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Implant Infection : Pathophysiology, Diagnosis and Treatment*

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ABSTRACT

The incidence of implant infection is increasing due to frequent use of internal fixation. The incidence varies from 1% - 3.5%. The pathological changes that occur in implant infection are marked by glycocalyx formation, bacterial colonisation and adhesion. Prevention of infection consists of prophylactic antibiotics and taking care of environmental factors. The author's observation reveals *Staph.aureus* is the common organism and infection rate can be reduced by taking care of perioperative and intraoperative factors. Presence of Biofilm makes treatment difficult. Diagnosis of imminent infection is very important and requires high index of suspicion. Implant infection treated early can reverse the changes. Established infection can be treated by thorough debridement, and external fixators or exchange nailing. Aseptic peri- and intraoperative enviroment and careful surgery will lead to reduction of implant infection.

Keywords : Infection, implant, glycocalyx.

Introduction

The subject of implant infection is of contemporary relevance in view of the frequent for arthritic joints with implants are also on the rise. In developing countries like India, the infrastructure being inadequate as well as asepsis being doubtful, it is necessary to pay attention to infection occurring after implant surgery.

It has been reported by various authors that the infection rate is significant

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even in closed nailing. Approximately two million fracture fixation devices are inserted annually and two million total hip replacements (THRs) are performed in U.S.A., out of which 5000 (1%) get infected. The infection rate in total knee replacement (TKR) is 1.5-2.5% and in revision hip surgery 3.4% (1). Charnley reported infection rate 9% in 1964, but the rate came down to 1% in 1996 after he introduced laminar flow system (2, 3). Winguist *et al* (4) reported infection rate in closed nailing 1% and in open nailing 2-9%. Khan *et al* (5) reported from Pakistan 5.7% infection rate. There are very few reports on implant infection from India. Sandhu *et al* (6) reported infection rate 8.8%, Mohanti & Sahu reported 12% (7). Mukhopadhyaya (8) observed 6000 cases of bone and soft tissue surgery and observed that while infection rate in soft tissue surgery was 0.5%, in bone surgery it was 15%. Mohanti *et al* studied the incidence in 2008 and reported it to be 3.8% (9).

Pathophysiology

Any infection in bone after surgery follows a particular course. The pathological changes that occur in implant infection take a different course. The implant influences the infection in two ways: (a) while inserting the implant a closed fracture is converted to an open fracture (b) the implant being a foreign body interacts with the host tissue environment in various ways. The environment consists of soft tissue changes resulting from fracture as well as the environment changes that occur due to the surgical wound. The fractured bone and implant also contribute to the changes in tissue environment.

Implant Interaction and Bacterial Colonisation and Adhesion

The implant to serve its purpose has to remain in the body for a variable period. In case of replacement for rest of the life. Inside the body, the material of implant interacts with the host cells and bacteria. This interaction either leads to integration or failure. Once the implant is in place, there is a race between the host cells and bacteria to colonise on its surface. The cells and bacteria along with serum protein and cellular debris form a film on the implant is known as 'Glycocalyx'. The formation of clycocalyx is an important step in the implant infection process and the predominance of host immune cells or load of bacteria decides teh onset of infection. If the host cells predominate,

biointegration of implant occurs, conversely if bacteria predominate it leads to infection. Bacterial glycocalyx enhances bacterial proliferation, interferes with phagocytosis and causes further aggregation of bacteria. The immunocompromised state enhance bacterial proliferation. After some time the bacterial colonies are envoloped by a substance which is known as Extracellular Polymeric Substance (EPS). This covering protects the bacteria from the effect of antibiotics. It also limits the usefulness of culture.

Since, bacterial are the main cause of infection, the causative organism and its sensitivity has been studied by various authors. Staphylocacous aureus is the most common infecting organism, while Trampaz (10) and Khan (11) have reported 50% cases are due to Staph.aureus, Mohanti and Sahu (7) and Mohanti *et al* (6) have reported Staph.pyogenous 24.2% and Pseudomonas 18.8% to be the causatie organisms. Sensitivity of these organisms have changed over the years with the introduction of newer antibiotics. In 1980s, it was ampicillin, gentamicin and chloromycetin (6, 7). Ciprofloxacin, linezolid and cefoperazone-salbactum are found to be effective in the past decade (5, 9, 10).

Preventive Measures

Antibiotic prophylaxis and control of various environmental factors are necessary to prevent infection in implant surgery. The role of prophylactic antibiotics has now been established in implant surgery after some initial debate about its beneficial effect. The most common organism is Staphylococcus aureus and coagulase negative Staphylococci. Sensitivity of these organisms have been studied by Sandhu *et al* (6) and Mohanti and Sahu (7), and has been discussed in preceeding paragraph. Trampaz *et al* (10) used ciprofloxacin and linozalid. However, Mohanti *et al* (9) found the organism sensitive to cefaperazone plus salbactum. Discovery of newer antibiotics has lead to changes in sensitivity. At present cefazolin or cefuroxime are the antibiotic of choice (11). Some authors have found rifampicin useful in treating resistant strains (10). Aminoglycosides can be used in fixation of open fractures. The best time to administer prophylactic antibiotics is 30-60 minutes before incision. One intraoperative dose should be given in case of prolonged procedure.

Regarding post operative antibiotics regime, western literature suggest 2-3 post operative dose. However, in India most surgeons recommend use of antibiotic to continue the cause atleast upto 5 days after surgery, if not more. One of the local methods of prophylactic antibiotic is the use of antibiotic impregnated cement, though it makes the treatment of implant infection difficult once the infection sets in.

Environmental Factors which can influence infection

The environmental factors which influence infection can be :

(a) Patient related factors; e.g. anaemia, diabetes, smoking, etc. and local: unhealthy skin, site, etc.

(b) Hospital related factors; e.g. O.T. personnel, traffic, talking, material, type of O.T.

(c) Intraoperative factors; e.g. procedure, duration, decision hemostasis, drain, implant.

(d) Skill of Surgeon and his team.

There are many other factors predisposing infection other than the factors mentioned above. In India, most of patients are anaemic. Though the surgeons wait to control diabetes before operating, he the same is not done he can not wait for correction of anaemia. Besides, the asepsis of OT material, number of OT personnel, OT traffic and talking are common problem in operation theatres in India. These factors are commonly ignored by the OT administration. Extensive dissection, lack of hemostasis, lengthy procedure predispose to infection. It has been reported that when duration of procedure is less than 1 hour the infection rate is 1.3%, while when it is more than 3 hours, it is 4% (12) Drains predispose to infection and it should be closely monitored. The quality of implant plays an important role. This is a problem in India where standardisation of implant is lacking and substandard implants are available in the market. Lastly but not the least, the skill of the surgeon and his team plays an important role which is often overlooked. The planning, decision making, meticulous dissection, choice of implant, hemostasis and closure are all in the surgeon's hand and all surgeons are not same.

Our Experience

As it has been already mentioned, there are very few studies on implant infection done in India. We have made two studies, one in 1982 and another is

an ongoing study from 2008-09. The main findings are shown in Table 1.

The carrier state was observed from examination of swab from skin, nose and throat of patients. In both the series 30-35% were positive for organism like Staph.aureus. There were one case each of proteus and Pseudomonas in the 1982 series. However relationship could not be established between wound infection and carrier state. Geeta Mehta (13) has also reported similar findings. Most of the infection with increased preoperative hospital stay. Sandhu *et al* (6) have also observed that long pre-operative hospital stay increases the chance of infection. Similarly, we have also observed that duration of surgery influences risk of infection. Sawyer *et al* (12) have observed that infection rate is 1.3% when duration is less than one hour while it is 4.4% when duration is more than 3 hours. Sometimes various specialities operate in the same operation theatre. In our series of 1982 the operations were less than one hour while it is 4.4% when duration is more than 3 hours. Sometimes various specialities operate in the same operation theatre. In our series of 1982 the operations were carried out in operation theatre where General surgical

Table 1 : Characteristics observed in implant infections in Indian studies

	Mohanti & Sahu 1982	**Mohanti et al 2008-09**	**Comments**	**Reference**
Carrier state Skin swab Nasal swab	30-35% Positive	30-40% Positive	Staph aureus Pseudomonas Proteus, E.coli	Mehta (2) Staph aureus, Staph.epidermis
Pre-op. hospital stay, Duration of surgery	15-20 days 1-2 hrs.	15 days 102 hrs.	Risk of infection↑ Risk of infection↑	Sandhu *et al* (6) Sawyer (12) < 1 hr - 1.3% < 3 hrs. - 4.4%
Type of OT	Combined OT	Specialized OT		
Pre-op. & Post-Op. Antibiotics	Ampicillin Chloromycetin	Cefoperazone + Salbactum	Rifampicin Vancomycin?	Trampaz (10)
Infection rate	12%	3.8%	Variable	

emergencies were done and as a result infection rate was very high. While in our series of 2008 infection rate was reduced as the theatre was used only for clean orthopaedic surgery. Antibiotic sensitivity as observed by the author has been discussed in preceeding pages. The infection rate in the 1982 series was very high (12%). This is due to operation being done in a combined OT. This was brought down in 2008 with the use of a separate operation theatre for clean Orthopaedic surgery.

Diagnosis

Every orthopaedic surgeon after putting the implant is afraid of one possibility, that is infection. Most other complications can be solved, but infection once established is difficult to threat. Some authors classify clinical features of infection as Type - I, II, III (14). Others classify as early, delayed and late (15), However, in order to prevent damage and retrieve the situation a very early diagnosis should be made and if possible infection controlled and changes reversed. We have grouped the symptoms as

(a) Imminent - 3rd - 4th day

(b) Early - 5th - 10 days

(c) Late - 10 - 20 days

It is the diagnosis of "imminent infection" which is most important. To diagnose imminent infection, surgeon has to have a "high index of suspension" and alert to the telltalle signs of infection.

Signs of Imminent Infection

(a) Pain and fever persisting beyond 72 hours. (Analgesics should be stopped after 48 hrs.)

(b) General well being and comfort of the patient disturbed.

(c) Throbbing pain at the site

(d) Persistence of distal edema.

If the above signs are present one should become alert and closely monitor the patient. The wound should be inspected after 72 hrs, with a close watch for tension and edema around and in between the sutures. Induration around the wound, tenderness around the area, and presence of discharge must be recorded for. These signs suggest imminent infection. The discharge should be sent for culture and sensitivity. At this stage, the laboratory investigations play only a supportive role with leucocytosis, ESR > 40, CRP > 10 mg/ltr are suggestive of infection. Aspiration cytology and culture can be

done.

Treatment of imminent infection

If the pain, fever persists beyond 4-5th day the patient should be taken to the operation theatre, remove the stitches, clean the wound, irrigate with antibiotic solution, if necessary set up suction irrigation and close the wound. Change the antibiotics if necessary. With these steps one can control the infection and reverse the process.

Treatment of established infection

Sometime, after 10-12 days when the stitches are removed there is a burst of pus discharge and partial wound dehesion. In such a situation, the wound should be opened up and debridement should be done till a healthy bleeding area is left behind. If possible close the wound with antibiotic beads or suction irrigation. Proper antibiotics should be given for atleast 3 weeks.

Treatment of deep infection

Sometimes patients come late weeks or months after with swelling and discharging sinus, X-Ray shows signs of osteomyelitis. After culture sensivitiy test, radical debridement, seqrestrectomy and some times corticotomy should be carried out. At this stage the surgeon is faced with a dilemma i.e., to remove the implant or not. For treatment of infection implant should be removed, but for healing of fracture fixation is necessary. The stability of fixation should be assessed. If fixation is stable keep the implant along with irrigation and prolonged antibiotics. Then wait and watch. If the union progresses, remove implant after union. If fixation is unstable, remove implant, apply external fixator and follow it up with exchange nailing.

Some of these patient may be left with skin loss, exposed implant, and they will need reconstructive procedure.

Conclusion

(a) An accurately reduced and internally fixed fracture but infected is a disaster.

(b) Presence of "Biofilm" makes the treatment of implant infection difficult.

(c) Awareness of factors predisposing infection and careful surgery can provide **"Safety with Excellence".**

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