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Review article

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Management of Surgical Site Infections in Spine Surgery: A Current Concept Review

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Abstract

Background: *Surgical sites infections (SSIs) in spine surgeries represent one of the commonest hospital-acquired infections. SSIs refers to infection of surgical wound within 30 days of surgery or one year of implant usage. SSIs portend a huge disease burden with devastating consequences to the patient and the hospital facility with attendant physical and psychological trauma to the patient and it is associated with increase rate of morbidity and mortality.*

Objective: *The aim of this review is to identify factors that predispose a spine patient to SSIs and to highlight the current preventive and management concepts.*

Methods: *We carried out a comprehensive review of literatures, using key words such as surgical site infections, spine surgery, predisposing factors, prevention, diagnosis, treatment, outcomes on search engines of Google Scholar, Scopus and PUBMED. Eligible articles for the review included full length published articles in English which we have access to contents.*

Results: *Twenty-five full length articles were found eligible for the review. In spite of improvement in spine care and surgery, SSIs continue be a source of great concern to the patients, surgeons and healthcare system of any nation. Gram positive organisms are more common than gram negative organisms. The risk factors for SSIs include patient- and surgeon - related factors. Albeit, there is no universally accepted protocol for the prevention and treatment of SSIs in spine surgery. The incidence of SSIs is on the increase worldwide with associated high risk of morbidity, overall decrease in the quality of life and sometimes mortality. The economic burdens of the management of SSI is huge and stressful for every nation. Treating SSIs after spine surgery is daunting as the choice between removing the implants for proper bacteria clearance and the risk of causing spinal instability is a hard nut to crack.*

Conclusions: *Despite the improved surgical technique, protocol on asepsis and role of prophylactic antibiotics in clean spine surgeries, there are still substantial increase in the rate of SSIs. Therefore, prevention is more profitable than the hope of proper treatment.*

Keywords: Spine Surgery, surgical site infections; predisposing factors; prevention; management, outcomes, review

Introduction

The last decade has seen a dramatic increase in the number of surgeries performed all over the world. Not surprisingly, spine surgery has increased in number, complexity and improved in quality over the years. This phenomenon is attributable to the demand of the aging population, high patient expectations and a resultant need to constantly improve spine surgical skills and attendant equipment, especially spinal instrumentation [1]. Despite the improvement in spine care vis-à-vis spine surgeries, surgical site infections continue to be a source of great concern to the patients, surgeons, and healthcare system of any nation.

In 1992, the center for disease control and prevention (CDC) renamed surgical wound infection as surgical site infection (SSI) and defined it as an infection occurring in the surgical incision as well as organs and spaces manipulated during surgery, which starts within 30 days of surgery or one year, if an implant was used [2]. It is characterized by the proliferation of micro-organisms in the surgical site with resultant inflammation and pus formation and discharge, wound dehiscence and sometimes, implant failure.

SSI is the most common hospital acquired infection and its incidence following spine surgeries varies greatly in the literature. Overall, the incidence after spine surgery is about 3.1%with a range of 0.2 to 16.7% without instrumentation and 2 to 20% with instrumentation [2-5]. This wide range of occurrence shows the disparity in patient volume, presentation and pathology. It also reflects the variation in diagnostic approaches, definition, treatment protocols and follow-up evaluation [4, 6].

SSI has far-reaching impacts on the patient, the spine surgeon and the healthcare system. For the patient, it leads to increased hospital stay, reoperation rates and cost. In addition, it portends a risk of morbidity, overall decrease in the quality of life and sometimes, mortality [3, 7]. The occurrence of SSI constitutes a psychological and physical strain, and burden to the spine surgeon and can result in a reduction in operation confidence. Meanwhile, the healthcare system suffers a financial burden as SSIs increases the overall cost of spine surgery and loss of valuable economic time. Blumberg et al found that, in addition to increasing hospital stay, spine SSIs increased the treatment expenses. At a single tertiary referral center, this amounted to an average cost of $16, 242 per case [8]. In our narrative case of a 54 old year obese patient who had L1-L4 spine decompression and fixation and subsequently had deep SSI, further cost of surgery and post-operative care was estimated to be about $2,500.

There are several risks factors for SSIs in spine surgery and these include patient - and surgery-related factors. In order to prevent these infections, a number of measures are effective and they are targeted at modifying identified predisposing factors. However, there is no universally accepted protocol for the prevention and treatment of SSIs in spine surgery in the literature. As a matter of fact, there are still many areas of controversies in the diagnosis and treatment of SSIs [6]. Nonetheless, the management of spine SSI is hinged on early diagnosis (clinical and laboratory) and treatment. Treating SSI after spine surgery is daunting as the spine surgeon has to make a choice between removing the implants for proper bacteria clearance and the risk of causing spinal instability. Ultimately, this underscore why prevention is more profitable than the hope of proper treatment.

The aim of this article is to review the literatures on the current trends in the prevention and management of SSI in spine surgery.

Aetiopathogenesis

Surgical site infections (SSIs) occur following the inoculation of micro-organisms into the surgical wound. A study by Donara et al showed that up to 98% spinal implant-associated infections were acquired during surgery [6]. This occurs from contamination with micro-organisms that make up the patient's normal flora mainly at surgical sites and nasal nares as well as those transferred from the theatre environment, including members of staff and equipment. This emphasizes the need for good pre-operative and intra-operative preventive measures. Aside this direct route of microbial acquisition, infectious agents can be gotten by a spread from a nearby focus and rarely through the haematogenous route [6, 9].

Generally, Gram-positive infection is more common than Gram-negative infection in most of cases of spine SSIs [3, 10]. Following a systematic review, Jiaming Zhou et al found that the proportions of Gram-positive and Gram-negative bacteria were 60.4% and 25.7%, respectively [3]. Worthy of note is that Gram-negative organisms were predominant in patients who had intra-operation local vancomycin use [11]. However, a negative culture was found in some cases [6,10,12]. The most common pathogens isolated in various studies were *Staphylococcus aureus* (30-45.2%) and *Staphylococcus epidermis* (25-30.4%) [3,6,10,13]. Other organisms implicated include *MRSA, Proprionibacterium acnes, Enterococcus faecalis, Escherichia coli, Enterobacter cloacae, Acinobacter spp, Klebsiella spp, Pseudomonas aeruginosa and Candi*da [3,6,10,12,13]. It is also not uncommon to find polymicrobial infection following spine surgery [6,10,12].

Interestingly, the bacteria varied with the anatomical site of the surgery. Staphylococci organisms were predominant in the cervical spine, *Cutibacterium* spp. in thoracic and lumbosacral region and Gram-negative bacilli in the lumbosacral part [6]. The finding in the distal spine may be connected to its proximity to the perineum and gut bacteria. Once in the surgical wound, the micro-organisms proliferate by means of several virulence factors (such as toxins, proteins and enzymes) and when the immunological defense is overwhelmed, infection ensues. In addition, many organisms (especially the staphylococci genus) form biofilm, which is a glycocalyx made up of extracellular polymeric substance, on implant [12]. In doing so, they evade detection and elimination and this makes treatment difficult.

Classification

According to the center for disease control and prevention (CDC), Surgical Site Infections can be classified as incisional, which was further divided into superficial and deep infection, and organ/space infection [2]. When applied to spine SSI, superficial infections are those involving the skin and subcutaneous tissues (supra-fascial) while deep infection affects the paraspinal fascia and muscles. Organ /space SSI include infection affecting anatomical structures that were manipulated during surgery, other than the skin incision, fascia, or muscle layers. These include osteomyelitis, discitis, meningitis, or empyema [14]. This classification is very important as the different SSI types vary in clinical presentation, causative pathogens and treatment approach. SSI following spine surgery can also be classified into early- and late-onset SSI, depending on duration of presentation after surgery. However, there is controversy about the duration necessary to make this classification. While some authors indicated 6 weeks [6], others have used 1 month or 3 months [6, 12]. Depending on the category, SSI differs in presentation and treatment. For example, while patients with early SSI did not require removal of implant, those with late-onset SSI occasionally need partial or complete retrieval of their hardware to allow for proper wound debridement and subsequent wound care [6].

Following a retrospective study of 1,279 patients who had spinal surgery, Rishi Mugesh and colleagues proposed an anatomical classification and a treatment algorithm for each of the identified types of infection [15]. In this system, SSIs were classified into 5 types, according to the structures affected, as follows:

- Type 1: suprafascial necrosis
- Type 2: wound dehiscence
- Type 3: pus around screws and rods
- Type 4: bone marrow oedema
- Type 5: pus in the disc space.

Predisposing factor for spine SSIs

SSIs develop from the interaction of the pathogenic organism, the environment and patient's immune system. Any factor that encourages the colonisation and proliferation of pathogens will predispose a patient to infection. Several of such factors have been identified with corresponding measures to mitigate the associated risk factors. These risks factors will be discussed in relation to their time of occurrence, as Pre-operative, Intra-operative and Post-operative factors.

Pre-operative factors

Age

Although SSIs tends to be higher in older persons who had spine surgeries, it was not an independent risk factor for surgical site infection [7]. The increased incidence with age was related to the presence of other co-morbidities that occurs commonly in the older age group and also decreasing organ-system functions with advancing age. The patients are more or less immunocomprised and age as factor predispose this age group to SSIs. We routinely admit them a day or two before surgery into a clean spine bay, and are made to do snare and intended surgical wound swabs as baseline. They are also made to have chlorhexidine bath, a practice which have been noted to significantly reduced SSIs.

Obesity

Obesity is an independent risk factor for the development of spine SSI [3,7,16]. According to findings by Meng F et al, a body mass index (BMI) of greater than 30kg/m2 was associated with a high risk of SSIs [7]. In addition to the BMI, an increasing thickness of subcutaneous fat (skin to lamina distance) correlated positively with an increasing odd for SSI [17]. The predisposition comes from the fact that fatty tissue is poorly perfused and as such does not support good healing. Moreover, a thick subcutaneous layer often requires more retraction, which can result in local tissue ischemia. To reduce the risk associated with obesity, patients should be optimized prior to spine surgery through dietary, physical and sometimes, surgical methods. It may be necessary to give higher doses of prophylactic antibiotics [18]. It is important to involve the dieticians, physiotherapist and psychologists to achieve better outcomes. In the above narrative 54-year-old obese patient who had deep SSI after lumbar spine decompression and fixation, the BMI was 38kg/m2. This underscore the role of obesity in predisposing to SSIs when compared with above literature. Our spine unit as part of routine, have put up a program of weight reduction as advised by the dieticians.

Diabetes Mellitus

There is enough evidence to prove that diabetes mellitus (DM), when poorly controlled, puts a patient at a great risk of SSIs [4, 7, 17, 18]. This is due to the micro-angiopathic changes associated with DM which reduces blood flow to tissue and thus discourages proper wound healing. Also, a persistently elevated blood sugar level inhibits leukocytes function (sick cell syndrome) and so makes the patient prone to infection [17,19]. As part of preparing DM patients for spine surgery, the surgeon should pay attention to the pre-operative blood sugar level and establish the level of glycaemic control using HbA1c. The later gives an idea about the level of control over the preceding 3 months. A HbA1c level of more than 7% is associated with a high risk of surgical site infections [16,17]. Furthermore, Hikata et al. showed that no patient in his study with a HbA1c less than 7% developed SSI [20]. It is important to work in conjunction with the Endocrinologist to achieve optimal glucose level, which, as Zach et al. [21] recommends, should be between 110 and 150mg/dl. Furthermore, it is important that tight glucose control is continued into the postoperative period because postoperative hyperglycemia has been identified as an independent risk factor for infection [21]. Estimating glucose level is routine in all adults in our spine clinic but for diabetic patients, the degree of control must be established by doing HbA1c. Our aim is to ensure tight glycaemic control prior to spine surgeries.

Other Medical Co-Morbidities

The presence of co-morbidities put a patient at risk of SSI. Identified conditions include chronic kidney disease (CKD), congestive cardiac failure (CCF), hypertension, malignancy, chronic obstructive airway disease (COAD) as well as HIV/AIDS and other immunosuppressive conditions [4,12,13,16]. These co-morbid conditions are routinely look out for in our review and preparing such patients for surgery should include collaboration with the specialist physicians in our settings.

Smoking

Smokers who undergo spine surgery are at risk of SSIs [7, 13, 16, 19] and this risk is higher for persons who smoke 20 to 40 pack-years [4]. Smoking is associated with a higher carbon dioxide level which results in vasoconstriction, and eventually leads to reduced tissue perfusion, reduced oxygenation and increased level of reactive oxygen free-radicals and poor wound healing. Additionally, cigarette smoke contains a lot of contaminants that can impede wound healing [4,16]. Cessation of smoking reduces this risk, although the benefits becomes appreciable after 4 to 6 weeks of stoppage of cigarette smoking [16,17]. In our local setting, all our spine patients who are known smokers are identified and counseled against further smoking for a period of four weeks before spine surgery.

Nutrition

Malnutrition is a risk factor for poor wound healing and SSIs. A serum albumin less than 3.5mg/dl was found to be associated with an increased rate of SSIs [22]. Therefore, it is an essential part of our surgical protocol to routinely carry out a nutritional assessment (history, examination and investigations) for patients before spine surgery with the aim of identifying deficiencies as it is done in most centers. When this is found, the patients are optimized prior to surgery, in conjunction with a nutritionist.

Steroids

Steroids are known to inhibit wound healing by affecting the formation of collagen. Also, they promote immunosuppression by inhibiting the function of the immune cells and phagocytic functions of the white blood cells. Thus, patients on perioperative steroids are at high risk of developing SSIs [18,23]. It may be necessary to taper off the medications as part of preparing the patients for spine surgery. Unidentified prolong steroid use that is concealed have been known to be associated with severe SSIs. Moreso, adrenocortical insufficiency (Addison's crisis) has been noted to be a sequela of sudden stoppage of steroid. The above 54-year-old woman earlier mentioned had concealed the use of steroid and subsequently had features of adrenocortical insufficiency. In our setting, a high index of suspicion is now a routine in patients with history of arthritis, obesity, chronic low back pain and asthmatic who would have share of providence of been on steroids.

Other predisposing factors include preoperative exposure to radiation, cancer patients, ASA >2 and revision spine surgery [7,10,18].

Intra-operative factors

Surgery-Related Factors

The rate of SSIs depends on the type of procedure performed as regards spine pathology. A higher rate of infection has been noted with surgeries for degenerative spinal disorders and corrective surgeries for scoliosis [1, 3]. Also, surgeries that include instrumentation have an overall higher rate of SSIs. This results from the formation of biofilm on the surface of the spinal implants, which leads to antibiotics resistance [3, 13]. Studies have also shown that infection rates differ with the part of the spine operated. Some authors have noted that surgeries that are performed on the lumbosacral spine have a higher incidence of surgical site infections [10] compared to other spine regions. Interestingly, the infection rate varied with the surgical approached used. The combined approached posed the highest risk of SSIs, followed by the posterior-only approach, while the least rate of infection were seen with the anterior approach [3, 4]. Another surgical factor for SSI was the number of spinal segments operated, especially with instrumentations [13, 18]. The risk was found to increase with increasing number of spinal levels instrumented and patients in whom greater than 2-spinal levels were operated have a significantly higher risk [18]. These may be related to longer operation time, prolong use of electrocautery, and the need for blood transfusion in longer spine segment surgeries.

The total duration of surgery is important when considering the risk for spine infection. Surgeries longer than 3 hours were found to be associated with higher SSI rates [3]. This is likely due to the prolong exposure to the theatre environment as well as breach in aseptic technique as surgeons and other staff gets fatigued over time. Data from a study by Wathen et al, suggested that an hour increase in the duration of surgery results in a 19% increase in infection risk [24] with tendency for more exposure to contamination [16], more blood loss and prolong use of electrocautery. Lastly, minimally invasive spine surgery is associated with a lower risk of infection when compared to the open methods [4,14].

Intra-operative contamination

A major determinant of the occurrence of SSIs after spine surgery is the contamination of the surgical site with pathogens. The sources may be the patient, the surgeons, other staff or the air in theatre. Due to the importance of this factor, several measures have been recommended to help prevent its occurrence. Firstly, all surgeries must be performed in a sterile theatre with staff that are knowledgeable in asepsis. In addition, the surgeon must scrub adequately and wear a proper, sterile theatre outfit which should include double gloves. Also, confirmed carriers should be decolonized with the use of intranasal mupirocin [16]. Another method of de-colonization is the use of antiseptic whole-body bath or scrubbing of proposed surgical site [4,25]. This should be done 3 times before surgery (2 nights before, and the morning of surgery). However, daily baths for about 5 days before spine surgery is also safe and effective in preventing SSIs [25].

The best antiseptic solution for skin preparation prior to surgery is still contentious and debatable. While some studies found no difference between the use of povidone iodine and chlorhexidine [26]; however, in our spine unit, our approach is for patient to have chlorhexidine bath the night before and morning of surgery and this has help to reduce SSIs. Others observed fewer infections when povidone or chlorhexidine was used with alcohol than when either of them was used alone [4]. However, our approach is to use chlorhexidine, alcohol and surgical site painted with povidone iodine at the time of surgery. The use of sterile, impervious drapes impedes the translocation of pathogens from the patient's skin and thus results in a lower infection rate, a practice that is adopted in our setting. Skin shaving on the day of surgery and adequate skin preparation on-table also reduces the load of bacteria on the skin and as such reduces the risk of SSIs. Our approach is to do on-table shaving of hair and this with all intended purposes has help to reduce the incidence of SSI.

Antibiotic prophylaxis

The administration of prophylactic antibiotics is an evidence-based method of preventing SSIs. It is recommended that an antimicrobial agent with activity against Staphylococcus is given 30 to 60 minutes prior to commencing surgery [13, 18]. This allows time to attain the minimum inhibiting concentration (MIC) of the drug at the surgical site before making surgical incision. Many authors use Cephalexin 1 gram or 20mg/kg prior to surgery. The dose is repeated after 4 hours (or after the loss of 1500ml of blood) and continued every 6-8 hour up to the 24 hours post-operatively [3,13,19]. In our local setting, we administer intravenous ceftriaxone 1g or 100mg/kg as our surgical antibiotic prophylaxis.

During spine surgery, immersing screws in a solution of vancomycin and ceftriaxone for 5 seconds before using them on the patient resulted in fewer SSI post-operatively [27]. Another measure of reducing the risk of colonisation of the surgical site is copious irrigation of wound with at least 2 litres of normal saline, prior to wound closure [3,28]. In addition, Ming-Te C et al. found even lower infection rate when the surgical wound is soaked with diluted povidone iodine for about 3 minutes prior to irrigation with saline [28]. The use of vancomycin powder on the surgical site before closure is very effective in reducing the occurrence of SSI in spine surgery. This is a routine practice in our unit in which we pour 1g of vancomycin powder into surgical wound. It is a safe method that results in a higher concentration of the drug at surgical wound with lower toxicity profile when compared to systemic administration [3,29] which has a higher toxicity profile. All these are geared towards reducing the chances of contamination.

Theatre Staff

Finally, the rate of SSI correlates positively with the number of staff and personnel turnover in theatre. Following the analysis of over 12,500 patients, Wathen et al. noted a 6% increase in the risk of infection for every additional individual in the theatre [24]. Also, the use of intra-operative equipments (such as microscopes, fluoroscopy and intraoperative computed tomography (CT) scan also increases the risk of infection through breaches in aseptic technique [12]. In our spine suite, we limit our team member to seven (two surgeons, two anaesthetist, one anaesthetist technician and two nurses) which is aim to reduced theatre congestion and help to reduce rate of SSI.

Hypothermia

Intra-operative hypothermia is a risk factor for SSIs post-operatively [16,19]. It can lead to hypo-coagulation which can lead to increase blood loss. Based on current evidence, it recommended that the body temperature is maintained between 36.5C and 37.5C throughout spinal procedures for optimal results [4]. Despite this, the temperature at our spine suite is maintained at 18.0C – 20.0C and we have had record of hypocoagulopathy which causes significant blood loss with attended SSIs.

Blood loss

Increased intra-operative blood loss has been noted to be associated with increased rate of SSIs. As Zhou et al. in their study revealed that the loss of over 500 ml of blood intraoperatively doubled the rate of infection [3]. This may be connected to the invasiveness/duration of surgery and the higher chances of anemia with associated poor tissue oxygenation cum perfusion, and peri-operative blood transfusion which are all risk factors for SSI [7, 18]. Therefore, efforts should be made to minimize blood loss as much as possible.

Dura Tear

Spine surgery that is complicated with leakage of cerebrospinal fluid (CSF) is associated with higher infection rate [7]. This emphasizes the need to achieve a water-tight repair of the dura following a durotomy for spinal tumour or unintended durotomy.

Post-Operative Factors

Drain

The use of a closed suction drain (such as Redivac drain), by reducing the formation of epidural haematoma and tissue oedema, leads to a decreased risk of SSI after spine surgery. However, unnecessarily prolonged use of a drain can become a nidus for microbial portal of entry and proliferation as microorganism can migrate into the wound via the drain tract. This is especially true when a drain is left in place after 1 week [23]. There is controversy regarding the best time to remove a wound drain in the literature. Some authors recommend the removal of drains when the output is less than 50ml/day or on the fifth day post-operatively, if output remains more than 50ml/day [30]. However, recent knowledge suggest that drains can be discontinued safely within 24-48 hours, rather than using a specific drain volume [13,16]. This method has been found to reduce SSI without any increase incidence of hematoma. For us at ISTH, we often use wound drain (closed suction drain) and it is removed after 48 hours aiming to prevent epidural haematoma collection, and minimized SSI when removed early.

Position

Following a posterior approach to the spine, nursing a patient in the supine position is associated with an increased risk of SSI. In the supine position, the tissues around the surgical site are compressed against the bed and this can lead to local tissue ischemia, hypoxia and muscle necrosis with resultant poor healing and infection [30]. In addition, the wound gets contaminated by the bed sheets and other fomites predisposing the surgical wound to infections. This can become a serious risk in patients with urinary and fecal incontinence [12,30]. Thus, it was recommended that patients are nursed in the lateral position with frequent turning and pressure relieving beds. In addition, early immobilization after surgery greatly reduces the risk of surgical site infections [18].

Post-Operative Contamination

As noted previously, the surgical site can become inoculated with microbes on the bed coverings and this can lead to infection. Another source of contamination is the direct acquisition during change of wound dressing. Laia et al. found that most dressing change are unnecessary and that leaving wound dressing for up to the fifth day post-operatively did not increase the rate of SSIs. It was recommended that earlier change of wound dressing should only be done if it is visibly stained with blood [18]. In any case, all wound dressing must be done under strict asepsis, by suitably qualified personnel. Our patients surgical wound is inspected and dressed with povidone iodine at 5th day after surgery.

Orthoses

The use of cervical collar after surgery on the cervical spine has been found to predispose to SSIs. Therefore, its use should be limited to a 48-hour period [4].

Prolong Hospital Stay

The longer the duration of hospitalization, the more prone the patient is to developing SSI. More so, a prolonged admission is associated with infection by multi-resistant organisms such as the Methicillin Resistant-Staphylococcus aureus (MRSA) [6, 23].

Management

Preventing spine SSIs is paramount but when it occurs, the best care possible must be offered to the patient. Managing such cases requires a high index of suspicion especially in late-onset cases where the clinical features are non-specific. In all, the management would involve a detailed history, thorough examination, as well as laboratory and radiological investigation. Once the diagnosis is confirmed, appropriate treatment measures are deployed to completely eradicate the causative organism.

Clinical Evaluation

In taking a history, attention is paid to the identification of the clinical features and risk factors. The most common symptom is back pain, which can be similar to the pain before surgical intervention [12]. Moreover, non-relenting back pain may be the only presenting complain in late-onset SSI. Typically, worsening back pain that is out of proportion to the surgical site pain was the classical presenting symptom in a study by Rishi Mugesh et al [15]. Other symptoms include purulent discharge from the surgical site, wound breakdown, fever and other non-specific symptoms such as anorexia, malaise, and weight loss [19]. Examination findings include signs of inflammation such as erythema, swelling, tenderness and differential warmth. These signs are particularly prominent in early SSI [19]. In addition, patient could have varying degree of wound dehiscence, with discharge of pus and necrosis of tissues. In most cases, the average duration for the development of infection was about 13 days, with a range of 3 to 23 days [27].

Investigations

The non-specific nature of the clinical features of SSIs makes it imperative for patients to be properly investigated. To achieve this, laboratory and radiological studies are often required. There are several laboratory investigations that can aid the diagnosis and follow-up evaluation of patients with spine SSIs. Firstly, the total white blood cells (WBC) count, which is elevated in the face of an infection, is a simple aid to diagnosis. Apart from microbial swab for culture study, the WBC analysis is among the first line of investigation requested. In a study by Burak E et al, a WBC of 10,000 cell/ml was a significant marker of post-operative infection [13]. However, it is non-specific as it can be elevated in other inflammatory conditions and trauma. In addition, an elevated WBC may be observed in patients on peri-operative steroid despite the absence of infection. In this case, a left-shift in the white blood cells becomes an important finding in distinguishing them because it is not influenced by steroids [19]. Another laboratory test that is useful in evaluating cases of SSIs is the erythrocyte sedimentation rate (ESR). The value of the ESR increases as a systemic response to an inflammation. This is non-specific for spine SSI. However, it is more sensitive than WBC level because the ESR is unlikely to remain within normal limits in the presence of an infection [19]. Therefore, it can be used to rule out an infection and for follow-up in patients with SSIs.

The most reliable haematological investigation is the measurement of the C-reactive protein (CRP) level [12,19,31]. CRP is an acute phase protein secreted by the liver in response to inflammatory cytokines especially interleukin-6. Therefore, it is also non-specific for an SSI although it is more sensitive than ESR and WBC count. The CRP level rises early with the onset of SSI and reduces in response to treatment (31). These features make it a veritable tool in diagnosis and monitoring of response to treatment. In using CRP and ESR, establishing a rising trend in the postoperative period is more suggestive of infection than a single abnormal value since these markers may be elevated in the early postoperative period even in the absence of infection [31]. The serum CRP can be combined with ESR to improve its reliability; however, no laboratory method has demonstrated excellent specificity and positive predictive value [19, 31]. Newer methods, such as measurement of pro-calcitonin, serum amyloid protein A, leucocyte esterase and pre-pepsin, require further studies to ascertain their relevance as diagnostic adjuncts [32]. We monitor established SSIs on clinical evaluation, WBC and ESR estimation with treatment.

Microbiological evidence of an ongoing infection is the most reliable means of making a diagnosis of SSIs after spine surgery [19,32]. This involves the culture of effluent, tissue and blood. By far, the most reliable diagnosis can be made from culture of tissues which can be obtained at surgical debridement or percutaneously with CT scan guidance [19]. Thus, this is the gold standard for identifying the causative pathogen [12]. Furthermore, Donara et al. found that sonication of retrieved implants provided the greatest yield of pathogens [6]. The importance of obtaining culture results cannot be overstated because understanding the microbiology of postoperative spine infections is valuable in choosing empiric antimicrobial treatment and infection prevention (as prophylactic antibiotics) [10]. It may be worthwhile to withhold antibiotics, for stable patients, until microbiology samples are collected [19].

Imaging studies such as Plain Radiograph, Computed Tomography (CT) scan and Magnetic Resonance Imaging (MRI) are useful methods of assessing a patient with spine SSI. Plain X-ray findings suggestive of an infection include soft tissue swelling, a reduction in adjacent level disc height, end-plate erosion and loosening of hardware. These features often become apparent after about 6 weeks post-operatively [33]. CT scan is more accurate than plain x-ray in defining spine SSIs [12, 19]. It gives better details of the bone changes, state of the implants and also shows the presence of fluid collection. Moreover, CT scan can be used for image guidance when obtaining biopsy for culture study [19]. The best radiological modality for evaluating these cases is MRI scan with gadolinium contrast. It has been shown to have a sensitivity of

93% and specificity of 97% for post-operative discitis, even after instrumentation [16]. In addition to the information derived from a MRI, it can clearly show the presence of discitis, osteomyelitis, and epidural abscesses after spinal surgery [12]. Other methods include positron emission tomography (PET) scan, PET-CT, and single photon emission computed tomography (SPECT) scan. As part of our protocol, radiological request is for deep SSIs and we routinely request for MRI scan.

However, current imaging modalities can only show anatomical alterations and abnormalities but cannot differentiate an infection from aseptic loosening, or assess the extent of an infection. Newer imaging methods are being tried to circumvent these shortcomings. An example is the use of a human monoclonal antibody (1D9), which targets the staphylococcal antigen A (IsaA) of S. aureus labeled with a radionuclide (89-zirconium [89Zr]), currently [34]. However, further research is still needed to prove their reliability.

Treatment

Treating spine SSIs following spine surgery is difficult and often requires long hospital admission, multiple surgeries for debridement and reoperation, removal of implants and prolong antibiotics use [3,19] with attendant huge cost to the patient and the economy.

Once a patient is suspected to have SSI after spine surgery, the initial treatment is aimed at stabilizing the patient. This is particularly important for patient who present in septic shock, which is a possible complication. Following resuscitation, the patient would require surgical debridement which should be done in the theatre. This involves drainage of pus and excision of necrotic tissue and slough. The excised tissues serve as specimen for microbial studies. Our protocol is aimed at wound care, targeted antibiotic therapy and wound debridement with the sole aim to curtail microbes and allow wound healing.

Whether or not to retain hardware used in surgery is controversial. Nonetheless, there is no doubt that removal of implant will allow for thorough debridement with removal of biofilm, thus making complete clearance a possibility. Despite the varying position, it is generally recommended that superficial and early (including deep SSIs) infections can be treated with complete retention of instrumentation [6, 19] and is our adopted standard of care. On the other hand, for late-onset deep SSIs, the decision to remove implants depends on the state of the implant as well as the condition of the spine [6]. Implants that are loosened can be replaced. Sometimes managing late-onset SSIs would require complete removal of screws and cages [5,6]. Furthermore, it is safer to remove hardware after arthrodesis has been achieved so as to prevent instability, pain and neurological deficit [5]. Using the algorithm described by Rishi Mugesh et al, type 1 infections can be managed by surgical debridement and closure while type 2 and 3 will require prolonged wound care including the use of vacuum assisted closure (VAC), however VAC is not readily available in our settings and not a part of our protocol. Treating Type 4 and 5 SSIs demand partial and complete removal of implants respectively [15].

Having achieved complete removal of dead and dying tissues, the wound is washed with hydrogen peroxide solution, normal saline, povidone-iodine solution and normal saline again, in that order. After this, the wound is soaked with povidone iodine for about 5 to 10 minutes. Yong Yin et al [5] found this method to be beneficial as the 42 patients he managed healed satisfactorily. A closed drain may be necessary if wound is closed immediately after debridement and irrigation. The drain can be left for 7 -10 days [5]. However, it is advisable to institute secondary closure to allow assessment of adequacy of debridement since most patients require more than one session [4,19]. A thorough wound debridement in which necrotic tissue is removed until a bleeding wound edge is achieved with or without implant removal is our standard of care. For these patients, negative pressure wound therapy (vacuum assisted wound closure [VAC) has been found to be very effective and safe even in the presence of CSF leak [6,15,35]. When using VAC in spine SSI, a lower pressure of 50-60 mmHg is recommended as against the over 125mmHg used for other types of deep wound [35].

Patients with spine SSIs requires a long-term antibiotic use. In general, the choice of antibiotics is guided by culture results and local antibiotic studies [19]. Some antibiotics commonly used include biofilm-active ones such rifampicin-combination with quinolones, cotrimoxazole, doxycycline or fusidic acid [6]. Ideally, it is started after tissue has been obtained for microbiological study. However, patients who are unstable, with signs of systemic toxicity, should have immediate intravenous antibiotic [19]. The duration of antibiotics usage and the time for conversion to oral antibiotics are subjects of debate, although it is agreed that patient need antibiotics for a long period, usually 6 to 12 weeks [5,6]. Palmowski et al. found that patients recovered satisfactorily with a regimen that used intravenous antibiotics for 1-2 weeks, followed by oral antibiotics for 6 weeks (when the implant was removed) and 12 weeks with retained implants [36]. Other authors have used intravenous antibiotic administration for 6 weeks, followed by oral antibiotic administration for another 6 weeks and good results was obtained [5]. Our antibiotics protocol follows a 12-week (4 weeks-parenteral and 8 weeks-oral with strict warning on compliance) administration based on sensitivity testing. Decisions regarding the optimal use of antibiotics should involve an infectious disease expert.

Other novel treatment modalities have been tried and found to be effective. Mehmet et al. treated 19 patients with a combination of hyperbaric oxygen (HBO) and antibiotics. They administered an average of 22-hour sessions of HBO (at 2 atm.) to the patients and observed improvement in wound healing [37]. Also, the application of a mixture ozone and oxygen to a non-healing wound resulted in prompt healing [9]. These can be considered adjuncts to treatment.

Ultimately, treating spine SSI is very demanding and best results are achieved when optimal care is instituted early. Moreover, the need for a protocol-based care cannot be over-stated. In an experimental study by Laia et al, a multidisciplinary approach to care that included the development of a preventive protocol, staff training and use of surveillance feedback from results was associated with a 78.1% decrease in the incidence of surgical infection in spinal surgery in the trauma service [18].

Conclusion

SSIs remains a huge disease burden in spine surgical parlance. Risk identification, stratification and prevention is a core part of any successful collaborative management efforts.

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