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REVIEW ARTICLE

Progress in diagnosis and treatment of cervical postoperative infection

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Postoperative infection is the commonest complication that causes failure of spinal surgery. Although the rate of infection after cervical surgery is lower than that after lumbar surgery, the absolute number of cases is increasing. In recent years, new techniques, such as serum amyloid A and fludeoxyglucose (^{18}F) positron emission tomography (18F-FDG PET), have emerged and gradually been employed in the diagnosis of postoperative infection, updating the ability to identify the presence of infection. Most patients with cervical postoperative infection require re-operation. There are three principles for such surgery: thorough debridement, adequate drainage and ensuring stability of the spine. Some severe cases even need emergency surgery. This article aims to discuss the controversial issues in diagnosis and treatment of cervical postoperative infection, as well as progress in related studies.

Key words: Cervical vertebrae; Diagnosis; Infection; Surgical procedures, operative; Therapy

Cervical postoperative infections occur after cervical spine surgery and other invasive operations. The incidence of cervical postoperative infection is lower than that of postoperative infection of other parts of the spine. However, in recent years with the increasing amount of cervical spine surgery and the launching of new treatment, the absolute number of cases has increased, which has drawn more clinical attention to this issue.

It has been reported that the infection rate after anterior cervical surgery is in the 0–1% range[1,2], and that posterior cervical surgery operation has a relatively higher risk of infection, about 1% with simple decompression and 4.5–9% with internal fixation[3,4].

Classification

Cervical postoperative infection is classified as superficial or deep according to the level of infection[5]. Superficial infection is limited to the skin and subcutaneous layers, and does not involve the deep fascia. Deep infection refers to the infection in the deep fascia (nuchal ligament and platysma muscle) and involves muscle and its underlying compartments. Deep infection includes intervertebral disc inflammation (also called intervertebral space infection), vertebral osteomyelitis and epidural abscess. Cervical postoperative infection can also be classified according to its time of occurrence as early (within 3 weeks of the operation) and late-onset infection (more than 4 weeks after surgery).

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Diagnosis

Clinical symptoms and signs

The main clinical manifestations of cervical postoperative infection are wound exudate and red swelling of surgical incisions. Infection should be strongly suspected when progressive pain develops at incision sites. Sterile hematoma is generally not associated with progressive pain or swelling, however persistent hematoma may be complicated by bacterial growth. Some patients have fever. Fever during the first 2–3 days after surgery is most often caused by absorption of hematoma, such fever generally being lower than 38.5°C; attention should be paid to temperatures above 38.5°C. In addition, infection cannot be ruled out in patients without fever, especially in the case of late-onset infection. In comparison, wound exudate is relatively specific to early onset infection, 93% of patients having this manifestation. However, it is rare in late-onset infection[6].

Laboratory examination

Blood should be taken for culture when the body temperature is at its highest. Other tests include total and differential white blood cell count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). An elevated white blood cell count and neutrophil percentage indicate postoperative infection. The ESR increases

rapidly, reaching a peak after 4–5 days and often returns to normal within 2 weeks. Infection should be strongly suspected when the ESR is higher than normal 4 days after surgery. The concentrations of CRP usually peak at day 2–3 postoperatively and quickly return to normal. The sensitivity of CRP in predicting early postoperative infection is 100% with a specificity of 96.8%[7], however CRP concentrations are affected by corticosteroids. Serum amyloid A can also be used for diagnosis of early postoperative spinal infection[8]. The half-life of serum amyloid A is only 50 minutes, shorter than that of CRP (5–7 hours). More importantly, its concentrations are not affected by corticosteroids. Moreover, serum amyloid A helps in distinguishing between bacterial and viral infections.

Imaging

Morphological spine imaging

Plain radiography provides little help in the diagnosis of an acute postoperative infection. An augmented soft tissue shadow indicates effusion or hematoma. Postoperative discitis is not visible on a plain film until a few weeks to several months after surgery. CT-guided biopsy may be useful where there is a suspicious lesion or fluid collection. MRI is most commonly used for morphological imaging[9]. However, the role of MRI is very limited. The main limitations are as follows: (i) it is difficult to identify whether end-plate changes are caused by degeneration or postoperative infection; (ii) it is difficult to distinguish between atypical early postoperative infection and compression fractures; (iii) to a large extent findings depend on MRI technical parameters; (iv) it is difficult to differentiate active infection from ongoing reparative and/or fibrotic tissue[10]; (v) it is difficult to distinguish septic from aseptic discitis in the early postoperative stages; and (vi) interpretation of findings is hampered by artifacts induced by spinal implants or hardware[11].

Functional spine imaging

Diagnosis of infection by nuclear techniques is based on two cascades in the inflammatory process[12], namely leukocyte migration and the congestive process at infection sites. The former is specific whereas the latter is nonspecific for inflammation. Conventional radionuclide techniques include bone scintigraphy, Gallium-67 citrate and radiolabeled leukocyte imaging. The spatial resolution, sensitivity and specificity of these techniques are low, limiting their diagnostic application in postoperative spinal infections.

In recent years, scholars have paid increasing attention to the role of 18F-FDG positron emission tomography (18F-FDG PET) in the diagnosis of infectious diseases[13,14]. Because intake of fluorodeoxyglucose (FDG) into cells with increased metabolism is enhanced, FDG uptake is increased in neutrophils and macrophages within inflammatory tissues. Compared to traditional nuclear medicine technology, 18F-FDG PET can provide results within 2 h with a resolution of up to 4–5 mm. Moreover, the image is not affected by metal implants. The sensitivity is not affected by antibiotics, and its specificity is in the acceptable range, even for early postoperative cases. 18F-FDG PET is especially suitable for patients who cannot undergo MRI testing. The sensitivity and specificity of 18F-FDG PET for detecting postoperative spinal infection have been reported to be 100% and 81%, respectively[14]. 18F-FDG PET is especially suitable for chronic infection occurring more than 6 months after surgery. Although there are few published studies, 18F-FDG PET appears to have an advantage in differentiating inflammation from degeneration of the end-plate[15]. Currently, its limitations are mainly in the distinguishing between tumors and inflammatory reactions[16].

Treatment of cervical postoperative infection

General principles

Management of cervical postoperative infection depends on the type of infection. Although some cases of minor discitis and superficial wound infection can be cured by non-surgical methods, most cervical spine infections still require re-operation. There are three principles for such surgery: thorough debridement, adequate drainage and ensuring stability of the spine. Some severe cases (epidural abscess, necrotizing fasciitis and muscle necrosis) require emergency surgery.

The initial management is mainly treatment with suitable antibiotics. Unless emergency surgery is planned, broad-spectrum antibiotics should be used initially to cover possible pathogens. It should be noted that the administration of antibiotics should be terminated 24 hours before surgery so as not to affect the positive rate of samples collected for culture during surgery. The antibiotics can be restarted once the specimens have been obtained.

Surgical debridement and drainage should be carried out as soon as possible. Wounds should be reopened along their original incisions and inspected at every level for fluid collections. Necrotic and fibrous tissue should be sharply debrided from all fascial planes. Muscle viability should be assessed by electrocautery stimulation. Devitalized tissues should be debrided as necessary. With posterior wounds, devitalized paraspinal muscles are the main problem. In contrast, anterior wounds are

more likely to result in so-called dead space infections. The longus colli and sternocleidomastoid muscles should be carefully checked. Particular attention should be paid to possible small tears of the esophagus, which may provide hidden sources of contamination. If such tears are repaired, the repairs should not be placed directly above the exposed surface of the vertebral bodies; otherwise fistula formation is prone to occur. Fistulas often appear in the perioperative period, but may occur as long as a year after surgery[17]. Once fistulas have formed, they can be repaired by placing the sternocleidomastoid muscle between the esophagus and spine[1]. Injection of indigo carmine through the esophagus may show the location of an esophageal tear by dye leakage into the operative field.

Another important principle of debridement is to maintain spinal stability. Implants should be thoroughly checked after exposure. Loose implants should be removed and replaced as needed. If no serious contamination of them has occurred, autogenous and allograft bone should be retained. Mondorf *et al*. reported treatment of cervical spondylodiscitis by using a polyetheretherketone (PEEK) material cage for support without a bone implant and achieved good results[18]. In the anterior spine, any prominent hardware that could erode into the esophagus should be replaced[19,20].

The wounds should be closed primarily or secondarily with absorbable non-braided sutures. Where no obvious suppuration has been observed during surgery, primary closure of the wound can be performed. Vacuum sealing drainage should be placed at each fascial level and maintained until fluid drainage is less than 40 mL every 8 h. It has been recommended that the drainage fluid be routinely cultured 2 days after surgery and the drainage tube tip after extubation. If the result is positive, treatment of the infection has probably been inadequate and additional surgical debridement and draining should be considered.

For those wounds where primary closure cannot be achieved, wet dressings soaked with physiological saline should be applied daily and gradually converted to dry dressings until granulation tissue has filled the cavity. A vacuum suction device can also be used to cover the wounds[21]. This can reduce the number of times the wound dressings have to be replaced. However, it is difficult to achieve continuous negative pressure in posterior wounds.

Discitis

Postoperative discitis, also known as disc-space infection, occurs after discectomy, corpectomy or minimally invasive procedures such as discograms. The infection rate after discograms is 3.2%[22]. The typical infecting organisms are *Staphylococcus aureus* and *Staphylococcus epidermidis*; other bacteria such as *Escherichia coli* have also been reported[23].

Standard treatment for postoperative cervical intervertebral infection includes bed rest, a hard collar and intravenous antibiotics. Because the adult intervertebral disc lacks vascular tissue, its nutrition depends mainly on penetration from the outer fibrous ring and the center cartilage. Thus, it is generally difficult for antibiotics to reach an effective concentration, particularly in the case of β-lactamase antibiotics (cephalosporins and penicillin). In contrast, gentamicin and glycopeptides (vancomycin and teicoplanin) can reach higher concentration due to their positive charge. Taking into account the renal toxicity of gentamicin and glycopeptides, the British Society of Antimicrobial Chemotherapy still recommends the first and second generation of cephalosporins and clindamycin as the treatments of choice for disc space infection. Where MRSA has been cultured, vancomycin plus gentamicin is recommended[24].

There is continuing controversy about dose, route and time of duration[22,25]. Some scholars have suggested that 6–8 weeks of intravenous antibiotics is enough. However, other scholars propose supplementation with oral antibiotics for 1–2 months after CRP concentrations have returned to normal[26].

Surgical treatment should be considered in the following situations: non-surgical treatment failure and persistent pain associated with infection or secondary sepsis.

Vertebral osteomyelitis

The standard treatments for postoperative vertebral osteomyelitis are the same as those for primary bone infection. After exposure, the necrotic bone is removed with curette and rongeur until a healthy bleeding surface is exposed. The surgeon should endeavor to protect nerve tissue at all times.

An anterior defect resulting from discectomy or corpectomy must be reconstructed regardless of whether autograft or allograft bone has been used, even when there is active infection. Posterior fusion and internal fixation should be conducted after the acute infection has been controlled, usually 2 weeks later.

Generally, bone infection requires longer usage of antibiotics, namely 6–12 weeks of intravenous drugs followed by oral administration. An intravenous catheter can facilitate drug administration. Depending on lesion size and amount of necrotic tissue, secondary debridement may be necessary.

Gangrenous fascia infection

There is only one published report concerning gangrenous fascia infection after vertebral surgery[27]. Emergency surgical debridement of massive scope is required for this rare complication. The necrotic fascia and muscles must be sharp cleared by sharp dissection. Repeated debridement is a basic principle and must be pursued until no remaining tissue necrosis is evident on intraoperative examination.

Epidural abscess

Preoperative examination by MRI is of great help in surgery for epidural abscess decompression[9]. The choice of surgical approach depends on the location of the epidural abscess. Laminectomy can be employed for an abscess located in the posterior or lateral parts of the spine, an anterior approach for an abscess located in the anterior part of the spine and an approach through mouth for an abscess in the high anterior part of the cervical spine. Reconstruction should be performed to correct any instability created by laminectomy and resection of the anterior column. Continuous checking of the ESR is of help in evaluation of infection control.

Risk factors and prevention

Cervical postoperative infection is caused by a number of different factors. Thus, a multi-disciplinary approach should be taken to prevent its occurrence.

Basic evaluation of overall health

Preoperative evaluation of the general condition of the patient is needed, with particular attention to aspects such as the need for improvement of the nutritional status. The indicators of malnutrition are as follows: serum albumin <35 g/L, lymphocyte count <1500–2000/dL, serum transferrin <150 μg/dL[28].

Surgical approach

Each surgical approach has its own advantages; it is not possible to guarantee prevention of post-operative infection. The risk of infection is lower with an anterior than with a posterior approach. Esophageal and tracheal fistulas are most unlikely when post-operative infection occurs after an anterior approach. The posterior approach requires a muscle stripping procedure, which can devascularize large areas of musculotendinous tissue.

Environmental control in the operating room is an effective way to reduce bacterial contamination during surgery. Aseptic principles, including scrubbing, dressing, draping and preparation of the surgical field, should be followed meticulously. Special attention should be paid to these measures during revision surgery.

The incision should be irrigated with massive volumes of normal saline before the incisions are sutured. To reduce the possibility of hematoma formation and secondary bacterial growth, bipolar coagulation and gelatin sponge with thrombin or hemostatic gauze should be used for hemostasis. Cheng *et al*. suggested that irrigating incisions with dilute iodine solution decreases the incidence of post-operative infection[29]. They found that no postoperative infection occurred in 208 patients whose incisions were irrigated with dilute iodine solution, whereas 2.9% of 206 patients who did not undergo this treatment suffered from a postoperative infection. Bose suggested that subcutaneous drainage of the incision reduces hematoma formation, thus reducing the risk of growth of bacteria without adding toxicity[30].

In addition to careful disinfection and dressing replacement of incisions after operation, sources of distant contamination should be eliminated. Drainage tubes should be removed 1–2 days after the surgery. Decubital ulcers should be prevented in spine injury patients and long-term bedridden patients. Gastrointestinal nutrition can reduce the risk of blood-born bacterial invasion. Feeding by mouth is the option of choice where possible. Feeding via a nasogastric tube or percutaneous intragastric nutrition can also be adopted.

Prophylactic use of antibiotics

The prophylactic use of antibiotics has become routine in spinal surgery. The best results are achieved if the antibiotics are given preoperatively and maintained for 24–48 hours after the surgery[31,32]. It has been reported that the incidence of infection after lumbar spine surgery in patients receiving prophylactic antibiotics is 1%, whereas it is 9.35% in patients without prophylactic antibiotic treatment, suggesting the value of prophylactic antibiotics. Kakimaru *et al*. suggested that for simple decompression, preoperative rather than postoperative prophylactic antibiotics are necessary[32]. Although research on the efficiency of prophylactic antibiotics in cervical spinal surgery is still not available, there is general consensus on their use.

Disclosure

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