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Surgical Management of Surgical Site Infections in Orthopaedics

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Abstract

Surgical site infections are a source of great misery to both patients and surgeons. The management requires a multipronged approach specially in orthopaedics. The current chapter outlines the various methods of source control when dealing with musculoskeletal infections.

Keywords: Surgical site infections, orthopaedics, management

Introduction

In the perennial war between microorganisms and the human race, there is no true victor - often there is but an uneasy truce. Each side is armed with several tricks. Bacteria have sheer numbers, a rapid duplication process and rapidly evolving adaptability. Humans have a strong immune system, antibiotics and antiseptics, and the entire armamentarium of modern medicine.

Prompt diagnosis of infection is one of the keys to a successful outcome following surgical site infections (SSIs) in orthopedics. Management of surgical site infections is a two-pronged attack that comprises of systemic control of infection and source control ie, local control of infection within the wound.

Systemic control of infection is achieved by targeted antibiotics for an adequate (often prolonged) length of time, and by bolstering the patient`s immune status with protein supplementation and maintenance of hemoglobin. Source control involves reduction of dead and infected tissue within the surgical wound thereby reducing the bacterial load. Source control may be obtained with mechanical irrigation and debridement of the surgical site, removal/ replacement of implants if necessary, application of local antibiotics/ antiseptics to the wound and negative pressure wound therapy (NWPT). Primary or early secondary closure of the wound will also aid in control of infection locally.

The current chapter outlines the various methods of source control when dealing with musculoskeletal infections.

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Irrigation & Debridement

Devitalized tissue in general, and necrotic tissue in particular, serve as a source of nutrients for bacteria[1]. Devitalized tissue also acts as a physical barrier for reepithelialization, preventing applied topical compounds from making direct contact with the wound bed to provide their beneficial properties. Necrotic tissue also prevents angiogenesis, granulation tissue formation, epidermal resurfacing, and normal extracellular matrix (ECM) formation. Finally, the presence of necrotic tissue may prevent the clinician from making an accurate assessment of the extent and severity of the wound, even masking possible underlying infections.

The first step in source control of infected surgical wounds is debridement and irrigation of the wound[1]. Surgical debridement aims to reduce the bacterial load within the wound by draining infected tissue fluid/ pus from the wound and removing all the devitalized tissue including biofilms from the wound bed to promote wound healing. Debridement also offers an opportunity to obtain deep tissue cultures which are more accurate and permit the employment of targeted antibiotics for infection control. Debridement also stimulates the wound bed to support healing and to prepare for a skin graft or flap.

Surgical debridement must be performed in a systematic manner starting with the skin and proceeding deeper. Each layer is debrided starting at the 12`o` clock position and then proceeding circumferentially around the wound in a clockwise manner. All necrotic tissue is removed and only viable tissue as judged by its red colour, soft consistency (not friable), bleeding and contractility when pinched or stimulated with electrocautery, is left behind. However, the skin is preserved, unless obviously necrotic. Bone which is pearly white, stripped of periosteum and not

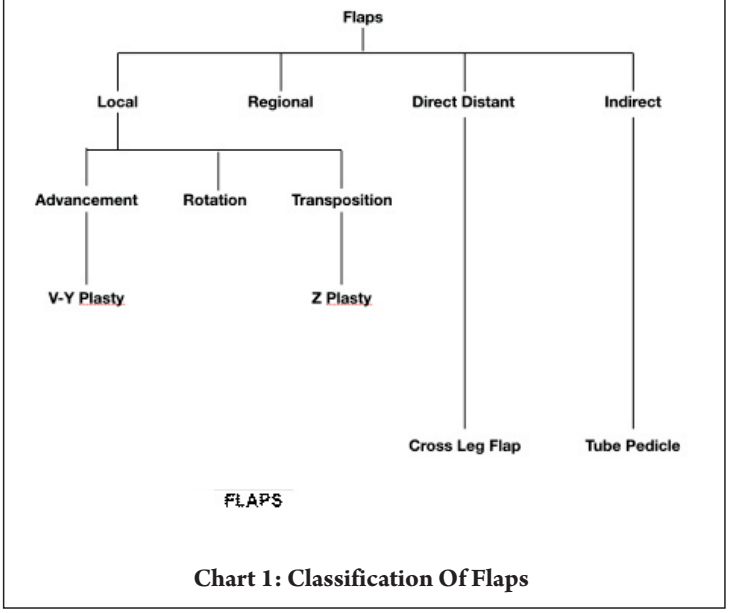


Chart 1: Classification Of Flaps

bleeding must also be excised, if deemed nonviable.

A thorough debridement is followed by a copious wash of the wound with 8 to 10 litres of sterile water/normal saline[2,3,4]. Normal saline is preferred as it is non-toxic to tissues and similar in tonicity to physiologic fluids. Antibiotics or cleansing agents such as povidone iodine can also be added to the solution. The wash can be administered in the form of a pulsatile lavage with pressures between 4 and 15 psi. Some surgeons prefer a slow, gravity assisted lavage to prevent dislodging clots and damaging healthy granulation tissue. The goal of wound irrigation is to remove cellular debris that is loosely clinging to the wound, surface bacteria, wound exudate, dressing residue and any residual topical agents.

In badly infected wounds, multiple debridements under general anaesthesia may be necessary before wound is healthy enough for closure to be attempted. All procedures after debridement should have a fresh start, including a fresh set of instruments, redraping, regowning and regloving. This is because bacteria in concentrations of more that 104 have been found lurking on instruments and in the operative field

Implant: Remove/ Replace/ Retain

Colonization of the implant can result in the formation of biofilms on implants/ bone/tissue[5]. Biofilms may form within a few days of infection, are often resistant to multiple antibiotics and act as a nidus for persistent infection that complicates both treatment and healing. Treatment of such infection then involves thorough excision of the biofilm which may even entail removal or replacement of the implant.

The decision whether implant should be retained, replaced or removed altogether is based on the following (Table 1)[6]:

1. Onset of symptoms (classification): early–delayed–late onset of infection?

When the infection presents early (within 2 weeks of the index operation), aggressive debridement of the wound may control the infection and prevent formation of biofilms. An immature biofilm may be more amenable to excision and subsequent suppression with antibiotics, allowing retaining of the implant. When implants are retained, debridement is followed by administration of targeted antibiotics for upto 12 weeks (2 weeks IV + 10 weeks oral). Rifampicin must be added to the regime when the biofilm infection is because of S aureus and Quinolones must be administered for biofilms formed by gram negative bacteria. Rifampicin is never administered as a single drug because of rapid development of drug resistance. It is usually combined with a quinolone. Ideally, the implant must be removed later when the fracture has healed.

With delayed infections (3- 10 weeks), the treatment is complicated by the maturation of the biofilm and development of progressive osteomyelitis. In this case thorough debridement and implant exchange is often the procedure of choice. When the infection presents more than 10 weeks following the index operation (late infection), inflammation, fibrous

Table 1: Guidelines for retaining implants
1. Early Infection (< 2- 3weeks)
2. Microorganism is identified and is sensitive to iv and oral antibiotics
3. Osteosynthetic construct is stable
4. Adequate soft tissue cover available
5. Host physiology is favorable

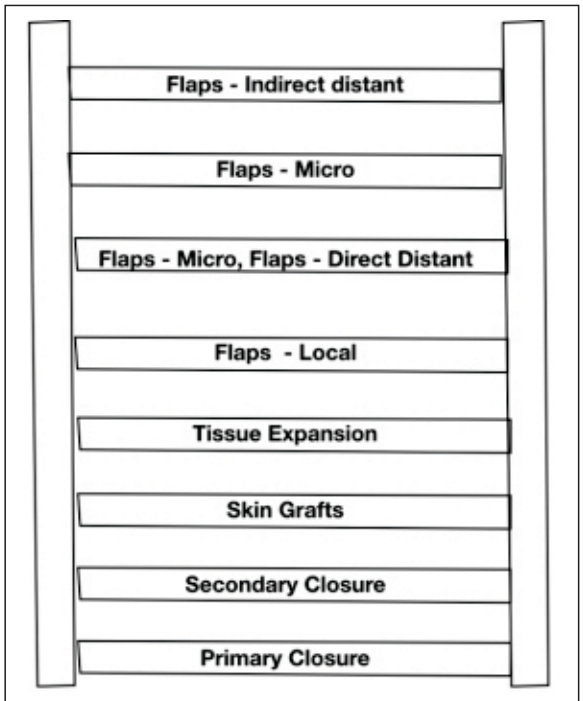


Figure 1: Classification of wound closure options

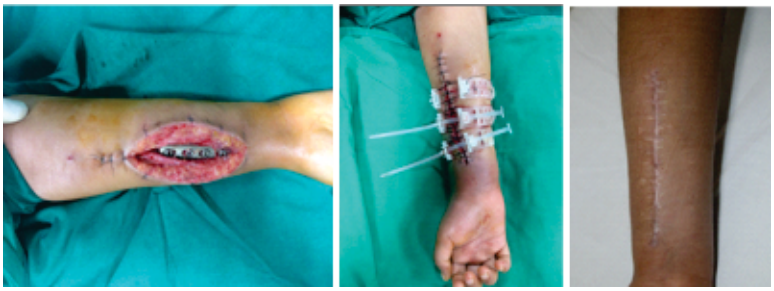


Figure 2: Application of a Top Closure system for an infected forearm wound with an exposed radius plate

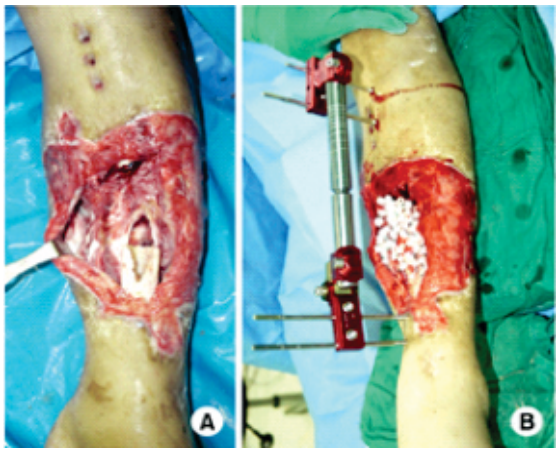


Figure 3: A) Clinical photograph shows bone and soft tissue defect after radical debridement. (B) Defect filled with antibiotic impregnated polymethyl methacrylate cement beads and external fixator application. Sourced from Kim JH, Yoon YC, Kim YW, Oh JK. Diagnosis and management of post-traumatic Chronic osteomyelitis. J Koren Fracture Soc 2014 Jan 1; 27:88- 104

encapsulation and osteolysis often leads to instability of the implants that may necessitate removal of the implant and if necessary, an alternative form of fixation.

2. Fracture healed or stable callus formed?

The decision about implant removal is also based on the status of fracture consolidation or healing of the fusion mass within the spine. If the fracture has healed or there is a strong soft callus or the fusion mass has matured, then implants can be removed. In early infections where there is no significant fracture healing, all attempts must be made to provide fracture stability by retaining or replacing the implant or using an alternative method of fixation, such as an external fixator.

3. Osteosynthetic construct: stable implant and satisfactory fracture reduction?

A loose osteosynthetic construct that does not provide the necessary stability for fracture healing must be removed and an alternative mode of fixation (preferably external fixation) must be employed. In this scenario, it is rare to be able to replace the loose implant with a new one because the anchorage points are severely compromised.

4. Type of implant (e.g. plate, nail, external fixation)?

Biofilms grow above and below the plate and within the screw holes. However, a large part of this can be excised. On the other hand, when using intramedullary nails, it is not possible to completely visualize, access or excise the biofilm. Hence, removal of the nail is necessary. This is followed by extensive reaming of the medullary canal and exchange nailing or external fixation. Berkes et al. investigated osseous union in patients who developed an infection within 6 weeks after the operative fracture fixation and that were treated with debridement, antibiotics and hardware retention. Fracture healing could only be achieved in 71% of the patients. An open fracture and presence of an intramedullary nail were predictors for treatment failure.

5. Condition of soft-tissue envelope?

In early infections, where there is limited loss of skin and soft tissue, permitting closure/ cover of the infected wound/ implants, implants may be retained. However, in delayed infections, severe infections or infections where the soft tissue envelope is severely compromised, preventing adequate soft tissue coverage of the implants/ wound, removal of implant with alternative fixation must be considered.

6. Local and systemic host physiology?

Diabetes, vascular insufficiency, smoking and alcoholism compromise local circulation, wound healing and immunity, making healing of the infection difficult.

7. Difficult to treat pathogen?

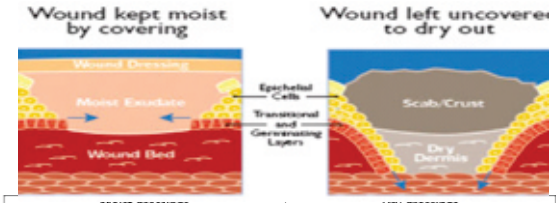
Implants can be retained only when targeted antibiotics can be administered after debridement. Hence isolation of the micro-organism is vital. The bacteria must be sensitive to intravenous and oral antibiotics. It is difficult to retain implants in the setting of polymicrobial infections.

Wound closure

At the end of the initial debridement, based on the severity of the infection, the condition of the wound, the nutritional status of the patient and other patient-specific risk factors, a decision has to be made regarding the most appropriate method of wound closure[7,8,9]. In general, wounds need to be covered as soon as they merit closure. Surgeon experience and judgement often dictate the timing and type of wound closure.

Primary closure reduces the risk of further contamination of the wound and the possibility of secondary infections by other microorganisms. It also limits loss of blood, proteins and electrolytes from the wound. A successful primary closure allows rapid wound healing, so that the patient can be mobilized and possibly sent home early. However, there is a risk that the infection may persist/ progress

Figure 4: 63y M with an osteoporotic vertebral fracture-(a) Preop xrays (b) Xrays and clinical picture 2 weeks post surgery when he presented with severe back pain and discharge from the wound. Lower screws have pulled out (C1) Wound intraoperatively after initial debridement and irrigation. The lower screws were removed, and screws inserted more distally with application of fresh rods (C2)NPWT applied. Culture grew Klebsiella (C3)Contraction of wound and healing with serial VAC applications (C4) Wound closure over drains (C5) Xrays after implant exchange (D1) 6 weeks later patient started developing severe right leg pain. Xrays showed that the distal screws had again pulled out. The cage had tilted even more and the spine was going into kyphosis. MRI showed no evidence of deep wound infection or anterior infection. (D2) Wound was re-explored. There was no evidence of infection. Distal screws were removed. It was possible to insert 7mm screws into the previous screw holes. Additional stabilization was provided with sublaminar wires and an additional cage was inserted from the opposite side to enhance stability. Rods were changed. (E) 10 days later, wound again started discharging serosanguinous fluid. Xrays and MRI showed the implant to be stable and no evidence of anterior infection (F)Wound was re-explore, debrided and a NPWT was started again. (G) Wound healed. Implants stable and patient asymptomatic 6 weeks later. Currently patient is 18 months post last surgery and doing well



Moist dressings	Dry dressings
No deterrent to epithelial cells travelling across base of wound	Dermis dries out and forms scab/ crust that impedes epithelial cell migration
Epithelial cells move effortlessly across moist dermal surface	Epithelial cells must travel further to repair wound site
Wound heals faster and without a scab	Scabs fall off causing scarring or reinjury

Figure 5: Schematic diagram showing the advantages of moist dressings. Adapted from Muhammet Uzun. A review of wound management materials. J Textile Eng & Fashion Tech. 2018 Jan; 4: 53-57. DOI: 10.15406/jteft.2018.04.00121

Figure 8: Hydrocolloid dressings

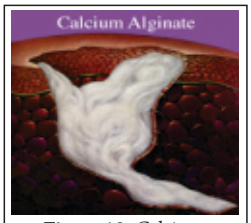


Figure 10: Calcium alginate dressings available as a ribbon that is packed into the wound

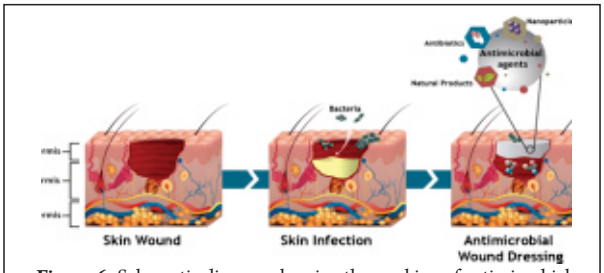


Figure 6: Schematic diagram showing the working of antimicrobial wound dressings. Adapted from Simoes D, Miguel SP, Ribeiro MP, et al. Recent advances on antimicrobial wound dressings. A Review. Eur J of Pharmaceutics & biopharmaceutics. 2018 June; 127: 130-141

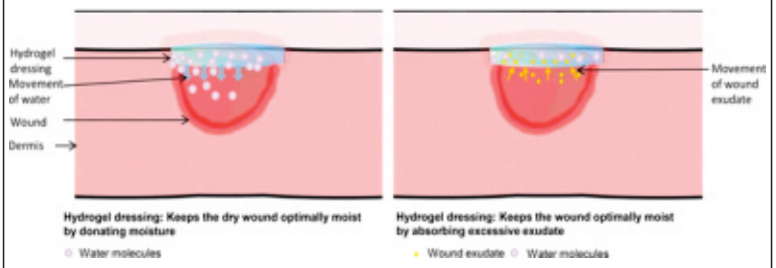


Figure 7: Mechanism of action of Hydrogel dressings. Adapted from Gupta A, Kowalczuk M, Heaselgrave W, et al. The production and application of hydrogels for wound management: A review. Eur Polymer J. 2019 Feb; 111: 134-151

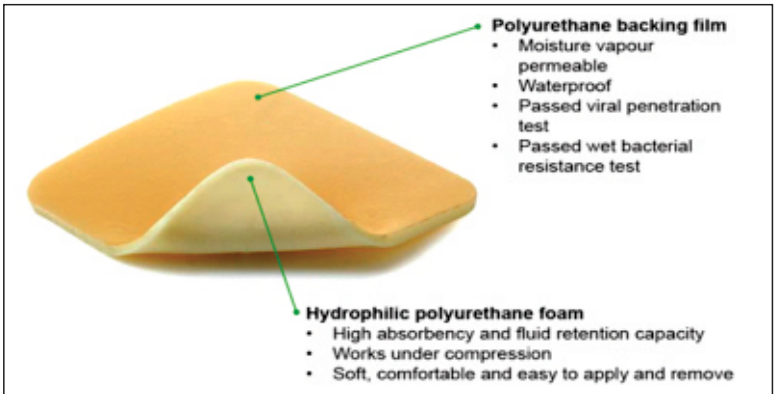


Figure 9: Polyurethane foam used for dressing superficial wounds Foutsizoglou S. A practical guide to the most commonly used dressings in wound care. PFMA Journal 2018 Oct 1; 6(1)

within the wound due to inadequate drainage of infected tissue fluids. Primary closure can be attempted in patients with early infections, when there is minimal devitalized tissue, no significant biofilm formation and minimum density of implants within the wound, besides having a favorable host physiology. Primary closure is attempted over a wide bore drain that is kept in situ till the 24 hour drainage is minimal.

Secondary closure is healing by secondary intent. Small wounds may be left to heal by secondary intention. The wound is left open to heal largely by the formation of granulation tissue and contraction. These wounds often have significant tissue loss precluding tension-free approximation of edges, with devitalized edges, ulcerations, or abscess cavities. Wound dressings are changed at least daily to aid in the formation of granulation tissue and subsequent contraction. A number of different dressing material are now available in the market in order to aid wound healing. These are outlined later in the chapter.

Tertiary closure, also known as delayed primary closure involves closure after a variable period of time for which the wound has been left open. Grossly contaminated/infected wounds with a large density of implants and compromised host physiology but without significant tissue loss are left open after the initial debridement. The wounds are dressed daily or negative pressure vacuum therapy (NPWT) can be applied to expedite control of

Table 2: Classsification of Newer wound care products (Copied from Sarabahi S. Recent advances in Topical Wound Care. Ind J Plastic Surgery 2012 May-Aug; 45(2): 379-387)

Products which enhance epithelialization	Collagen dressings, Hydrogels, Hydro foams, hydrocolloid, growth factors
Products which prevent infection	Antimicrobials like silver impregnated dressings, mupirocin, retapamulin
Desloughing and debriding agents	Maggots , Debridace, enzymatic agents (Collagenase , papaya extracts), Hydrocision
Products which enhance granulation tissue formation	Hydrocolloids , Hydrogels, Alginates, Collagen granules, VAC

infection, formation of granulation tissue and contraction of the wound. After adequate control of infection and improvement in the wound milieu, closure of the wound can be attempted. The options for delayed primary closure of the wound are (Figure 1)[10]:

1. Primary closure of a delayed primary closure

Once the infection within the wound has been adequately controlled, and there is healthy granulation tissue within the wound bed, if the tissues can be easily approximated, then a direct closure may be attempted over a negative suction drain.

A method that uses the elastic properties of skin in order to achieve a closure of the wound is Top Closure- Tension Relieving System (IVT Medical Ltd, Ra`anana, Israel). This device is fixed over the skin, perpendicular to the wound, and over a period of several minutes the wound edges are brought together for a closure. (Figure 2) The device is retained in the area of fixation until the wound heals. Forces bringing the wound edges together are transmitted away from the wound edges, by sutures passed through the device, thus preventing skin necrosis of the wound edges.

2. Skin grafts

Wounds, the edges of which are too far apart, but which have good granulation upto the surface, may be skin grafted. Skin grafts may be of variable thickness ranging from thin to thick or full thickness grafts. The more hostile the environment, the thinner the graft should be. Wound bed contraction and graft thickness have an inverse relationship, with thinner grafts permitting more contraction. Grafts survive in the initial forty-eight hours by plasmatic imbibation. Within the next week, there is a rapid ingrowth of neovasculature into the graft, with an active circulation being established by seven days. Grafts then mature over a period of the next six months or so. Grafts have a lot of advantages. They can be harvested as large sheets. They can be expanded by meshing them and quite often, donor sites of thin skin grafts can be re harvested. However, they stay dry and require attention for a long time. They also are less able to withstand trauma and infection. Additionally, it is not possible to perform further procedures through a skin graft

3. Flaps

Traditionally, flaps are the next step in the wound reconstruction cascade. In contradistinction to skin grafts that require a healthy recipient bed to survive, flaps bring their own blood supply through their attachment to their site of origin or donor site. A flap, in general, may be defined as a unit of tissue that retains its attachment to the body vasculature at all times during the process of its transfer from its site of origin - donor site, to its area of transfer - the recipient site.

Flaps may be classified in many ways. (Chart 1) Classification is usually based on

1) Circulation
2) Composition or
3) Closeness or Contiguity to the defect

Thus according to circulatory patterns, flaps may be either Random Pattern or Axial Pattern flaps. Random Pattern flaps have no named vessel running through their axis and are dependent on perfusion through dermal and sub-dermal plexuses for survival. In order to recruit as much of vasculature as feasible, these are conventionally as broad as they are long. Axial Pattern Flaps, on the other hand, have an anatomically identifiable vessel running through the axis of the flap. A classic example of such a flap is the groin flap that is nourished by the Superficial Circumflex Iliac Artery. The presence of such a vessel increases the perfusion pressures and these flaps need not follow the length to breadth ratio rule. Better understanding of anatomy has enabled the identification of perforators that arise from deeper vessels and supply specific areas of tissue. Thus, we have a new breed of flaps that combine the advantages of axial pattern supply, which may not be dependent on nomenclature. These are Perforator Flaps. Perforators require identification using a doppler probe and require some expertise and usually require magnification for accurate localization.

The tissue content of the flap can also form the basis for classification. Thus, one may have simple flaps, such as skin flaps, fascial flaps, muscle flaps and osseous flaps. These tissues may be combined to give various compound flaps. These include fasciocutaneous, musculocutaneous, osteocutaneous or composite flaps.

Finally, based on their proximity to the

wound, flaps can be classified as local, distant- direct & indirect, and microvascular. A lot of the direct distant flaps have been largely supplanted by microsurgical flaps. Microsurgical flaps can supply large volumes of tissue and also contribute multiple components in a compound defect, converting a potentially multi-staged reconstruction into a single staged procedure. However, failure of a flap due to vascular thrombosis is real and can lead to disastrous consequences. Microsurgery also has a long learning curve, requires teamwork and is preferably done under a microscope and with institutional support.

Local options for infection control

The outcomes of treating surgical wound infections with debridement followed by application of antibiotics/ antiseptics locally have (Figure 3) been shown to be significantly better in some studies than surgical debridement alone. The local release of antibiotics in combination with systemic therapy has been shown to be superior to systemic therapy alone in two-stage arthroplasty revision procedures.

Controlled release and local delivery of antibiotics within an infected wound using a suitable carrier may be useful to maintain at local level, a high concentration of the antibiotics, many times the minimum inhibitory concentration (MIC) which could not have been reached by the systemic route without systemic toxicity. Some studies suggest that such high concentrations can even penetrate a biofilm [11, 12].

Carrier

Since the 1970s, polymethylmethacrylate (bone cement) has been used as a carrier for the antibiotics. However, PMMA has a number of disadvantages as a carrier. It is a dense, acrylic, and non-resorbing material, which generally must be removed in a second surgical procedure when its function has been fulfilled to avoid becoming a nidus for future infection. Also, it can release subinhibitory concentrations of drugs over an extended implantation period, and bacteria adherent to PMMA cement thus can acquire resistance to the loaded antibiotic because of long exposure to the sub-inhibitory concentratio. In addition, PMMA is not suitable for delivery of thermosensitive antibiotics because of the high temperatures generated during PMMA curing. Retention of antibiotic within PMMA is inevitable, and the drug is fully removed only with surgical removal of the non-biodegradable implant. The percentage of total delivery from acrylic cement is variable. In fact, one study found only 20% of total gentamicin was delivered during the functional period of the PMMA implant.

A number of other materials have been tested as carriers for the antibiotics. Recently, calcium sulphate (Calcium sulphate alfa hemihydrate powder; Stimulan®, Biocomposites Ltd, Keele, Staffordshire, United Kingdom) has gained popularity as a carrier because it is safe and efficacious besides being fully bioabsorbable, so that it does not require a second surgery for removal. Other carriers that are being researched are synthetic polymers, cancellous bone and bone substitutes, and proteins like collagen, thrombin and autologous blood clot.

Antibiotic

The antibiotic used must be bactericidal, have a broad antibacterial spectrum and a low percentage of resistant species. The antibiotic must be heat stable to withstand the temperatures reached during curing of cement and it must be hydrophilic. The most commonly used antibiotics include gentamycin, tobramycin and vancomycin. Rifampicin is also being used in recent times because of its effectiveness against biofilms. Mixing more than one antibiotic to the cement has been shown to have a synergistic effect, so that, a combination of antibiotics not only broadens the antibacterial spectrum, but also increases the elution of both the drugs leading to higher concentration within the tissues.

Tissue Penetration

The antibiotics elute into the tissues through minute cracks within the bone cement. Alterations can be made in the bone cement to increase or decrease its porosity. The factors that determine the elution of antibiotics into the tissues include cement used, the antibiotic used and its concentration, the porosity of the cement and the size and shape of the cement beads. Wahlig et al tested the elution properties of gentamicin from PMMA in a buffer solution and found 600 mg/L of gentamicin per bead eluted on the first day, 120 mg/L on the 10th day, and 10 mg/L on the 80th day. Normal gentamicin serum trough concentrations with systemic antibiotic therapy are near 1 mg/L, thus highlighting the efficacy of local therapy.

Cement Bead Preparation

Although a number of antibiotic loaded cements such as Simplex P and Palacos G are commercially available, they are mainly used for prophylaxis in joint replacement surgery. Commercially available cement beads (Septopal, Biomed, Merck, Netherlands) and prostheses (Prostalac, Depuy Inc) are extremely expensive. Most surgeons prefer to prepare the antibiotic loaded cement beads in the operation theatre just before insertion into the wound.

Two grams of antibiotic powder is first mixed with 40mg of cement powder. Then the liquid monomer is added and the components are mixed in open air till a doughy mixture is achieved. The doughy cement is then rolled into small beads (3- 6mm in diameter) which are then placed onto a thick nonabsorbable suture. The suture acts as a string that holds the beads together once the cement is dry. The entire string of beads is placed

within the infected wound for management of dead space and local antibiotic delivery. The number of beads are counted, and the number documented in the operative notes so that it can be confirmed that the entire string with all the beads are removed at the end of treatment.

In the treatment of infected joint replacement or in cases of segmental bone loss, a cement block can be fashioned with concentrations of up to 4 to 8 g antibiotic per 40 g pack of cement. An alternative treatment in such cases is use of cement in the case of infected joint arthroplasty as a temporary prosthesis coated with antibiotic-impregnated cement, which can continue to keep the soft tissues out to length but also maintain joint range of motion.

Negative pressure wound therapy (NPWT)

The application of sub-atmospheric negative pressure to an infected wound in order to permit continuous drainage of infected/ tissue fluid from the wound has been shown to promote wound healing in a number of ways [13,14]:

I) By preventing accumulation of infected fluid, it facilitates maintenance of cytokines, proteases and growth factors within the wound, thereby optimizing the conditions for control of infection, formation of healthy granulation tissue and healing of the wound.

ii) The suction force generated by the system reduces tissue oedema, thereby improving circulation and promoting neoangiogenesis, leading to formation of profuse and healthy granulation tissue.

iii) The reduction of the tissue oedema as well as the negative pressure brings the wound edges closer together.

iv) NPWT has also been shown to reduce the bioburden in the wound permitting step down of systemic antibiotic therapy, if clinically indicated

The commercially available systems consist of an open cell sponge that is loosely packed into the infected wound after debridement. The wound is then sealed with an adhesive dressing/ drape and negative pressure is applied through a small rent made in the adhesive drape. (Figure 4) Pressure applied may be continuous or intermittent and may vary from 50mmHg to 200mMHg. Most studies point to an optimum pressure of 125mmHg. While patients have been known to complain of pain during the NPWT, it is more apparent during intermittent therapy. Dressings are changed every 3-5 days. Aggressive debridement is avoided during dressings, unless there is significant devitalized tissue or slough. Instead, a gentle wash is given with normal saline, and the NPWT system is reapplied. Based on the type of initial wound, 2- 5 dressing changes are usually necessary. Once the wound is healthy and granulating, coverage must be planned as described above in the section on wound closure.

Newer systems also allow simultaneous instillation of fluids into the wound in a cyclical fashion, to promote a more rapid cleaning and to promote an even more rapid proliferation of granulation. The most commonly used solution is saline, although some surgeons have reported using solutions of targeted antimicrobials such as Prontosan (B Braun Melsungen AG, Hessen, Germany) and antiseptics such as Silver Stream (EnzySurge Ltd, Rosh Ha`Ayin, Israel) so as to periodically cleanse the wound. The active ingredient in Prontosan is Polyhexamethylene biguanide - an anti microbial agent - as a 0.1% solution. The other ingredient is Betaine 0.1% which acts as a surfactant permitting destruction of and entry into biofilms by PHMB. Silver Stream has as its active ingredient, ionic silver. Added to the solution is glycerol, menthol and a surfactant. The use of the surfactant is again to penetrate biofilm, thereby promoting the antiseptic action of ionic silver on microbes.

NPWT systems are not applied over exposed blood vessels. Active bleeding and malignancy is a contraindication to the use of use of NPWT.

Dressings

The phase between a good debridement and closure of the wound is the period when dressings are required. An ideal dressing material should not only accelerate wound healing but also reduce loss of protein, electrolytes and fluid from the wound, and help to minimize pain and infection. In the past, dressings meant vaseline gauze and gamgees prepared in the ward and the goal was to allow the wound to dry (Figure 5). On the contrary, the the current concept is that of moist wound healing[15,16]. Newer occlusive dressings that preserve and protect the moist environment within the wound, speed up re-epithelialization, stimulate collagen synthesis, create a hypoxic environment at the wound bed to promote angiogenesis & decrease pH at wound surface, creating an environment inhospitable to bacterial growth, which decreases the rate of wound infection.

Dressings can be classified into passive and interactive dressings. Passive dressings are simple products like gauze which have no direct effect on the wound except protecting it. Most modern dressing products are interactive dressings as they interact with the wound bed to provide optimum environment at the wound dressing interface. Recently, wound dressings loaded with antimicrobial agents have been introduced. These dressings reduce the bacterial colonization and infection of the wound thereby aiding the healing process. (Figure 6)

Dressings must be changed as frequently as required. Dressings that have a strike through - that is wetness caused by heavy exudate - need to be changed. The exudate is often a portal through which

bacteria can recolonize or reinfect a wound. The use of bulky dressings has been a time honoured method of absorbing copious discharge with minimal changes. Hydrogel dressings (Figure 7), hydrocolloid dressings (Duoderm®, Hydrocoll®)- (Figure 8) or foam based dressings (Figure 9) (Alewyn®, Tiele®, Mepilex®) absorb a significant amount of the exudate from the wound and lock the discharge, thus obviating the need for more frequent changes. Alginate dressings are derived from sea weed. These Calcium alginate fibres are available as sheets - for flat wounds and ribbons, for deep cavities. They are capable of absorbing 15 to 20 times their volume in fluid, slowly forming into an easily removable gel. (Figure 10)

Dressings must also be atraumatic in their application and removal. The peeling off of an adherent dressing destroys budding capillary loops and newly formed tissue including regenerating epithelium, causing the wound to revert to a primary inflammatory state every time. A dressing should also not leave any foreign material in the wound. It has been found that particulate matter reduces infection resistance by a power of 106.. Unfortunately, no dressing material meets all of these conditions. Hence dressings must be chosen with the wound in mind. Given the plethora of dressings currently available, it were better that they be broken down into certain classes (Table 2)

Summary

The goals of management of orthopedic Surgical Site Infections is primarily control/ healing of the infection whilst allowing bone healing to proceed, maximizing joint function and rapid return to function. The management of an orthopedic wound infection can be challenging because of the presence of a foreign body within the wound, the possibility of underlying chronic osteomyelitis and the unavailability of adequate soft tissue cover, as in the subcutaneous bones of the extremities.

Successful management of SSIs combines early diagnosis with systemic control of the infection using antibiotics and source control. Control of infection within the wound is achieved by prompt and aggressive debridement, removal/ replacement of implants if necessary, provision of adequate stability and early wound closure when possible. Although primary closure of the infected wound has many advantages, it carries the risk of festering infection within the wound. Hence often wounds are left open, especially in the presence of severe infection, a high density of implants and poor host physiology.

A number of methods have been successfully used for local control of wound infection including topical application of antibiotics/ antiseptics, newer dressing materials and antibiotic loaded cement packed into the wound. The advent of negative pressure wound therapy has been a big boon in the fight against surgical site infections. Application of Negative pressure wound therapy also helps in rapid control of infection locally while promoting granulation tissue formation

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