Antibiotic and hyperbaric oxygen therapy in the management of post-operative discitis.

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OBJECTIVE: Despite the use of antibiotics, the management of postoperative discitis (POD) still presents a challenge. This study was designed to evaluate the effect of adjuvant hyperbaric oxygen (HBO₂) therapy on the duration of antibiotic treatment. METHODS: Between 1999 and 2004, 22 patients diagnosed with POD were treated with antibiotic and HBO₂ therapy. There were 14 male (63.6 %) and 8 female (36.3 %) patients, and their mean age at the time of surgery was 45.4 years (range, 20-59 years). Diagnosis of a POD was established on the basis of clinical, laboratory, and radiographic findings. All patients were given a 4-week course of vancomycin (1g IV every 12 h). Additionally, patients received HBO₂ (100% O₂ at 2.4 ATA for 90 min) twice daily for the initial five consecutive days, and an additional treatment (100% O₂ at 2.4 ATA for 90 min daily) was given for 25 days. The duration of follow-up was 24 months. RESULTS: This treatment modality allowed infection control and healing for all 22 patients with 0% recurrence rate. HBO₂ treatment was tolerated well. CONCLUSION: This series represents the first reported group of POD patients treated with antibiotic and HBO₂ therapy. Our preliminary results indicate that the length of time on antibiotic therapy can be shortened with the use of HBO₂ as an adjunctive treatment. Erythrocyte sedimentation rates and serum C-reactive protein levels returned to the preoperative levels earlier (within 8-30 days after the initiation of treatment) and a reasonable length of immobility was obtained (mean 12.2 days). After completion of the one-month period of antibiotic and HBO₂ therapy, patients were accepted disease-free regarding pain and mobility.

INTRODUCTION

Postoperative discitis (POD) was first described as a clinical entity by Turnbull in 1953 (1). Since that time it has been shown to be an uncommon but one of the most disabling causes of failed back surgery or might be accepted as a late complication of spinal surgery (2-9). It has also been reported after minimally invasive spinal procedure such as discography, chemonucleolysis, and myelography (10-12). According to the literature, the incidence of postprocedural discitis after any type of spinal procedure ranges from 0% to 4.0% (2-8,11,13-21). POD may lead to long-lasting and sometimes permanent morbidity (3,6-9). Despite the use of antibiotics, the management of POD still presents a challenging problem (2,4-6,8,9,22). The current mainstay for discitis treatment is a combination of bed rest and prolonged administration of antibiotics; surgical intervention is rarely necessary in patients failing conservative treatment (4,7,17,19,20,23). Although the duration of medical therapy is variable, six weeks of intravenous antibiotics followed by an additional 6 weeks of oral antibiotics is a course commonly administered
However, the period of strict bed rest and antibiotic treatment can last up to several months, and this might lead to undesired dramatic medical and psychosocial consequences (3-8,13). Hyperbaric oxygen (HBO₂) therapy, that is the administration of 100% oxygen at pressures greater than atmospheric pressure, has become a recognized treatment for a number of disorders such as gas gangrene, severe necrotizing soft tissue infections, and chronic refractory osteomyelitis (28-32). HBO₂ therapy has also been shown to have a beneficial effect in the management of a variety of surgical infections including postoperative neurosurgical infectious complications (32-37). On the basis of considerations similar to the rationale for the use of HBO₂ therapy to treat these disorders, we think that it may be worthwhile to try a combination of HBO₂ and antibiotic therapy in the management of POD.

PATIENTS AND METHODS

Between September 1999 and August 2004, 809 patients underwent microsurgical discectomy because of herniated lumbar discs at the Neurosurgical Department of GATA Haydarpaşa Training Hospital. All patients had preoperative radiating leg pain refractory to conservative therapy. All surgical procedures were performed via a standard midline microsurgical approach. Prophylactic antibiotic therapy (intravenous cefuroxime, a second-generation cephalosporin) was administered preoperatively (just before induction of anesthesia), and postoperatively (every 12 hours for the first 24 hours). Immediate postoperative course of all of the patients was uneventful in the first 24-48 hours till their discharge. During the study period of 5 years, 22 patients developed POD, accounting for an incidence rate of 2.7%. Fourteen patients (63.6%) were male and eight (36.3%) were female. The mean age of 22 patients at the time of surgery was 45.4 years (range, 20-59 years). Characteristics of these 22 patients are summarized in Table 1, see page 436. Informed consent of each patient was obtained before enrolling them in the study. Upon admission of the patients with symptoms of discitis such as progressive back pain, restriction of back motion, they were hospitalized for further evaluation. In addition to the neurological examinations including bed-shaking test, routine laboratory evaluation with complete blood count, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), blood cultures, and urine analysis were performed. Initially, plain radiographs including flexion and extension views (in nine patients could not be obtained because of severe pain), and then MR images (before and after i.v. contrast administration) and CT scans (when necessary) were obtained to rule out other causes of postoperative pain, such as recurrent or residual disk herniations, lateral recess stenosis syndrome, epidural abscess, scar tissue formation, postoperative segmental instability. The diagnosis of discitis was established when all three of the following criteria were present: 1) clinical symptoms and signs: recurrent low back pain, decreased back motion, paravertebral muscle spasm, and positive bed-shaking test (pain can be aggravated by shaking the bed back and forth); 2) laboratory findings of elevated ESR, and CRP values; 3) MR imaging findings compatible with discitis: decreased signal intensity on T1-weighted images, increased signal intensity on T2-weighted images in both the disc space and adjacent vertebral bodies, and enhancement of the same areas with gadolinium (4,17,20,25,27,38,39,40). The following clinical and paraclinical data were also collected: 1) demographic characteristics (age, sex); 2) time (days) between the operation and the onset
of symptoms, type of pain, and inflammatory signs in the spine (local erythema, swelling and/or heat), fever (>38°C), white blood cell count, blood cultures; 3) patient-related risk factors of chronic underlying diseases (e.g., diabetes mellitus, steroidal, or nonsteroidal anti-inflammatory therapy, chronic renal failure, chronic respiratory failure, heart failure, chronic alcoholism, intravenous drug use, previous bacteremia or focal infections). According to the findings obtained from neurological examinations performed at admission, the patients were graded as follows: patients able to stand up and walk without assistance (Grade I), patients able to stand up and walk with assistance despite pain (Grade II), and the patients unable to stand up and walk because of severe pain (Grade III). A visual analog scale (VAS) was also used for assessing the patient’s pain levels.

All patients were treated with vancomycin 1g IV every 12 h for a 4 wk course, analgesics, and bed rest. The antibiotic therapy was planned to be changed according to the results of blood cultures. Additionally, in accordance with our protocol, patients received HBO₂ (100% O₂ at 2.4 ATA for 90 min) twice daily for the initial five consecutive days, and then an additional treatment (100% O₂ at 2.4 ATA for 90 min daily) was given for 25 days (Figure 1). The patients were mobilised in lumbo-sacral corsets when she or he was comfortable. The efficacy of treatment was followed by serial detection of laboratory markers and clinical examinations. WBC count, ESR and CRP levels were determined every 2 days for the first week, and thereafter twice a week for the duration of therapy. Invasive procedures for identification of pathogens responsible for discitis were reserved for patients with persistent clinical findings, presence of increasing course or consistently elevated ESR and CRP values without any down-ward progression. At the end of the treatment, neurological examinations and sequential ESR and CRP levels were performed monthly for the first three months and then once in three months time for the rest of the first year. Likewise, we obtained the first follow-up MR images at the end of the treatment, and regular follow-up MRI studies were planned to be performed till the detection of complete resolution of the MRI findings of discitis with the frequency of 3-month intervals for the first year and then 6-month interval fort the second year. Although follow-up MR images might reveal normal signal intensity, conventional AP/L, and dynamic radiographs were obtained every 6 months for two years. At the final examination when MR images revealed complete resolution of discitis findings, current clinical outcome was graded as ‘excellent’, ‘good’, ‘no change’, or ‘poor’. The result was defined as excellent when return to full activity without any symptoms was confirmed. A good outcome was assigned if lumbar pain of low intensity was periodically present but did not alter the daily activity of the patient, who remained in the same employment as before the operation, no change when no noticeable change was observed in the symptoms before and after treatment and poor when the symptoms were worse after treatment.

Fig. 1. Multiplace hyperbaric chamber; 100% oxygen given by hood at 2.4 ATA.
RESULTS

All patients who were enrolled in the study had received a clinical diagnosis of a POD, on the basis of clinical, laboratory, and radiographic findings. The surgical procedure and the postoperative course of all the patients were uneventful. They had experienced good relief of symptoms immediately after surgery (up to in a week’s time). The mean interval between surgery and onset of POD symptoms was 21.3 days (range 4-77 days. Most of the patients (n=18, 81.8%) became symptomatic within 4 weeks after surgery. There were only five patients who presented discitis symptomatology in the first week and three of them were diabetic. All patients had moderate to severe back pain. Nine patients (40.9%) rated their pain 10 over 10 on the VAS. The mean VAS was 8.8. On admission, 6 patients (27.2%) were able to stand up and walk without assistance (Grade I), 7 patients (31.8%) were able to stand up and walk with assistance (Grade II), and 9 patients (40.9%) were unable to stand up and walk because of severe pain (Grade III). The pain was described as continuous and deep-seated and was frequently associated with morning stiffness (86.3%). It was accompanied by severe paravertebral muscle spasm in 17 cases (77.2%), and was radiating into the buttocks, thighs, groin, perineum or the abdomen. Typically, it was easily exacerbated by any motion, or attempts at examination. It was noteworthy that, bed-shaking test was positive in all patients, regardless of their clinical grade. Neurological examination revealed that none of these patients had neurological deterioration comparing with the preoperative findings. Straight leg raising tests were positive at small angles and it could not even be tested in most of the Grade III patients. The surgical skin incision appeared to heal uneventfully in all patients. Local erythema, swelling, or a draining sinus were not seen. Fever (to as high as 38°C) was present in only 54.5 per cent of the patients. ESR and CRP values were increased in all patients. The highest ESR ranged between 42-110 mm/hour (mean, 67 mm/hour), and the highest CRP values ranged between 15-125 mg/L (mean, 41 mg/L). 7 of 22 patients had WBC counts above 10,000/mm³.

Initially obtained plain radiographs showed little evidence of intervertebral discitis. There was some decrease in disc height (however this frequently accompanies discectomies). In contrast, the characteristic MRI findings of discitis in the acute stages were found in all of the patients. The involved intervertebral disc space and adjacent vertebral bodies were visualized as a region of low signal intensity on T1-weighted images and high signal intensity on T2-weighted images. The addition of intravenously administered gadopentate dimeglumine gadolinium resulted in homogeneous enhancement of the same areas. The intervertebral disc spaces were narrowed in all patients. Vertebral edema was also present in 100% of patients. This was particularly important in differential diagnosis of the patients who had the diagnosis of discitis in the first week after surgery, because, in the early postoperative setting, the absence of vertebral edema has strong negative predictive value for infectious discitis (64).

During their treatment, none of the patients suffered neurological deterioration. In the majority of the patients (n=19, 86.3%), elevated ESR/CRP values returned to the preoperative baseline values within 8 to 30 days (mean 21 days) after initiation of the treatment. In the remaining 3 patients, 1 more month was needed for ESR/CRP values to come to baseline values. They remained at bed rest until they were comfortable. They were mobilized in lumbosacral corsets, in which they remained for an additional 4 weeks. The overall mean time of immobilization was 12.2 days (4-22 days). It was 19.6 days (17-22 days), 9.4 days (7-13 days).
days), and 4.5 days (4-6 days) in Grade III, II, and I patients respectively.

Blood cultures were positive in only 36% of patients. The organisms from these cultures included methicillin-sensitive *Staphylococcus aureus* in 5 cases, methicillin-resistant *S. aureus* in 2, and *S. Epidermidis* in 1. Because of the clinical improvement and the presence of a downward trend of the ESR, CRP values, needle biopsy for confirmation of the diagnosis and adjustment of the antibiotic therapy according to the results of culture and sensitivity studies were not required for any patient in this series. Although, clinical and laboratory findings of rapidly resolving infection were determined after only 25 HBO2 sessions in two patients, treatment was not discontinued early because of our protocol. HBO2 treatment was tolerated well. In the entire series of 22 patients managed with this protocol, no signs of cerebral oxygen toxicity were observed nor were other adverse effects of pressurization seen.

After completion of the one-month period of antibiotic and HBO2 therapy, all the patients were discharged in satisfactory condition regarding pain and mobility. The mean VAS at discharge was 2.2. While 7 patients were entirely free of back pain, the other 15 patients had pain levels between 1 and 4 on the VAS.

MR images performed after completion of the treatment and sequential MRI’s performed in the follow-up period showed progressive increase in signal intensity within the disc and adjacent vertebral body marrow on T1-weighted images and decrease in signal intensity in the same areas on T2-weighted images. However, radiological decline of inflammatory symptoms appeared to come after the improvement of clinical and laboratory findings (Figure 2 A,B,C,D,E,F,G, see page 436). Normalization of T1 and T2 signal pattern of disc, adjacent vertebral bodies and paravertebral soft tissue were discernable on MR images obtained about 9-12 months (15 patients after 12 months, 7 patients after 9 months) after treatment (Figure 3 A,B,C,D,E,F,G) see page 437. Plain radiographs obtained at the end of the two-year follow-up period, revealed a complete spontaneous interbody fusion in only three patients (13.6%). There have been no recurrences in this follow-up period, and none of the patients required surgery for debridement of the infected disc space, decompression of neural elements or spinal instability. At their last follow-up visit, according to the study criteria, fourteen patients (63.6%) were graded as excellent, 8 (36.3%) as good. There were no patients graded as no change or as poor.

In all patients, predisposing factors were also searched. The main predisposing factor was diabetes mellitus. Five patients (22.7%) were diabetic. Other risk factors consisted of chronic alcoholism (n=1, 4.5%), long-term steroid administration (n=1, 4.5%), smoking (n=2, 9.0%, one of them was also diabetic), and another one (n=1, 4.5%) had a body mass index greater than 30kg/m². The remaining fourteen patients (63.6%) did not bear any predisposing factors. None of the patients beared middle ear barotraumas. See Table 2 page 438.

**DISCUSSION**

POD is considered a severe complication of lumbar disc surgery. Although it is controversial whether discitis can be caused by an aseptic or infectious process, recent data suggest that POD is almost always bacterial (2,3,7,10,11,14,17,19,21,41). The majority of spine surgeons think that it results from direct inoculation of an offending pathogen into the avascular disc space (8,9,11,21,23,25,42). In all reported series, the clinical manifestations of postoperative disc space infection have followed a very similar pattern (7,8,23,25). The usual clinical scenario includes severe recurrent back pain after the initial relief of symptoms,
but the duration of the postoperative pain relief period is variable ranging between a few days to 10 weeks after surgery (2,5-9,13,19,20,23,25). In the present study, the mean interval between surgery and the onset of POD symptoms onset was 21.3 days (range 4-77 days). There may be a delay in diagnosis because reappearance of spinal pain after surgery may be attributed to recurring disc herniation, unsatisfactory performance and/or outcome of surgery, or psychoneurotic disorders (4,7,18,23,38). The pain, most common presenting symptom in every series is usually out of proportion to the clinical signs, and the physical examination is generally remarkable. The relative paucity of physical findings in the face of the extreme pain suffered by the patient may lead to misdiagnosis of conversion disorders, and may also lead to delay in accurate diagnosis in this patient population (7,18,23). However, exacerbation by virtually any motion of the spine including jarring of the bed is one of the most important characteristics of this pain. In our series, not surprisingly, back pain was the most common presenting symptom, and bed-shaking test was positive in all 22 patients whereas it was negative in the follow-up evaluations of the rest of 809 patients who underwent uncomplicated disc surgery. Therefore, we think that the presence of positive bed-shaking test should raise the suspicion of discitis.

The early and accurate diagnosis frequently depends on a combination of clinical, laboratory and imaging findings. The diagnosis is strongly suggested by a persistently elevated ESR, CRP values, and by typical changes on MRI (3,4,7,8,13,20,23,34,38,40). Although elevation of the ESR and CRP is almost uniformly present in discitis, they are supportive but not confirmatory of the diagnosis. A raised ESR and CRP values secondary to the operation or underlying disease may be confusing (2,14,16,18,20,38). Additionally, the elevation may be masked in patients taking corticosteroids (7,15,26). However, they are very useful parameters for following the course of POD and also for following the response to therapy (3,7,8,20,23,38,42,43). In the current series of patients, all of them have an associated elevation of the ESR, and CRP level at time of diagnosis. During the course of antibiotic and HBO₂ treatment, all patients have a steady decline, and the values returned to preoperative baseline values within 8 to 30 days (mean 21 days). The decline of ESR and CRP values significantly correlated with the clinical improvement.

The key to accurate and early diagnosis is the use of reliable confirmatory diagnostic study. In recent years, MRI has become the imaging modality of choice in diagnosing POD with reported sensitivity and specificity of more than 92% (4,8,13,20,23,38-40). MRI can demonstrate disc space changes consistent with an infection as early as 3 to 5 days after operation (40) These changes include a reduction in signal intensity on T1-weighted images and an increase in signal intensity on T2-weighted images in the involved disc, and adjacent vertebral bodies. Post-contrast enhancement in the same areas also has diagnostic value as a sign of bacterial infection (9,17,22,25,38-40). MRI, especially with gadolinium enhancement can also be regarded as the preferred imaging method for monitoring response of treatment (9,17,44-46). An increase of the T1 signal due to fatty marrow, and a decrease of the T2 signal and of the enhancement following gadolinium application have been described as definitive signs of healing (44,46). When the inflammatory process responds well to medical management, the bone marrow changes appear to resolve first at 2-4 months after, with the disc space enhancement persisting longer in many cases (17,22,24,38,45). Normalization of T1 and T2 signal pattern of disc, and adjacent vertebral bodies was also reported at about two years or later (9,13,22). However, in our
study, radiological decline of inflammatory symptoms could be detected at the end of the first month, and follow-up MRI studies showed the normalization of the signal intensity at about 9-12 months after completion of the therapy.

Despite dramatic improvements in diagnostic capabilities particularly afforded by MRI, effective treatment of discitis is still a challenge and the management of discitis has also been a matter of controversy (2,20,22). Although a universally accepted treatment protocol has not been written and the management decisions vary among surgeons, the current mainstay for discitis treatment is a combination of bed rest and prolonged administration of antibiotics( 4 weeks to 6 months) (4,5,7,8,15,19,20,22-27,47). Patients rarely develop persistent infection, pain, epidural abscess formation, and/or spinal deformity despite the aforementioned treatment modality of antibiotics and bed rest leading to surgical intervention (2,7,16,18,20,23-27,38). Though conservative treatment along with spinal immobilization has been shown to produce good long-term outcomes in the majority of patients, the period of strict bed rest can last up to several months, and might lead to dramatic medical and psychosocial consequences (2,4-7,9,23). Additionally, major complications (e.g., colitis, renal failure, allergic reactions) as side effects of long-term antibiotic therapy were also reported (24). The duration of antibiotic therapy recommended in the literature for POD has been variable. Systemic antibiotics are usually administered by i.v. infusion for a minimum of 4-6 weeks, followed by oral administration for a further 2-3 months (2,4,5,8,9,15,20,23,24). Parenteral therapy for less than four weeks result in a higher rate of failure (7,43). In fact, repeated laboratory markers as well as the clinical response of the patient are the key parameters in determining the exact duration of antibiotic administration (3,7,20). In our study, although, parenteral antibiotic and HBO2 therapy were administered for a total of four weeks, even in patients without bacteriological diagnosis, this treatment modality allowed rapid infection control and healing for all 22 patients with 0% recurrence rate. The main difference between our study and those reported in the literature is the reduced duration of antibiotic therapy. We think that this might be attributable to some beneficial effects of HBO2 therapy.

HBO2 therapy has been used in the management of a variety of infections and postoperative complications in bone and soft tissue as a supplement to medical treatment (28-32,36,37). Most infectious tissues including infectious osteomyelitic bones are hypoxic because of ischemia secondary to inflammation-induced tissue edema (28,48). However, adequate delivery of oxygen to the wound tissue is vital for the healing process and for resistance to infection (20,49). In the surgical procedure, injury to end plates, operative trauma to small vessels, hematomas in the intervertebral space, and necrotic tissue caused by surgery provide viable culture specimens and are risk factors for postoperative intervertebral disc space inflammation (18,20,23,25). Once inoculated in an adult disc, which is an avascular structure, the process of discitis begins. Because of infections, and concurrent inflammation, oxygenation and resistance to infection are thus further compromised. The leukocyte bacteria-killing capacity is substantially impaired in hypoxic surroundings (29,48-51). It has been shown that HBO2 therapy increases the oxygen tension in infected tissues, including bone (51). Improved tissue oxygen tensions in ischemic tissues stimulates bactericidal action of white blood cells and inhibits the growth of aerobic and facultative anaerobic bacteria by inducing a variety of metabolic effects involved with the synthesis of proteins, nucleic acids and essential cofactors of metabolic reactions (29,31,51-56). These effects of this treatment...
are mediated in large part by oxygen-based free radicals that oxidize proteins and membrane lipids, damage DNA, and inhibit metabolic functions essential for growth (29,31,54,57). The lack of an adequate vascular supply to the adult disc decreases the ability of the patient’s immune system to fight the infection (20). Therefore, angiogenesis is critically important in wound healing. It has also been shown that HBO2 therapy induces the formation of new capillaries, making the tissues less ischemic (30,58). It exhibits dose-dependent angiogenic effects by causing eight-to ninefold increase in the vascular density of tissues (30). Improved vascularity not only improve tissue oxygen tensions and host defenses but also facilitates entry of leukocytes, antibodies and antibiotics to the infective focus (28,29,48).

Some authors advocate the use of percutaneous discal biopsy to provide a definitive pathogen and thus enhance the efficacy of antibacterial treatment (3,5,7,12,14,15,26,59). Using computed tomography guidance or fluoroscopy assistance, the complication rate of the needle biopsy is now acceptably low, but the rate of false negative results is still high (11,20,22,23,25,59,60). False positive and false negative cultures also limit the accuracy and reliability of the bacteriologic diagnosis. A positive culture from the material obtained by percutaneous needle biopsy is reported to occur in only 50-70 % of cases (7,8,15,20,23,25). Of those that are positive, over 90 percent grow a *Staphylococcus* species, which are found in up to 100 % of cases in some studies (2,7,20,21,25,26,60-62). Other less common organisms include anaerobic organisms, *Streptococcus viridans* and other *Streptococcus* species, *Escherichia coli*, *Pseudomonas aeruginosa*, fungi and others (15,23,60-62). Therefore, in the absence of definitive microbiological data, empiric broad-spectrum antibiotic coverage including agents effective against *S. aureus* is recommended (7,18,25,27).

On the other hand, HBO2 can be considered as a wide-spectrum antibiotic (28,29,31,55); a) the lack of adequate antioxidant defenses in anaerobic microorganisms contributes to their susceptibility to HBO2 (31); b) the growth of some aerobic bacteria including *Escherichia coli* and other enteric bacteria, *P aeruginosa* is inhibited by HBO2 (56,57,63); c) Hyperoxia is fungicidal for *C. Albicans* and several other *Candida* species (33,37). HBO2 also potentiates the activity of certain antimicrobial agents by elevating pO2 in ischemic tissue to levels required for optimal activity of antimicrobials (e.g., vancomycin, aminoglycosides, certain sulfonamides, fluoroquinolones, trimethoprim) or by altering the oxidation-reduction potential in bacteria (e.g., nitrofurantoin, metronidazole) (28,29,31,51,56). Furthermore, HBO2 by itself has been shown to be as effective as cephalosporins in controlling staphylococcal osteomyelitis in rabbits (64).

Dramatic beneficial effects of HBO2 therapy were also observed for patients with spinal infections caused by a variety of microorganisms (28,29,32,34,36,37). Ravicovitch and Spallone obtained good results for treatment of spinal epidural abscesses with HBO2 therapy after laminectomy (32). Larsson et al., applied HBO2 therapy for the treatment of neurosurgical infections after cranial and spinal surgeries (36). Five of their seven patients with osteomyelitis and wound infections after spinal surgery showed resolution, with the use of combined therapy and without removal of foreign materials. Moreover, they presented a case of MRSA wound infection that was cured solely by HBO2 therapy. The results obtained from our study also strongly suggest that HBO2 therapy is a useful adjunctive therapeutic measure in the management of POD as in other spinal infections. However, the issues of the dose and duration of HBO2 therapy remain unsettled. With our protocol of 35 sessions at 2.4 ATA, we may have overtreated some...
patients. We believe that time will tell whether or not 2.4 ATA/35 sessions is the optimal treatment pressure for these patients, and future refinements could certainly improve individual responses to treatment. In the entire series of 22 patients managed with this protocol, no signs of cerebral oxygen toxicity were observed nor were other adverse effects of pressurization seen.

The overall long-term prognosis of discitis varies markedly in different series, different authors report variable success in returning patients to work. The percentage of patients who were unable to resume their former work varied from 12% to 90% (2,4,6-8,18,23). In our series, at the end of the follow-up period, 14 patients (63.6%) were graded as excellent, 8 (36.3%) as good.

In most POD patients, healing and new bone formation leads to eventual bony fusion. The process from active destruction to fusion takes from 6 months to 2 years (7,22,25). Regarding the conservative treatment, in the major reported series, the fusion rate varied between 50% and 100% (7,18,22,26,65). However, in the present study, 13.6% of the patients had complete fusion. Paradoxically, this low fusion rate may be directly related to HBO₂ therapy, and may explain its efficacy; it is commonly accepted that prompt diagnosis and appropriate treatment in these cases is capable of shortening its course and reducing severe sequelae (2,4,16,19,22,27,38,42), and also some authors reported that antibiotics were unable to arrest the progression of discitis once it had been established (18,41,65).

CONCLUSION

Although the number of patients is small to make any definite conclusions, this study represents the first series of cases in which HBO₂ therapy was used as an adjunct to treat POD. Our preliminary results indicate that HBO₂ therapy is a safe, effective, and noninvasive adjunctive treatment modality in the management of postoperative discitis. Radiologic and serologic consolidation was obtained earlier and clinical outcome was more pleasant in terms of hospital stay, duration of immobility, pain relief. The length of time on antibiotics and the need for long-term hospitalization can be shortened with the use of HBO₂ as an adjunctive treatment; therefore, it also seems cost-effective compared to other treatment modalities without HBO₂ therapy which usually require use of antibiotics and hospital stay for a longer time. We think that HBO₂ therapy accelerated the healing process in the disc space and adjacent vertebra, which is normally very prolonged due to slow local metabolism, and prevented progression of bone destruction, leading to low fusion rate. Our clinical experience regarding HBO₂ treatment dose and duration indicates that infection control and establishment of the healing process can be quite rapid and many patients continue to exhibit improvement after cessation of HBO₂ therapy.
Table 1. Characteristics of 22 patients with postoperative discitis.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No. of patients &amp; (%)</th>
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<tbody>
<tr>
<td>Total patients</td>
<td>22</td>
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<tr>
<td>Male</td>
<td>14 (63.3 %)</td>
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<tr>
<td>Female</td>
<td>8 (36.3 %)</td>
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<tr>
<td>Age (yr)</td>
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<tr>
<td>Mean</td>
<td>43.3</td>
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<td>Range</td>
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<td>Onset of symptoms (days after operation)</td>
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<tr>
<td>Mean interval</td>
<td>21.4 days</td>
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<tr>
<td>Range</td>
<td>4-77 days</td>
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<tr>
<td>&lt; 7 days</td>
<td>5 (22.7 %)</td>
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<td>7-28 days</td>
<td>13 (59.0 %)</td>
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<tr>
<td>&gt; 28 days</td>
<td>4 (18.1 %)</td>
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<tr>
<td>Low back pain</td>
<td>22 (100 %)</td>
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<td>Bed-shaking test</td>
<td>22 (100 %)</td>
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<tr>
<td>Neurological deficits</td>
<td>-</td>
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<tr>
<td>Elevated ESR/CRP</td>
<td>22 (100 %)</td>
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<tr>
<td>Typical MRI findings</td>
<td>22 (100 %)</td>
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Co-morbidities
- Diabetes Mellitus: 5 (22.7 %)
- Hypertension: -
- Chronic alcoholism: 1 (4.5 %)
- Smoking: 2 (9.0 %)
- Obesity: 1 (4.5 %)
- Long-term steroid administration: (n=1, 4.5 %)

Neurological state at admission:
- Grade I: 6 (27.2 %)
- Grade II: 7 (31.8 %)
- Grade III: 9 (40.9 %)

Isolated microorganisms:
- S. aureus: 5 (22.7 %)
- S. aureus (MRSA): 2 (9.0 %)
- S. epidermidis: 1 (4.5 %)

Outcome:
- Excellent: 16 (72.7 %)
- Good: 8 (36.3 %)
- No change: -
- Bad: -

* Grade I, patients unable to stand up and walk because of severe pain; Grade II, to stand up and walk with assistance; Grade III, patients able to stand up and walk.
* Blood cultures were negative in 14 (63.6 %) patients.
* Excellent, when return to full activity and to the same work as before the disc pain of low intensity was periodically present but did not alter the daily activity; when no noticeable change was observed in the symptoms before and after treatment.

Figure 2 - a, b, c, d, e, f, g, opposite
Legend to Figure 2, opposite page

**Fig 2.** Typical MRI appearance of acute postoperative discitis in a 22-year-old man, 3 weeks after surgery. T1-weighted sagittal image demonstrating decreased signal intensity at the L5-S1 intervertebral disc space and adjacent L5-S1 vertebral bodies (A), and intense enhancement after administration of gadolinium-DTPA (B). On T2-weighted sagittal imaging, high signal intensity is seen in the vertebral bodies and involved disc space (C). Corresponding T1-weighted axial image after contrast enhancement showing hyperintense adjacent soft tissue and abscess formations in the anterolateral paravertebral space (D). T1-weighted (E) and T2-weighted (F) sagittal MRI images obtained after completion of the therapy (one month after diagnosis) showing decreased T1-weighted and increased T2-weighted signals respectively, in 1/2 of the L5-S1 vertebral bodies (comparing with the Figure 2 A and C, approximately 50% decrease in bone marrow edema is noted). On follow-up at 6 months T2-weighted sagittal (G) MR images is still demonstrating abnormal signal on either side of the L5-S1 disc space, despite complete relief of symptoms.

**Figure 3 a, b, c, d, e, f, g**

**Fig. 3-a**  **Fig. 3-b**  **Fig. 3-c**  **Fig. 3-d**  **Fig. 3-e**

**Fig. 3-f**  **Fig. 3-g**

**Fig. 3.** MR images of 32-year-old man with L5-S1 herniated disc who developed discitis after laminotomy and disc excision. T1-weighted sagittal MRI (A) demonstrates decreased marrow signal intensity above and below the involved disc space. After administration of gadolinium-DTPA, enhancement of the bone marrow and intervertebral disc space can be seen (B). Corresponding T2-weighted sagittal MR image (C) shows increased marrow signal intensity in the same distribution, as well as increased signal intensity within the disc space. T1-weighted (D) and T2-weighted (E) sagittal MR images obtained six months after completion of the therapy showing regression of the above findings. On follow-up at 12 months, T1-weighted (F) and T2-weighted (G) sagittal MR images demonstrating disc space narrowing and resolution of the infectious process.
Table 2 Comparison of data obtained from the study to the available present data in
the literature

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>PRESENT STUDY</th>
<th>HISTORICAL CONTROLS IN THE LITERATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANTIBIOTIC DURATION</td>
<td>4 weeks IV</td>
<td>4-6 weeks IV, then 2-3 months PO</td>
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<tr>
<td>ESR/CRP RESPONSE</td>
<td>Decrease in 8-30 days (mean 21) N=19</td>
<td>Decrease in several months</td>
</tr>
<tr>
<td>LENGTH OF IMOBILITY</td>
<td>12.2 days (range 4-22)</td>
<td>several months</td>
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<td>WBC</td>
<td>7 of 22&gt;10K</td>
<td>Usually &gt;10K</td>
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<tr>
<td>VAS (MEAN)</td>
<td>8.8 before; 2.2 after treatment (mean)</td>
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<tr>
<td>RADIOLOGIC CONSOLIDATION</td>
<td>9-12 months</td>
<td>More than 12 months</td>
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<tr>
<td>INTERBODY FUSION</td>
<td>3 of 22 patients (13.6 %)</td>
<td>50-100 %</td>
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<tr>
<td>WORK RESUMPTION ADVERSE SIDE EFFECTS OF AB</td>
<td>100%</td>
<td>12-90%</td>
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<tr>
<td>USE OF CORSET</td>
<td>6-8 weeks</td>
<td>controversial</td>
</tr>
</tbody>
</table>

REFERENCES


