

Surgical infection and development: an overview

Yogendra Singh¹

Basista Rijal²

Abstract

Surgical infection is an important indicator of quality of care. Despite elucidation of consistent surgical development, surgical infection remains to be a serious problem in surgical practice. The sequential development in hospital design, surgical care and control measures to tackle the counterpart determinants of an infection environment, host and agent, respectively, do not stop the march of surgical infection. Specific actions are warranted in surgical practice to bring down the infection rate to a minimum.

Keywords: surgery, infection, triangular model, development

Introduction

Surgery primarily attempts the healing of wounds without serious complications. Infection that is a consequence of surgery is an important indicator of the quality of care. The incidence of wound infection is largely influenced by the type of surgical procedure. However, infection is still the most serious postoperative complication despite the development of increasingly more powerful antimicrobial drugs. It may impair the therapeutic effects of an operation, and in some cases lead to temporary, partial or complete disability and even increased mortality rate especially for patients with deep infections.¹ Therefore, data on surgical infection have an important impact on surgical development, in terms of hospital design, surgical technique and infection control measures. The growing focus of surgical research is, therefore, the understanding of these factors in order to prevent surgical infections. It seems that infections are more challenging even in the developed surgical centres.

Infection-model

The well-known triangular model of an infection consists of an agent, a host and an environment.² Infections in surgical patients arise as a result of exogenous or endogenous bacterial contamination, and both aerobic and anaerobic bacteria can be responsible for most of infections. Among aerobes, *Staphylococcus aureus* is the most common organism in wound infection. *Streptococci*, *Klebsiella*, *Escherichia* and *Pseudomonas* are also common pathogens. The presence of anaerobic microbes has been recognized for a long time, ever since Pasteur became aware that the microbes which produced butyric acid (*Clostridium butyricum*) were immobile when exposed to air, but were mobile when the air was removed. Among the human anaerobic pathogens, *Bacteroides*, *Peptococci*, and *Clostridium* species are the most often encountered in surgical infection. Some fungi, yeasts and parasites may also cause surgical infections.

A susceptible host is the other side of the infection-triangle. Both endogenous and exogenous factors are believed to affect the susceptibility of any wound to infection. Endogenous factors are the unique attributes of the patient which may or may not be variable prior to surgery. Exogenous factors are not unique to any patient, and can often be influenced by the surgeon, for example, the length of the operation. Surgical infections are more common in immunosuppressed patients, and acquired immunodeficiency syndrome (AIDS), transplant immunosuppression, and agammaglobulinemia are associated with a high risk of infection. Similarly, burn patients are highly susceptible to infection. In general, specific immunosuppression leads to long-term morbidity and mortality due to wide-spread infections, such as pneumonia, meningitis and viral diseases. Patients with nonspecific immunosuppression such as granulocytopenia, defective chemotaxis and malnutrition are prone to infection. In pulmonary disease, severe trauma, congestive heart failure and hypovolemia, the peripheral tissues are hypoxic and may therefore be susceptible to infection. The host's ability to resist an infection can also be reduced by tissue destruction including clumsy surgery, prolonged anesthesia, and ischemia.

Diabetic patients are also vulnerable to surgical infection. Furthermore, parenteral drug abusers often develop soft-tissue infections.

An infective agent needs an environment to complete the triangle of infection in a susceptible host. The barrier, which keeps the infective agents away from the normally sterile tissue, such as the intact skin or bowel mucosa, is the key step in infection. In general, poorly vascularized tissues are more susceptible to infection. Some natural spaces (lumen) in the body, for example, the appendix, gallbladder and intestines, are prone to become obstructed and infected. Foreign bodies, dead tissues, and injury interfere with the normal defence mechanisms of the sliding surfaces of the peritoneal and pleural cavities, and thus promote infection.

The most common nosocomial infections may include wound infections, urinary tract infections and respiratory infections. The principal factor responsible for wound infections is the type of operation. In the case of a clean operation, there is the least risk of infection, whereas in a contaminated operation the risk of infection is quite high. Urinary tract infections occur in patients with prolonged bed rest postoperatively, or postinstrumentation. Postoperative cases in bed, especially after general anesthesia, are also at risk of respiratory infection. Person to person droplet transfer is the main mode of respiratory transmission in nosocomial infections.



Fig.: Imaginary triangular models.

Development-Model

Similar to the infection-triangle, it seems that a triangular model is applicable for surgical development, which consists of the growth of surgical knowledge and the subsequent modern hospital design (environment), surgical care (host), and control measures (agent). This surgical development has been substantially determined by technological and economical efficiency. Louis Pasteur laid the foundation for the development of vaccines by attenuating virulent strains and also prevented the natural spread of pathogens from an infected to a noninfected subject. Subsequently, Joseph Lister, the father of modern surgery, introduced antiseptic techniques to surgery in 1867. However, it was later recognised that despite meticulous aseptic techniques, a wound can still be infected by either initial contamination or by cross infection.

With the advent of antibiotics in the 1940s, it became obvious that all those microbes would be tackled successfully. Depending on the microbial response, a wide range of antibiotics have subsequently evolved. However, treatment requires surgical drainage of the infection and debridement of necrotic or grossly contaminated tissue. The use of antibiotic prophylaxis remains controversial in clean operations, but it has provided promising control measures against infection. In surgical practice, antibiotics are also used to treat established infections after culture and drug sensitivity testing of the microorganisms. Antisepsis, including prophylactic antibiotics, is now reaching its zenith. However, genetic adaptations by these microbes have enabled them to survive in a hostile antibiotic environment. The incidence of multiresistant staphylococcal infection, even today, is not uncommon.

Hospital design also contributes a great deal to surgical development, especially the surgical ward and operating room, because wounds are at risk of contamination both in the operating room and ward.

Therefore, hospitals should be designed to prevent microbial contamination. However, the maximum

contribution that surgical room design can offer to asepsis in surgery seems to have been reached. In busy surgical units, the risk of cross-infection must be minimized. The efficiency of the hospital design must also be supplemented by central supply departments for sterilizing instruments.

There has been revolutionary development in the area of surgical care for infection. Recent progress in surgical research has made it possible to diagnose an infection accurately, and then to treat it properly. New surgical techniques involving tiny incisions and special instruments that enable the surgeons to see and operate deep within a patient's body are now becoming more frequent in all surgical fields. These methods should help to avoid large incisions and the trauma of traditional surgery. Minimal invasive surgery or non-operative treatment for surgical cases, for example, shock wave lithotripsy, endoscopic and laser therapy, remarkably reduced the risk of surgical infection. The oldest concept in infection control, which consists of reducing damage to the host and supporting his/her resistance, appears to be the most fertile area for modern surgical progress. With the advent of autosuture technique, it shortens the length of operation than the hand-sewing method. Furthermore, the infection rates can be reduced with enhanced nutrition, the maintenance of tissue perfusion, oxygenation and immune stimulation.

Viewpoints

Despite the elucidation of new knowledge and the development of novel techniques that have led to the control of certain infections, surgical infections continue to be important in terms of its use of time and resources. The horrors of septic infection in the pre-Listerian era have been well-documented, and yet the dictum of Florence Nightingale made over a century ago, that 'the very first requirement of a hospital is that it do the patient no harm', is still not being met. Historically, in the 1860s, Lister became aware of the germ theory of disease developed by Louis Pasteur, and attempted to apply it to surgery. Although his ideas were accepted gradually over time, the development of aseptic technique has in fact reduced the mortality of surgery remarkably. Penicillin was subsequently proven to be the most effective agent available against Gram-positive pathogens in 1941.

After almost two decades of development of broad-spectrum antibiotics, one of the earliest and most comprehensive reports of wound infection by the National Research Council: Perioperative wound infections revealed that overall infection rate was 7.5% in 1964.³ A substantial improvement in management of infection has been made thereafter. Another larger series reported a 4.7% of wound infection rate after 16 years of the earlier report.⁴ A set of guidelines for antibiotic prophylaxis against these infections was proposed.⁵ This antibiotic prophylaxis has been found to be useful in preventing bacteremia and wound infection postoperatively or post-instrumentation in a site with normal flora or where an infection was already present. Recently, a multicentred trial has indicated the use of a new supplemental drug in complicated infections.⁶ Other points, such as avoiding or minimizing microbial contamination and doing nothing to compromise the host's defence mechanism, are also important for the prevention of infection.⁷

Invasive therapeutic procedures, for example, intravenous cannulation, catheterization or other invasive surgical procedures, provide the opportunity for opportunistic organisms of low pathogenicity, to invade the tissues. Some infections can be easily controlled by these surgical developments, but the problem of resistance in surgical infections has been emerging. Recent studies continue to report constant infection rates for general surgical services, despite the immense developments in surgery.^{8,9} This continued rate causes the greatest delay in hospital discharge for all types of surgeries and ultimately invites an extra financial burden.¹⁰ Surprisingly, this infection rate is also not correlated with the technological or economical developments. The rising complexity and resistance of surgical infection seem to run parallel to the sequential developments in the surgical fields.

Conclusion

If the complete elimination of surgical infection is not possible, a reduction to a minimum level, should be the goal of all concerned and this can be a justification for continued development in the surgical field. However, surgical infection is not a thing

of the past in this modern era of surgery, and there could be multiple factors for the persistence of this infection rate. We must, therefore, strive very specifically against those factors in the battle against surgical infection. The preservation and enhancement of host defences remain the core of surgical practice. The newer modalities of manipulating cellular factors hold promise for future therapies. Nevertheless, surgical infection and development are so closely related that they are no doubt two sides of the same coin.

Acknowledgement

We thank our teachers of Surgery, Professors A.K. Sharma, G.P. Sharma, B.R. Joshi and M. Khakurel for their constant inspirations during our surgical residentship.

References

1. Poulsen KB, Wachmann CH, Bremmelgaard A, Sørensen AI, Raahave D, and Petersen JV. Survival of patients with surgical wound infection: a case-control study of common surgical interventions. *Br J Surg* 1995; **82**: 208-209.
2. Meakins JL, Wicklund B, Forse RA, and McLean APH. The surgical intensive care unit: current concepts in infection. *Surg Clin North Am* 1980; **60**: 117-132.
3. Report of an *ad hoc* Committee on Trauma, Division of Medical Sciences, National Academy of Sciences - National Research Council: Perioperative wound infections. The influence of ultraviolet irradiation of the operating room and of various other factors. *Ann Surg* 1964; **160** (suppl): 1-192.
4. Cruse PJE, and Foord R: The epidemiology of wound infection: a 10-year prospective study of 62,939 wounds. *Surg Clin North Am* 1980; **60**: 27-40.
5. Page CP, Bohnen JM, Fletcher JR, Mc Manus AT, Solomkin JS, and Wittmann DH: Antimicrobial prophylaxis for surgical wounds: guidelines for clinical care. *Arch Surg* 1993; **128**: 79-88.
6. Pollock AV: Surgical prophylaxis - the emerging picture. *Lancet* 1988; **1**: 225-230.
7. Solomkin JS, Reinhart HH, Dellinger EP, *et al*: Results of a randomized trial comparing sequential intravenous/oral treatment with ciprofloxacin plus metronidazole to imipenem/cilastatin for intraabdominal infections. *Ann Surg* 1996; **223**: 303-315.
8. Culver DH, Horan TC, Gaynes RP, *et al*: Surgical wound infection rates by wound class, operative procedure, and patient risk index. *Am J Med* 1991; **91** (suppl): 3B: 152S-157S.
9. Anderson G, Boldiston C, Woods S, and O'Brien P: A cost effectiveness evaluation of 3 antimicrobial regimens for the prevention of infective complications after abdominal surgery. *Arch Surg* 1996; **131**: 744-748.
10. Olson MM, Lee JT Jr: Continuous 10-year wound infection surveillance. *Arch Surg* 1990; **1**