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REVIEW ARTICLE

Infections associated with spinal implants

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Abstract Spinal infections represent a difficult challenge to treating clinicians. Infections in the presence of implants are even more so. In this review the literature appears to reflect a change of practice in which the aim is to retain implants if possible. The newer spinal procedures such as disc replacements pose different problems largely due to the more difficult access. The situation in the spine is more difficult than in general orthopaedics when dealing with infection due to the requirement for stability and to protect neurological function. The main thrust of management, therefore, is early diagnosis and a high index of suspicion followed by adequate if not radical management in a multidisciplinary setting. In the event prevention is better than cure and therefore consideration of the various mechanisms to avoid infection must be taken. There are some 'novel' considerations for the avoidance of infection alongside the tried and tested techniques. There are also new procedures for wound closure and the elimination of dead space.

Introduction

Infections associated with spinal implants represent a major diagnostic and therapeutic challenge to the spinal surgeon and physician. Further spinal infections in general appear to be on the increase, particularly over the last decade [49]. In this review article it appears that attitudes appear to have changed more recently with more thought being given to implant retention and the achievement of the original therapeutic goals. Despite this there is wide variation in individual practice from the treatment of post-operative haematoma to dealing with the various types of implant involved in infection. Spinal infections can also be of acute onset and delayed appearance. There is now consensus of opinion in instrumented spinal surgery that antibiotic prophylaxis is desirable, indeed perhaps mandatory and certainly for lumbar fusions where the risk of infection in various studies varies between 1% and 12% in the literature. It is also suggested that prophylaxis is probably indicated for decompressions and discectomies. The type of antimicrobial used and its duration is still a matter of debate. Prevention of infection is far more valuable than reacting to an adverse clinical situation should it arise. Methods quoted for prevention are antibiotic prophylaxis, surgical technique to avoid necrotic tissue, avoiding 'at risk patients', reduction of haematomas, optimising surgical conditions and treating co-existing infections. Post-operatively care needs to be taken as infection can also occur due to soiling of the incision in the fresh postoperative phase [43]. More than ever the treatment of spinal infections requires a multidisciplinary team to include microbiologists, neuroradiologists and spinal surgeons with the key being early detection [5, 22]. It is also possible to acquire an anterior spinal infection during a posterior approach as anterior structures are being operated upon [9, 11, 30]. Late onset infections were thought to be associated with intra-operative seeding, metal fretting causing a sterile inflammatory response or stimulating low-virulence organisms to fester and haematogenous seeding [31]. The use of implants in itself is associated with an increased risk of infection. It is believed this relates to longer operating times, prolonged retraction, instrumentation and bone grafting [36].

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Antibiotic prophylaxis

In most centres the antibiotic prophylaxis used is intravenous and starts at induction of anaesthesia. There is a difference of

opinion with regard to the duration of these injections but the majority opinion favours a total of three to five doses. Although, there was no statistical difference between a single pre-operative antibiotic dose versus a pre and post-operative protocol [20, 42]. The drugs used vary but there is a necessity to cover the most frequent causes of infection such as *Staphylococcus aureus* [34] and the gram negative bacteria. Colonic bacteria are more likely to be a problem associated with anterior approaches and novel techniques such as the axialif. There is evidence that the use of topical antibiotics such as vancomycin as well as intravenous prophylaxis further reduces infection rates [8, 45]. Consideration should also be given to identifying potential infections by nasal swabs and the use of antibiotic nasal ointment, wound lavage with normal saline or with normal saline and antibiotic [39]. More chronic infections have been shown to be associated with propionibacterium acnes [40, 43].

Surgical technique

This is reported to be important with respect to avoiding the formation of necrotic tissue by either rough handling or excessive retractor times. It is recommended that retractors are slackened off or moved at frequent intervals to prevent muscle tissue damage. Anoxic tissue is a fertile breeding ground for infection. There is evidence to suggest that the operative time and intra-operative blood loss are significant factors in developing infections [10]. The interest in minimally invasive spinal surgery may well be justified in terms of reduced spinal infection. A reduction as much as tenfold has been reported in comparison to similar surgery being carried by the more traditional open techniques [14].

Cervical spine

The rate of infection with an anterior cervical approach appears to be lower than that in the thoraco-lumbar spine (0–1%), although the posterior approach to the cervical spine appears to be similar to the lumbar spine [42]. After anterior cervical spine surgery there may be painful swallowing due to a retropharyngeal abscess.

At risk patients

These are essentially patients who run a greater risk of the development of infection. They include patients suffering from co-existing medical conditions such as diabetes, renal failure, immunosuppression, rheumatoid arthritis, advanced age, alcoholism, malnutrition, obesity and steroid therapy [1, 26]. The decision to operate can be more complicated in these patients and it should be explained that there are relatively higher risks for wound problems and infection. Any treatable medical conditions should be optimised before surgery if possible. There is also evidence to suggest that the use of blood transfusion leads to an increased risk of spinal infections due to the modification of the immune response [3].

Postoperative haematoma

The use of suction drainage has reduced the incidence of haematomas, and closed suction drains may be useful for the removal of fluid from large potential dead spaces, but do not, themselves, prevent infection [2]. Compressive haematomas in the presence of a decompression are known to cause potential neurological problems. Haematomas also present a potential medium for the development of infection. Their incidence can be reduced by careful surgical technique and adequate haemostasis. Despite this, reactive haemorrhage can occur. It is thought that the emphasis on minimally invasive techniques may reduce infection by reducing the sources of haemorrhage and the ‘dead space’ for the development of an haematoma.

Optimising surgical conditions

The surgery, if planned and not emergency, should be performed in a controlled environment in a theatre with positive pressure ventilation and with orthopaedic standard sterile precautions for staff, instruments and patient. That includes proper draping and skin preparation, minimising traffic in and out of theatre, correct theatre garb, reducing delays for provision of instruments, adequate lighting, etc. A major source of infection is related to perforation of surgical gloves [2]. Also, the addition of instrumentation alone is associated with a higher infection risk. The use of urinary catheters should be discussed with the patient and the relevant prophylaxis arranged. The wound dressing should be considered along with the wound closure to protect the wound in the immediate postoperative period. For a clinical infection to occur at the surgical site bacteria must be present in substantial quantity, i.e. $>10^5$ [43].

Co-existing infections

Co-existing infections should be eradicated as far as possible. The causative organism should be identified and if there is a systemic infection surgery should not be performed unless absolutely essential. Any infection should

be isolated from the surgical site. Viral infections are not so much a cause for concern.

Diagnosis

The diagnosis of a spinal infection in the immediate postoperative period can be difficult. It is not possible to completely rely on the standard blood tests such as CRP, ESR and FBC as the inflammatory indices are raised and remain so for some weeks. They are more useful in delayed onset infection. The CRP proved to be the only reliable marker and returned to its normal level in 48% of patients at 14 days. It was noted not to be higher at day seven than it was at day four [23]. The diagnosis is often made on clinical grounds via examination and the temperature chart. Elevation of temperature on its own is probably not enough as it needs to be seen in the context of a haematoma elevating temperature and the general condition of the patient. Diagnosis requires clinical skill and a high index of suspicion is required in an 'ill patient' with more pain than would normally be explained by the surgery. Many present with a wound discharge and the wound edges and surrounding tissue are often inflamed. MRI scan can be useful in these circumstances but is difficult to interpret as postoperative changes of oedema can mimic infection. Collections of fluid are not necessarily helpful as they could be uninfected haematoma or seroma. Also the presence of implants poses further difficulties of interpretation. It is thought that the addition of gadolinium may be of value in the diagnosis of postoperative discitis, although this also requires interpretation as there is likely to be signal change following surgical intervention.

Spinal implants

Previously placed spinal implants are a risk factor for late onset epidural abscesses. It needs to be borne in mind that a bacteraemia from a distant source may reach spinal implants to find a good medium for infection [6]. Surgery with revision instrumentation increased the risk of infection still further, up to 4.4% in one series [38]. There is some potential for the development of antibiotic impregnated implants.

With regard to infections involving disc replacements the literature is very sparse. There is a case of revision of a lumbar disc arthroplasty in the literature following late infection which was converted to a spinal fusion after the treatment of the surrounding retroperitoneal abscess [46]. When discussed further it is noted there is no standard algorithm for dealing with infected disc replacement. The point was made that in acute early infections with good soft tissues, a stable implant and an appropriate antibiotic the implant could be retained after thorough debridement. In the more chronic situation, after three weeks, the implant should not be retained and a fusion should be performed [47]. One of the most difficult aspects is the revision approach and it appears sensible to operate with a vascular surgeon. The position of a cervical disc replacement may be similar in terms of treatment protocol but the presentation is likely to be different in view of the surrounding anatomy.

Treatment

Treatment is necessarily complicated depending upon the position, timing and implants involved. Generally the thrust of management would be retention of the implants and achievement of the goals of treatment. Early diagnosis and expedited treatment facilitate those objectives. Indeed some authors would suggest that early diagnosis and treatment is more likely to lead to implant retention [15].

There is quite marked difference of opinion with some authors suggesting an aggressive approach with returns to theatre and radical debridement [1], although it is noted that instrumentation provides stability. Some authors noted that removal of implants and appropriate antibiotics was effective but accepted the consequent deformity [12, 16, 28]. Whereas others take the view that implants can be retained where stable and replaced primarily when loose, whilst carrying out debridement, with wound closure over multiple drains and that these operations can be done as a single procedure leading to a successful fusion and avoidance of deformity [4, 7, 17, 18, 24, 27, 29, 32, 33, 41, 44]. A further view is that it is a legitimate strategy to treat the infection retaining the implants until successful fusion when they should be removed, as the infection is never completely eradicated; this does not always cause significant loss of any correction [40]. A further 'take' on that approach is to remove implants in association with chronic or late onset infection [44].

The absolute indications for surgery have been noted to be the failure of medical treatment, deep postoperative infections in association with implants and abundant drainage and significant or increasing neurological deficit.

The treatment of postoperative haematomas ranges from no action to the re-opening and lavage of a wound with haematoma evacuation. There is no consensus of opinion. It would seem reasonable to put a patient with a leaking wound from a haematoma on prophylactic antibiotics to prevent haematoma infection. If the haematoma is symptomatic it would further seem reasonable to drain it by aspiration and strapping. If there are neurological concerns or the haematoma does not respond to aspiration and is symptomatic then surgical drainage may need to be considered. The implants would be retained. Generally, wound haematomas can be

washed out with minimal if any disturbance of associated bone graft. The anatomical position may be important as anterior cervical haematomas may cause difficulty with swallowing or breathing. Swabs would need to be taken at re-operation to ensure the absence of infection.

Superficial wound infections and stitch abscesses would be treated by wound care and antibiotics after sensitivities were obtained and are unlikely to lead to long-term sequelae if adequately treated.

Deeper infections would need to be explored. Some can be localised to the subcutaneous fat and can be dealt with by wound debridement and lavage. Those that penetrate the deep fascia into the muscle layer and around implants need extensive exploration with debridement and lavage. If the bone graft is involved, in a fusion, it should be washed out but could be retained. Similarly the implants can be retained, particularly if they are not loose. The analogy would be an infected femoral nail where removal would lead to the worst scenario of an infected unhealed and unstable fracture. In chronic infections with loose pedicle screws and infection around the screw threads consideration should be given to removing the screws, debriding the pedicles and the use of larger screws. If there is a sound fusion the screws could be omitted. The position of disc replacement either in the neck or lumbar spine has been described before. Every effort should be made to retain the implant if infection is diagnosed early unless it became loose, unstable and symptomatic. It would then be removed and a fusion attempted without an implant in the disc space using a bone grafting technique instead. It is not likely that the situation could be treated as a knee or hip replacement which had become infected, by simple implant removal, due to the requirement to have an immediately stable situation to address neurological concerns. There is one report of the retention of an infected interbody cage with conservative treatment which was successful although this is not recommended [13]. There appears to be an argument for simultaneous anterior and posterior surgery as it allows the manipulation of both the anterior and posterior aspects of the spine as well as reducing both operating time and complications [48].

The antibiotic treatment for deep infections and osteomyelitis would extend for six weeks intravenously and be followed by a further six weeks orally. It is often sensible to involve a microbiologist in the treatment of such patients.

Other considerations

The use of antibiotic impregnated beads can be considered in wounds which may require repeated lavage and debridement [35]. The best single antibiotic appears to be clindamycin in treating staphylococcus infections. The use of suction dressings has been reported as having benefit in the treatment of infected wounds in relation to implants. The use of continuous indwelling surgical site irrigation has been shown to be useful in managing infections and avoiding implant removal [10]. Vacuum-assisted wound closure has been described for the closure of infected wounds after instrumented spinal surgery and it is thought to contribute to implant retention [19, 25, 41]. Wound infections appear to be reduced by the use of silver impregnated dressings [21]. Some late infections were found to be foreign body reactions to metallic debris. This resolved after debridement and implant removal [37].

Conclusions

The North American Spine Society has compiled evidenced-based clinical guidelines with regard to antibiotic prophylaxis in spine surgery in a 2007 publication. They note that there is fair evidence that patients undergoing spine surgery should receive pre-operative prophylactic antibiotics. They also support the use of antibiotics in non-instrumented spinal surgery. They note poor quality of evidence to support prophylactic antibiotics following spinal fusion but note fair quality evidence to support pre-operative prophylactic antibiotics in reducing infection but note that there is no one superior agent. There was little support for the use of broad spectrum antibiotics in patients with risk factors and there was no evidence to support multiple antibiotic doses against single doses. There was insufficient evidence to support the use of drains to reduce infection rates. There was no evidence to support a change to antibiotic protocol in obese patients. Although smoking, nutritional depletion and immunodeficiencies increase risk for infection there is insufficient evidence to suggest a change to antibiotic protocols.

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