some of the recommendations[23]:

(1) The definitions of the Centers for Disease Control and Prevention regarding wound infection should be adopted without modification;
(2) Either direct observational or traditional infection control surveillance techniques are acceptable for case finding of wound infections;
(3) Surgeon-specific wound infection rates should be calculated and reported to individual surgeons and the chairman of surgery. The report must be kept coded and confidential and stratified by risk;
(4) Studies are needed to determine whether wound infections following 'out-patient' and 'minor' surgical procedures have similar importance to infections that develop after in-patient procedures;
(5) Surgical procedures should be classified according to surgical wound class and a measure of patient susceptibility to infection, such as the ASA score or duration of operation;
(6) The surgical wound class criteria need to be more accurately defined and standardised; and
(7) Post-discharge surveillance for wound infection is important and should be done. Santos et al[24] in a 6-month prospective surveillance reported that the majority (52.7%) of surgical site infections were apparent only after patients had been discharged from hospital.

Conclusion

Surgical wound infections are common and consume a considerable portion of health care finances. Although surgical wound infections cannot be completely eliminated, a reduction in the infection rate to a minimal level could have significant benefits, by reducing postoperative morbidity and mortality, and wastage of health care resources. A pre-existing medical illness, prolonged operating time, the wound class, and wound contamination strongly predispose to wound infection. The judicious use of antibiotic prophylaxis and the use of an organised system of wound surveillance and reporting are the most effective means to reduce the wound infection rate to an attainable minimum.

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