Diagnosis of Surgical Site Infection

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Abstract

Diagnosis of Surgical site infection is one of the most important factors that determines the further management of SSI. The diagnosis is based on various factors including clinical, laboratory investigations, Radiology, Bacteriology and molecular modalities. The current review summarises the salient features in all modalities

Keywords: Surgical Site infection, Diagnosis,

Introduction

Surgical site infection is the greatest setback to an otherwise successful surgery. It is a terribly dreaded complication after any orthopaedic surgery which results in poor outcomes, increased morbidity, prolonged stay in the hospital, increased expenditure [1]. Timely diagnosis is essential in the successful eradication of infection without compromising the intended outcome of the primary surgery. Delayed diagnosis and subsequent medical/ surgical intervention may result in the need for repeated debridement, implant removal due to loosening and formation of biofilms, prolonged hospitalization and an unsatisfactory result[2].

Definition of SSI

Initial detection of a SSI rests on clinical evidence of infection. Laboratory tests and imaging support the diagnosis. Isolation of a microorganism helps plan targeted antibiotic therapy.

The Centre for Disease Control (CDC) definition describes three levels of SSI [3]:

Superficial incisional-
affecting the skin and subcutaneous tissue, superficial to the deep fascia.

Deep incisional-
affecting the fascial and muscle layers, deep to the deep fascia.

Organ or space infection, which involves any part of the anatomy other than the incision that is opened or manipulated during the surgical procedure, for example joint or peritoneum. These infections may be indicated by the drainage of pus or the formation of an abscess detected by histopathological or radiological examination or during re-operation. Organ infection is not included within the scope of this chapter.

Diagnosis

Clinical presentation

These infections are detected on the basis of a local rise in temperature, redness, shininess, oedema, induration and stretching of skin with tenderness and swelling at the site of the incision. There may or may not be drainage of serosanguinous/ purulent fluid from the wound. Systemic signs may be absent or the patient may have fever with tachycardia, as also increased pain and restricted mobility of the part.

Deep infections often lack the obvious signs and symptoms. Most common feature is unexplained and progressive pain which may start as early as first week after surgery or up to 3 months. The presentation will vary according to the virulence of the organism, mode of infection, status of fracture healing and depth. Presence of a cast can obscure local features and delay the diagnosis [4]. Delayed infections often have less severe features as they are often caused by low virulent microorganisms such as coagulase negative staphylococci. Fever and constitutional symptoms are seen in 40% of the patients only [5]. The clinical picture is often clouded due to empirically started antibiotics, anti-inflammatory medications and dreadfully, even steroids. A high index of suspicion is required for early diagnosis. These infections are indicated initially by progressively increasing pain at the surgical site. The intensity of pain is beyond what is expected for the type of surgery. The patient may complain of difficulty in moving the part. Systemic signs of infection such as fever and tachycardia may be present. If the infection is contained below the deep fascia, there may be specific tenderness at the surgical site or a more diffuse

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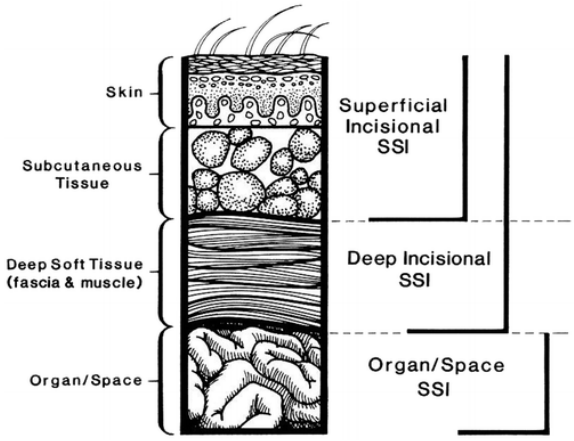

Figure 2: Algorithm for sequential assessment of a prosthetic joint infection

tenderness with muscle spam. A diffuse swelling of the part may be seen. Difficulties in wound healing may be seen. The infection may track superficially resulting in a discharge from the wound and signs of superficial infection. Rarely, the wound gapes open exposing the deeper tissues.

Laboratory diagnosis

The first tests usually done are complete blood count with erythrocyte sedimentation rate (ESR) and C- reactive protein (CRP). The white cell counts may be elevated in less than 50% of the cases and are often unreliable. Both ESR and CRP are routinely elevated after surgery and gradually decline to normal in non-infected cases. CRP levels peak on post-operative day 3 and return to baseline by day 10 to day 14. ESR levels peak at around day 14 and take up to 6 weeks to return to normal. CRP level is more sensitive (95%) than ESR (80%), although the specificity is poor (31%). When CRP levels are higher on day 7 than on day 3, the suspicion of infection arises. Persistently elevated ESR and CRP levels more than 15 days after surgery strongly suggest infections [5,6,7,8,9,10]. However, normal levels do not exclude the diagnosis. Certain medications like NSAIDs and statins are known to falsely decrease the CRP levels [11], although this aspect in the setting of acute infection is not clear.

Serum pro calcitonin (PCT) and serum amyloid A (SAA) are other blood markers studied in the setting of SSI. They are not influenced by factors such as age, gender, DM, operative duration etc. PCT has been reported to be the most sensitive and specific marker for the detection of surgical site infection in the immediate post-operative period with sensitivity and specificity of 100% and 95.2% respectively [12].It has been shown to be elevated in bacterial infections but not in viral infections or other inflammatory conditions. In patients with a significantly elevated baseline procalcitonin level, a subsequent drop of >80% appears to be reasonable for discontinuing antibiotics. Although Procalcitonin is an inflammatory marker, extent of surgical physiological insult does not alter its biokinetics as opposed to the other inflammatory markers making it a valuable marker of infection. However, there is no uniformity as heterogenity exists among patients, and surgery and trauma alone elevate PCT even in the absence of infection. SAA levels reach their peak 3 days following surgery, but they normalize much faster compared to CRP. Hence it is useful in the early diagnosis of SSI.

Table 1: Nuclear Imaging

	^{99m}Tc-MDP/HDP bone scan	^{99m}Tc-anti-granulocyte scan (IgG/Fab AGA)	^{99m}Tc-HMPAO/^{111}In-oxine-WBC scan	[^{18}F]FDG-PET/CT
Pros	High sensitivity Useful as screening method in chronic infections Widely available and low cost	High sensitivity and specificity; however, generally lower than for WBC scan Data support the preferential use of IgG over Fab in chronic infections. Widely available and medium cost Often to be used coupled with bone marrow scan and/or bone scan	High sensitivity and specificity Data support preferential use in acute infections Poor availability and medium cost Often to be used coupled with bone marrow scan SPECT/CT images improve accuracy	High sensitivity
Cons	Low specificity Moderate radiation exposure	Possible contraindications for IgG and HAMA induction Moderate radiation exposure IgG scan requires a late acquisition at 20 h p.i.	Moderate radiation exposure Always requires a late acquisition at 20 h p.i. Blood manipulation Needs an approved laboratory and method and trained personnel	Low specificity High radiation exposure Difficult interpretation of images Poor availability and high cost

Imaging

Radiographs are the usually the first imaging in a patient suspected of infection. However, the radiological findings may not be present until 2 to 8 weeks of active infection. Increase in soft tissue swelling is the earliest sign seen on X rays, although it is not specific and frequently overlooked. Halo around the implants, osteolysis are signs of infection. However, plain radiographs are crucial to the overall management of the case to assess implant stability and fracture healing.

Computed tomography (CT) is usually definitive in confirming the status of fracture healing, the presence of sequestrum and collection of fluid/abscess. Intravenous contrast administration enhances the visualization of

inflamed soft tissue and the rims around abscess. Soft tissue signal findings are 100% sensitive and 87% specific for orthopaedic implant-related infection [13]. Artefacts often compromise the imaging due to scatter. Titanium metalis less susceptible to artefacts than stainless steel. The implant can be aligned along the axis of the gantry, so that beam traversal is minimized. Other methods which reduce the artefact include using high energy settings, narrow collimation, thin sections and extended dynamic ranges [14].

Ultrasonography is very useful for detecting collections and simultaneously performing aspiration for culture sampling as well as relieving symptoms. Implant and bone surfaces are highly echogenic against which fluid signals are well defined. Metallic artefacts are minimal compared to CT or MRI scans. The limited acoustic window may fail to penetrate very deep locations at the hip and pelvis in obese patients [15].

Magnetic Resonance Imaging (MRI) is the most sensitive (93%) and specific (96%) for the evaluation of infection [16]. The diagnostic features can be picked up as early as 3 to 5 days post operatively. Characteristic findings include high intensity signals on T2 and STIR sequences and hypo intensity signal on T1 sequences with contrast enhancement. Presence of soft tissue collection makes the diagnosis highly suggestive. Presence of implants can interfere with the clear visualisation on MRI and hence newer sequences like the Metal Artefact Reduction Sequence (MARS) by various MRI companies allows better visualisation [17].

It is not uncommon for the diagnosis to be uncertain even after a MRI. In such scenario, nuclear imaging is of help. Various radionucleotide agents have been studied for their role in diagnosing SSI, especially periprosthetic joint infections. The pros and cons have been summarised in Table 1.

Positron emission tomography (PET) has been discovered to be increasingly useful in infections as glucose metabolism is involved. The test has a sensitivity of nearly 100% and specificity of above 90% in occult and early musculoskeletal infections, including OAI [18,19]. Since 2010, the European Medicines Agency (EMEA) considered PET scans to be indicated for the diagnosis of chronic bone and joint and adjacent infection including osteomyelitis, spondylosis, discitis or osteitis including presence of metallic implants. The advantage of PET lies in that it is a functional imaging which has higher sensitivity. Another advantage is that it provides with three dimensional images which helps in subsequent management.

Nuclear imaging centres are available in our country only in the larger cities as compared to availability of MRI which is more commonly available. Thus, from our perspective a multi-modality diagnostic approach including MRI followed by CT scan or Ultrasonography guided biopsies / aspiration usually gives satisfactory results.

Bacteriologic diagnosis

Identification of the causative organism is the single most important factor in the success of antibiotic treatment. In patients spiking temperature and toxaemia, serial blood cultures should be sent. However, a local tissue sample be needed from the local part with infection, as in 10-15% patients different bacteria are cultured from blood and the local tissue. Although blood cultures are not specific or sensitive enough to detect the culprit pathogen, they should be sent as patients with bacteraemia are at risk of developing sepsis and need careful in-patient treatment with intravenous antibiotics and supportive treatment. A raised Procalcitonin is such a scenario is suggestive of early septicaemia and indicates close monitoring for any signs of physiologic worsening.

In patients with draining wounds, swab from the sinus may not reflect the actual deep seated organism causing infection due to the risk of contamination of skin flora. USG or CT guided aspiration / biopsy obtained under strict aseptic conditions should be sent for cultures. For patients already treated with antibiotics, if clinical condition allows, a waiting period is suggested so as to allow higher chances of identification of the organisms. Fluid should be sent in blood culture bottles with antibiotic adsorbent beads. A direct communication with the microbiologist helps, as the sample may then be incubated for longer duration (2-weeks) rather than the standard 48 hours which may miss some of the fastidious organisms especially for microorganisms with low virulence, such as Propioni - bacterium acnes, Peptostreptococcus spp, and Corynebacterium spp[20]. Additionally, the microbiologist may also decide upon the culture media to be used as per the clinical suspicions.

Molecular methods

Culture remains the gold standard in the diagnosis of PJI. However, they are frequently negative. Molecular techniques have a role in patients with negative cultures in whom there is a strong suspicion of infection, or for diagnoses of fastidious microorganisms [21, 22]. Molecular techniques can confirm the presence of microorganisms and provide their identification, but they do not give a full and exhaustive antibiotic-sensitivity profile for all the antimicrobials indicated for PJIs therapy. Currently, molecular tests have not been fully incorporated into routine laboratory diagnostic protocols for PJI because of the high costs and lack of data to support the superiority of polymerase chain reaction (PCR) compared with culture methods.

The best shot at treating the infection is at identification of the organism and its drug sensitivity. There are newer methods, though not widely available, which aim to increase the yield of

cultures.

Sonication or Dithiothreitol (DTT) Biofilm Dislodging Procedures

Sonication improves the sensitivity of culture of prosthetic components or osteosynthesis devices [23, 24].

The ability of sonication to disrupt bacteria present within biofilms, increases the number of culturable bacterial cells. Sonication may help to identify a broader spectrum of infectious organisms which usually exist primarily within protected biofilm structures and cause infection and loosening, otherwise characterized as aseptic failures. Occult infections responsible for implant loosening, chronic pain, and instabilitymay be underdiagnosed by traditional culture methods [25]. Multiple studies have evaluated the performance of sonication fluid culture with reported sensitivities ranging from 73% to 88% and specificities from 87% to 99%.

A solution of dithiothreitol (DTT) may be used as an alternative to sonication [26]. In this approach a sterile solution of 0.1% (w: v) of dithiothreitol (DTT, formula C4H10O2S2, molecular weight: 154.2 in phosphate buffer saline (PBS) is added to cover the prosthetic components. The container with prosthetic components and DTT solution is shaken up at about 80 rpm for 15 min. Each method used by the laboratory should be properly certified to ensure standard approaches to micro-biological culture and micro-organism identification.

Histopathology

Although the diagnosis of SSI is largely based on cultures and imaging, all samples taken for cultures should also be sent for histopathology. Mycobacterium Tuberculosis is difficult to grow and many a times appropriate cultures may not have been sent.

The histopathological picture will alert the clinician about the missed diagnosis. Many round cell tumours, especially, Ewings Sarcoma, present like acute infections and result in "negative" cultures [27]. Lymphoma mass may be misdiagnosed as infection. Solitary histiocytic involvement of the long bone may, also, be identical with bone infection - the final diagnosis is established on biopsy [28].

Conclusions

Early diagnosis of SSI has the best chance of treating the infection without compromising the results of the primary surgery. Bacteriologic diagnosis with drug sensitivity is the gold standard test for diagnosis and every possible attempt should be made to achieve this. A combination of clinical signs and symptoms along with laboratory tests and imaging, performed sequentially is essential to make the diagnosis.

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