Original Article

Krishna Sharma, MS, DNB
Department of Neurosurgery
Nepal Medial College
Kathmandu, Nepal

Address for correspondence:
Krishna Sharma, MS, DNB
Department of Neurosurgery
Nepal Medial College
Kathmandu, Nepal
Email: krishnashamra@yahoo.com

Received, 17 November, 2016
Accepted, 25 November, 2016

Nepal Journal of Neuroscience 13:81-87, 2016

Postoperative Pyogenic Cervical Discovertebral Spondylitis

Postoperative cervical discovertebral spondylitis is an uncommon problem, especially if it occurs soon after another surgery somewhere else in the body. The diagnosis is late as the symptoms like neck pain, are initially ignored and may present later with features of unstable spine and neurological deficits. Management is like for any other pygenic spondylitis and may need surgical debridement, decompression and fixation. Overall prognosis is good with timely treatment. Since the neck problem occurs soon after a surgery elsewhere in the body, the previous surgery could be blamed for the present spondylitis. Thus this may add a medico-legal dimension to the problem.

Key Words: decompression, fixation, Postoperative pyogenic discovertebral spondylitis

Development of cervical spine infection soon after being operated for some other problem at some other site is usually attributed to lot of other causes but not to the possible unexpected infection of cervical spine. It implicates additional time, cost and likelihood of another surgery. If detected early, the problem probably can be managed by conservative method. However when they present with large abscess, neurological deficits or instability, it additionally needs surgical intervention. A series of such cases and the diagnosis and management are presented here.

Materials and Methods

From July 2006 to June 2012, 52 patients presented with stiff painful neck. There was history of being operated else where in the body under general anesthesia with endo-tracheal intubation about two to four weeks back in all patients. The neck pain, mostly localized and severe, and was not present ever before the surgery. It started from immediate postoperative period, and persisted and progressed despite analgesics and rest. As it was attributed to other minor causes, the diagnosis was delayed from 1 to 9 months.

There was history of orthopaedic surgeries in 21 patients, abdominal surgeries in 11 patients, gynaecological surgeries in 14, craniotomy in three patients and spinal surgery in three patients **(Table 1)**. The age ranged from 18 to 76 years and the male to female ratio was 2:1. Sixteen patients had neurological deficit corresponding to the brachial nerve root and cord compression at the level of cervical involvement. There was no history of fever or any other constitutional symptoms. None had history of Diabetes mellitus, drug addiction or any other immuno-compromised state.

Surgery	Total number
Orthopaedic surgery	21
Abdominal surgery	11
Gynaecological surgery	14
Craniotomy	3
Spinal surgery	3

Table 1: List of surgeries after which patient developed infection

On investigations, there was raised total count in 36 patients and in all patients ESR and CRP were raised. Blood culture was positive only in 5 patients (10%). X-rays showed radiological evidence of instability in 28 patients (54%). MRI was done in all and showed various forms of infections like abscess, oedematous bones, collapsed, subluxated and deformed vertebral bodies, disc involvement with pus compressing the root and the cord, etc. The upper cervical spine was involved in 16 (31%) patients and lower cervical spine in 36 (69%) patients. Other spines were not seen to be involved in screening MRI. PCR for Mycobacterium tuberculosis was present in six patients.

The neck was immobilized on a cervical collar and adequate analgesics were given. All were started on antibiotic empirically, mainly targeting staphylococcus. In those 21 patients with minimal symptoms, oral antibiotics were started and followed up in OPD basis for at least six weeks or till the ESR and CRP became normal. Four of these patients continued to have pain and there was radiological deterioration in X-ray and MRI. These four were admitted started on injectable antibiotics. Those presenting with severe neck pain, neurological deficit and unstable spine were admitted, put on cervical traction and administered antibiotics parenteraly. The antibiotics were continued for three weeks and then switched to oral form for another three weeks guided by clinical and biochemical (ESR and CRP) improvement. In six patients where PCR for mycobacterium tuberculosis and Mantoux test were positive and later had biopsy confirmation, antitubercular medication was given for one year guided by ESR and CRP.

Thirty-six patients underwent drainage of abscess, discectomy (14 patients) or corpectomy (22 patients), fusion and fixation using titanium plates and screws through anterior approach.

Results

None of the patients had progression of the infection, instability or neurological deficit with treatment. Those 36 patients, treated surgically had no surgically related complications. However, in 8 cases, on follow up, were found to have developed mild kypho-scoliotic deformity and were kept on follow up. Total count, ESR and CRP were monitored in every two weeks and found to have normalized in average on 1 month in all these patients. All of the patients had complete pain relief and returned to their previous state of work within three months.

Discussion

Pyogenic vertebral osteomyelitis refers to bacterial infections of the spine that cause purulence and a predominantly neutrophilic response.[40] It encompasses a spectrum of pathological conditions, including discitis, spondylitis, and spondylodiscitis.[15] Establishing the diagnosis of cervical osteomyelitis in a timely fashion is critical to prevent catastrophic neurological injury. Improvements in surgical and radiological techniques and the discovery of antimicrobial therapy have transformed the outlook for patients with this condition, but morbidity remains significant.

Historical background

Infection of the spine is an ancient disease and was described in human skeletons dating back to the Iron Age.[41] Hippocrates was the first to describe osteomyelitis of the spine in 400 BC.[7]. In 1864 Boudof described draining an abscess of the cervical spine via an anterior approach. The first account of pyogenic vertebral osteomyelitis is credited to the French physician Lannelongue in 1879. The first large series of pyogenic vertebral infections in the English literature was published by Kulowski in 1936.[21]

Epidemiology

Data from developing countries is not available but the incidence of vertebral osteomyelitis in developed countries ranges from 4 to 24 per million per year.[14,17] Vertebral osteomyelitis accounts for approximately 1 to 7% of all bone infections[37] The cervical region is affected in 3 to 10% of spinal infections.[15, 37, 39] There is an increasing incidence of spinal infections in recent years, due to better diagnostic modalities available, the increasing prevalence of elderly and immune-compromised individuals in the population, like patients with diabetes, a history of intravenous drug abuse, chronic immunosuppression, or human immunodeficiency virus. A bimodal age distribution is observed with peaks at less than 20 years and between 50 to 70 years, though all ages can be affected.[6,20] The male to female ratio is of 1.5– 2:1.[14,27]

Pathogenesis

The disc is avascular and the intraosseous anastomoses involute by the third decade of life, effectively creating end arteries. Thus a septic embolus results in a large infarct. The subsequent spread of infection to the neighbouring disc and vertebra creates the characteristic lesion of spondylodiscitis: wedging, cavitation and compression fractures with resulting spinal instability, deformity and risk of cord compression. Uncontrolled infection can breach the bone and track into surrounding soft tissues, causing paravertebral or psoas abscesses, and spread posteriorly into the spinal canal, forming an epidural abscess[35,43]

The cervical spine is particularly susceptible to infection that spreads from adjacent tissues, or that occurs

from contamination after invasive diagnostic or therapeutic procedures. For example, osteomyelitis of the cervical spine has been reported to occur after tracheotomy[29], Pharyngeal surgery (Ell SR1992), Cervical discography [47], Tonsillectomy[4], Zenker diverticulum [12], Cervical spine trauma.[38]

The mode of spread is mainly haematogenous through arterial and venous plexus affecting mainly lumber and thoracic spines and rarely the cervical region and multifocal involvement in 4% of cases.[27] Vertebral osteomyelitis typically begins with hematogenous metastasis of microbial organisms to the richly vascularized vertebral metaphysis. Pyogenic osteomyelitis of the posterior elements of the vertebrae (pedicles, transverse processes, laminae and posterior spinous processes) is very rarely encountered in haematogenous infections due to their relatively poor blood supply compared with the vertebral body. Posterior involvement is more common with tuberculous and fungal spondylitis.[13]

Other routes include direct inoculation after spinal instrumentation, and less commonly, contiguous spread from the adjacent muscle to the disc.[22, 37] A distant focus of infection has been identified in almost half of cases of spondylodiscitis.[27] The common routes are the genitourinary tract (17%), skin and soft tissue (11%), intravascular devices (5%), gastrointestinal tract (5%), respiratory tract (2%), the oral cavity (2%), infective endocarditis (12%). Case of postoperative spondylodiscitis has been described.[3,8]

The causative organisms are mainly three types: pyogenic, granulomatous (tuberculous, brucellar, fungal), parasitic (Echinococcus infection) and fungal (0.5%–1.6%) (Aspergillum, Actinomyces odontolycus and Neisseria perflave**.** Among the pyogenic, Staphylococcus, aureus is the predominant pathogen, accounting for about half of non-tuberculous cases. Other organisms are Streptococcus, Pyocyanic bacillus, Escherichia coli, Capnocytophaga, Propionibacterium acnes, etc. Poly-microbial infections are uncommon (10%) and spread from contiguous spread.[15]

Clinical features

For clinical diagnosis, a high index of suspicion is needed especially for intravenous drug abusers, immune-compromised patients, patients in chronic renal failure, etc. Initially the presentation is vague and non-specific which is responsible for its delayed diagnosis and the subsequent treatment.[7]

The most common symptom is spinal tenderness, back or neck pain and restricted range of movement and paravertebral muscle spasm which is present in almost 85% of cases.[10, 44] Pain that is insidious onset and aggravating at night raises a strong suspicion of this problem. In some cases, the pain can lead to severe spasm, causing torticollis.[37] Dysphagia, spinal deformities, predominantly kyphosis and gibbus formation, fluctuant swelling could be present in 15 to 20% of cases.[30,37] Fever is presentin about 14 to 50% and may be absent early in the course of the illness.[37] A few can progress to florid sepsis especially in those with severe infection or immune-compromised.[40]

Of all the cases of osteomyelitis of spine, only a third of these cases present with neurological deficit.[27] However, the incidence is as high as 60% with cervical involvement.[37,40] The incidence is higher in cases with Staphylococcus. aureus infection, diabetes mellitus, rheumatoid arthritis, systemic steroid therapy, and age older than 50 years.[32] The development of neurological deficits can correlate with the rate of progression of infection. However in slowly progressive pathology like chronic infection, symptoms may appear late. The deficits can range from cervical radiculopathy to complete quadriplegia.[37]

Diagnosis

Diagnosis is the collective results of clinical, laboratory and radiological findings. Many infections (including postoperative ones) are indolent and the symptoms, physical signs and radiographic features can be subtle. Diagnosis is difficult and often delayed or missed due to the rarity of the disease, the insidious onset of symptoms and the high frequency of neck pain in the general population.

Laboratory features

Laboratory markers of systemic infections are WBC count, ESR, and CRP level in the initial screening of patients suspected of having a spinal infection, especially when initial neuroimaging studies are non-diagnostic.[40]

Erythrocyte sedimentation rate (ESR) is a sensitive marker but lacks specificity. The ESR is elevated in 70 to 100% of these cases with mean values ranging from 43 mm/h to 87 mm/h.[15,19] No relation has been found to the severity of the infection or patient's age.[1] Fall in ESR to below 25% of the presenting value was a good prognostic marker and an unchanged or rising ESR was more difficult to interpret and it is suggested to evaluate this marker in conjunction with other parameters.

C-reactive protein (CRP) is raied in a large majority of cases with spondylo-discitis. CRP had returned to normal in all survivors at 3 months follow-up.[46] It is a more sensitive indicator of spinal infection than the leukocyte count. Both the ESR and CRP level may be useful in evaluating response to treatment as well.[18] Total leucocyte count is the least useful amongst all the inflammatory markers. It is high in only a third to half of affected patients.

The single most important diagnostic tool for pyogenic vertebral osteomyelitis is tissue sampling. Diagnosis, however, can be firmly established without direct biopsy sampling in patients with positive blood cultures. Thus a pre-biopsy blood cultures can give diagnosis as well as the pathogen and the choice of the sensitive antibiotics. However it is positive in only 20 to 60% of cases. [8, 22, 28] Molecular diagnostic methods are not commonly used but the usually done is 16S rDNA PCR.[16, 11]

Radiology

The diagnosis of cervical osteomyelitis is first established on neuro-images and later confirmed with tissue samples to determine the causative organism.[37] X-ray spine is more of a screening test. A proper plain X-ray has sensitivity of 82%, specificity of 57% and accuracy of 73%. It is normal in the initial two to four weeks of spondylitis.[7,40] In three weeks, there may be a decrease in the disc space, loss of definition of the endplate with endplate destruction, subchondral radiolucency and loss of disc height. Later changes include destruction of the opposite endplate, loss of vertebral height and paravertebral soft tissue mass. Weeks after the onset of infection, it can show other changes such as paravertebral soft-tissue edema, disc height loss, and eventually vertebral collapse and kyphotic deformity.[23]

Computed tomography (CT) is the best modality at delineating bony abnormalities early, including early endplate destruction (before they become visible on X-ray). Contrast-enhanced CT scans can reveal paravertebral soft-tissue inflammation, enhancing epidural collections, and intra-discal and intra-vertebral abscesses. The CT-guided percutaneous aspiration of an infected spinal segment or fluid collection provides tissue for identification of a causative organism. CT myelography is useful in demonstrating spinal cord compression from an epidural abscess when MR imaging cannot be performed.[7,9,37,40]

MRI

Magnetic resonance imaging with and without Gadollinium contrast is the gold standard in the diagnosis of cervical osteomyelitis and has facilitated the diagnosis of cervical osteomyelitis, even before the onset of neurological signs or symptoms. It has 96% sensitivity, 93% specificity, and 94% accuracy in detecting vertebral osteomyelitis.[7, 10, 26]

Radionuclide imaging helps in identifying the problems in difficult cases. However these modalities are not widely available and are not routinely performed. Technetium-99m–methylene diphosphonate bone scintigraphy has sensitivity of 90% and specificity of 78%. The Gallium-67 scintigraphy scans are more specific because Gallium binds to iron-binding proteins at the site of inflammation. [31] It is a valuable adjunct to bone scan. When Technetium-99m–methylene diphosphonate bone and Gallium-67 scintigraphies are combined, they have a sensitivity of 90%, a specificity of 100% and accuracy of 94%. Indium-111-leucocyte count is not recommended due to poor sensitivity for spondylodiscitis lesions often displaying non-specific photopenic regions. Fluorine-18 fluorodeoxyglucose positron emission tomography (FDG-PET) is showing promise as a very sensitive modality.

Treatment

After establishing the diagnosis of cervical osteomyelitis in a timely fashion it is critical to prevent catastrophic neurological injury.[25, 7] Treatment aims to eradicate the infection, restore and preserve the structure and function of the spine, and alleviate pain.

Nonsurgical therapy

Is appropriate if there are no neurological signs or symptoms, instability, deformity, or spinal cord compression. With appropriate antimicrobial therapy, mortality has dropped from 56% to less than 5%. Positive blood cultures, presence of neurological abnormalities and staphylococcal infections (compared with negative microbiology) were associated with longer intravenous courses.[22, 45]

Outpatient parenteral antimicrobial therapy (OPAT) has been has been used successfully and very cost effectively in some cases of osteomyelitis presenting early with subtle signs and symptoms.[36] The antibiotics should have high bioavailability and possible options include fluoroquinolones, clindamycin, rifampicin and fusidic acid.[32,42,48]

It has been proposed that a weekly decrease in CRP by 50% represents adequate progress.[22] Criteria for discontinuation of antimicrobial treatment include symptom resolution or improvement and the normalization of ESR or CRP.[25, 22]

Non-pharmacological treatments besides antibiotics include physiotherapy and also immobilization when pain is significant or there is a risk of spinal instability. [34]

Surgical treatment

Failure of conservative management, presence of intractable pain, epidural abscess even in the absence of neurological deficits, more advanced disease with spinal instability, cord compression, repeated negative result of percutaneous biopsy and neurological deficits required surgical decompression and stabilization.[2,5] Compression of neural elements, spinal instability due to extensive bony destruction, severe kyphosis, Spinal cord compression is a surgical emergency.

Despite advancements in diagnosis, disagreement remains regarding appropriate surgical treatment. Surgical decompression, debridement, stabilization, and deformity correction are the goals once the decision to perform surgery has been made. The later instruments of titanium can be used for fixation even in presence of infection. [33]

Among the minimally invasive techniques, a percutaneous disco-vertebral biopsy is a safe and minimally invasive intervention performed under fluoroscopic or CT guidance to obtain a biopsy specimen.

The current surgical options include anterior or posterior decompression with or without fusion, and with or without instrumentation.[24] The use of bone graft and instrumentation for internal fixation, particularly in the setting of an already infected spine, raises the concern of secondary infection from these devices.

Outcome

Patients with cervical disco-vertebral osteomyelitis with incomplete neurological deficits often recover normal function after prompt surgical decompression [37] under cover of appropriate and adequate antibiotics. Neuroimaging evidence of successful treatment lags significantly behind clinical response and is not useful in determining response to treatment. Prognosis is worse in presence of advanced age, complete neurological deficit, a delay in diagnosis, treatment duration of greater than 2 months, if the infection is hospital acquired, presenting with sepsis, significant spinal cord compression, slow rate of decrease in ESR, low immune state, virulence of the infecting organism (*S. aureus* being particularly virulent), etc.[40,25] In 75% of relapse cases, it occurs within the first year (McHenry MC 2002). They are associated with recurrent bacteraemia, the presence of a chronically draining sinus and paravertebral abscess. They present with recurrent pain, unexplained fever, bacteraemia, weight loss or rising ESR. The mortality ranges from 0 to 11%. [31, 44]

Conclusion

Improvements in diagnostic modalities, management strategies including better surgical techniques and the discovery of better antimicrobial therapy have greatly transformed the outlook for patients with infected disco-vertebral spondylitis. Though it was thought to be rare, its incidence is rising, due to an increasingly susceptible population and the availability of more effective diagnostic tools. A high index of suspicion is needed for prompt diagnosis to ensure improved long-term outcomes. A microbiological diagnosis is essential to enable appropriate choice of therapeutic agents. If diagnosed early, i.e. before the appearance of neurological deficit or severe pain, the problem can be managed non-surgically with appropriate antibiotics and immobilization. Surgery has an important role in alleviating pain, correcting deformities and neural compromise and restoring function. Thus with its definitive indications, surgery prevents and improves morbidity and mortality. Randomized trials are needed to assess the optimal treatment duration, route of administration and the role of combination therapy and newer agents.

Reference

1. Belzunegui J, Intxausti JJ, De Dios JR et al. Haematogenous vertebral osteomyelitis in the elderly. **Clin Rheumatol 19:** 344–347, 2000
2. Chen WH, Jiang LS, Dai LY. Surgical treatment of pyogenic vertebral osteomyelitis with spinal instrumentation. **Eur Spine J 16:** 1307–1316, 2007
3. Colmenero JD, Jimenez-Mejias ME, Reguera JM, et al. Tuberculous vertebral osteomyelitis in the new millennium: still a diagnostic and therapeutic challenge. **Eur J Clin Microbiol Infect Dis 23:**477–483, 2004
4. Cyna AM, Bell KR, Flood LM. Cervical osteomyelitis following tonsillectomy. **Anaesthesia 52:**1084–1087, 1997
5. Darouiche RO. Spinal epidural abscess. **N Engl J Med 355:** 2012–2020, 2006
6. Digby JM, Kersley JB. Pyogenic non-tuberculous spinal infection: an analysis of thirty cases. **J Bone Joint Surg Br 61:**47–55, 1979
7. Dimar JR, Carreon LY, Glassman SD, et al: Treatment of pyogenicvertebral osteomyelitis with anterior debridement and fusion followed by delayed posterior spinal fusion. **Spine 29:**326–332, 2004
8. Dufour V, Feydy A, Rillardon L et al. Comparative study of postoperative and spontaneous pyogenic spondylodiscitis. **Semin Arthritis Rheum 34:**766–771, 2005
9. Enoch DA, Cargill JS, Laing R et al. Value of CT-guided biopsy in the diagnosis of septic discitis. **J Clin Pathol 61:**750–753, 2008
10. Euba G, Narvaez JA, Nolla JM et al. Long-term clinical and radiological magnetic resonance imaging outcome of abscess-associated spontaneous pyogenic vertebral osteomyelitis under conservative management. **Semin Arthritis Rheum 38:**28–40, 2008
11. Fenollar F, Levy PY, Raoult D. Usefulness of broad-range PCR for the diagnosis of osteoarticular infections. **Curr Opin Rheumatol 20:**463–4670,

2008

12. Frot-Martin B, Carlier RY, Morand-Blot V, et al: Zenker's diverticulum associated with multilevel cervical osteomyelitis. **Spine 26:**E193–E197, 2001
13. Govender S, Mutasa E, Parbhoo AH. Cryptococcal osteomyelitis of the spine. **J Bone Joint Surg Br 81:**459–461, 1999
14. Grammatico L, Baron S, Rusch E, et al. Epidemiology of vertebral osteomyelitis (VO) in France: analysis of hospital-discharge data 2002–2003. **Epidemiol Infect 136:**653–660, 2008
15. Hadjipavlou AG, Mader JT, Necessary JT, et al. Hematogenous pyogenic spinal infections and their surgical management. **Spine 25:**1668–1679, 2000
16. Harris KA, Hartley JC. Development of broad-range 16S rDNA PCR for use in the routine diagnostic clinical microbiology service. **J Med Microbiol 52:**685–691, 2003
17. Hopkinson N, Stevenson J, Benjamin S. A case ascertainment study of septic discitis: clinical, microbiological and radiological features. **International Journal of Medicine 94:**465–470, 2001
18. Hsieh PC, Wienecke RJ, O'Shaughnessy BA et al. Surgical strategies for vertebral osteomyelitis and epidural abscess. **Neurosurg Focus 17:** E4, 2004
19. Jensen AG, Espersen F, Skinhoj P, et al. Increasing frequency of vertebral osteomyelitis following Staphylococcus aureus bacteraemia in Denmark 1980–1990. **J Infect 34:**113–118, 1997
20. Krogsgaard MR, Wagn P, Bengtsson J. Epidemiology of acute vertebral osteomyelitis in Denmark: 137 cases in Denmark 1978–1982, compared to cases reported to the National Patient Register 1991–1993. **Acta Orthop Scand 69:**513–517, 1998
21. Kulowski J. Pyogenic osteomyelitis of the spine: an analysis and discussion of 102 cases. **J Bone Joint Surg Am 18:**343–364, 1936
22. Legrand E, Flipo RM, Guggenbuhl P et al. Management of nontuberculous infectious discitis. Treatments used in 110 patients admitted to 12 teaching hospitals in France. **Joint Bone Spine 68:**504–509, 2001
23. Li Yee Wan. A case of cervical tuberculous spondylitis: an uncommon cause of neck pain. **Hong Kong j.emerg.med 14:**103-106, 2007
24. Matsui H, Hirano N, Sakaguchi Y. Vertebral osteomyelitis: an analysis of 38 surgically treated cases. **Eur Spine J 7:**50–54, 1998
25. McHenry MC, Easley KA, Locker GA. Vertebral osteomyelitis: long-term outcome for 253 patients from 7 Clevelandarea hospitals. **Clin Infect Dis 34:**1342–1350, 2002
26. Modic MT, Feiglin DH, Piraino DW et al. Vertebral osteomyelitis: assessment using MR. **Radiology 157:**157–166, 1985
27. Mylona E, Samarkos M, Kakalou E et al. Pyogenic vertebral osteomyelitis: a systematic review of clinical characteristics. **Semin Arthritis Rheum 39:** 10–17, 2009
28. Nather A, David V, Hee HT et al. Pyogenic vertebral osteomyelitis: a review of 14 cases. **J Orthop Surg (Hong Kong) 13:** 240–244, 2005
29. Newlands SD, Makielski KH. Cervical osteomyelitis after percutaneous transtracheal ventilation and tracheotomy. **Head Neck 18:**295–298, 1996
30. Nolla JM, Ariza J, Gomez-Vaquero C et al. Spontaneous pyogenic vertebral osteomyelitis in nondrug users. **Semin Arthritis Rheum 31:** 271–278, 2002
31. Nolla-Sole JM, Mateo-Soria L, Rozadilla-Sacanell A, et al. Role of technetium-99m diphosphonate and gallium-67 citrate bone scanning in the early diagnosis of infectious spondylodiscitis. A comparative study. **Ann Rheum Dis 51:**665–667, 1992
32. Pigrau C, Almirante B, Flores X et al. Spontaneous pyogenic vertebral osteomyelitis and endocarditis: incidence, risk factors, and outcome. **Am J Med 118:**1287, 2005
33. Przybylski GJ, Sharan AD. Single-stage autogenous bone grafting and internal fixation in the surgical management of pyogenic discitis and vertebral osteomyelitis. **J Neurosurg (Spine) 94:**1–7, 2001
34. Quinones-Hinojosa A, Jun P, Jacobs R et al. General principles in the medical and surgical management of spinal infections: a multidisciplinary approach. **Neurosurg Focus 17:** E, 2004
35. Ratcliffe JF. Anatomic basis for the pathogenesis and radiologic features of vertebral osteomyelitis and its differentiation from childhood discitis. A microarteriographic investigation. **Acta Radiol Diagn (Stockh) 26:**137–143, 1985
36. Roblot F, Besnier JM, Juhel L et al. Optimal duration of antibiotic therapy in vertebral osteomyelitis. **Semin Arthritis Rheum 36:**269–277, 2007
37. Schimmer RC, Jeanneret C, Nunley PD, et al. Osteomyelitis of the cervical spine: a potentially dramatic disease. **J Spinal Disord Tech 15:**110–117, 2002
38. Sidiropoulos P, Piperos G, et al. Spinal epidural abscess complicated closed vertebral fracture. A case report and review of literature. **Spine 18:**671–674, 1993
39. Spies EH, Stucker R, Reichelt A. Conservative

management of pyogenic osteomyelitis of the occipitocervical junction. **Spine 24:**818–822, 1999

40. Tandon N, Vollmer DG: Infections of the spine and spinal cord, in Winn HR (ed): Youmans Neurological Surgery, ed 5. Philadelphia: Saunders, (4), 4363–4394, 2004
41. Tayles N, Buckley HR. Leprosy and tuberculosis in Iron Age Southeast Asia? **Am J Phys Anthropol 125:**239–256, 2004
42. Tice AD, Hoaglund PA, Shoultz DA. Outcomes of osteomyelitis among patients treated with outpatient parenteral antimicrobial therapy. **Am J Med 114:**723–728, 2003
43. Wiley AM, Trueta J. The vascular anatomy of the spine and its relationship to pyogenic vertebral osteomyelitis. **J Bone Joint Surg Br 41-B:**796–809, 1959
44. Wirtz DC, Genius I, Wildberger JE et al. Diagnostic and therapeutic management of lumbar and thoracic spondylodiscitis—an evaluation of 59 cases. **Arch Orthop Trauma Surg 120:**245–251, 2000
45. Woertgen C, Rothoerl RD, Englert C, et al. Pyogenic spinal infections and outcome according to the 36-item short form health survey. **J Neurosurg Spine 4:**441–446, 2006
46. Zarrouk V, Feydy A, Salles F, et al. Imaging does not predict the clinical outcome of bacterial vertebral osteomyelitis. **Rheumatology (Oxford) 46:**292–295, 2007
47. Zeidman SM, Thompson K, Ducker TB. Complications of cervical discography: analysis of 4400 diagnostic disc injections. **Neurosurgery 37:**414–417, 1995
48. Zeller V, Desplaces N. Antibiotherapy of bone and joint infections. **Rev Rhum 73:**183–190, 2006