reported ten patients with intractable angina pectoris despite medical therapy who were successfully treated with implanted epidural dorsal column stimulation electrodes.[9] Six of the ten patients continued to have successful pain amelioration with observation of up to 5 yr.

The patient in the current case report could well have had "silent" or asymptomatic myocardial ischemia unrelated to the epidural fentanyl. Silent ischemia is being recognized with increasing frequency in patients with coronary artery disease, and asymptomatic myocardial infarctions occur in the majority of patients suffering postoperative infarctions.[10,11] However, the current patient's history of painful myocardial ischemia in the past and similar ECG findings with this episode suggest that sensation of pain from myocardial ischemia was blocked by the continuous epidural infusion of fentanyl.

Pain is a valuable warning signal of myocardial ischemia, and there are dangers to unrecognized and untreated ischemia, such as arrhythmias and progression to infarction. This report suggests that patients at high risk for postoperative myocardial ischemia who are treated with spinal opioids analgesics may be at risk for the masking of myocardial ischemia pain by the analgesic effects of the spinally administered opiates. In these patients, a high index of suspicion must be maintained, and they should have increased surveillance to enhance their safety. Surveillance may include appropriate ECG monitoring (*e.g.*, V5 lead), preferably with on-line ST-segment analysis and observation for secondary manifestations of myocardial ischemia such as decreased blood pressure or cardiac output, dyspnea, or increased pulmonary artery wedge pressure. These patients may then receive the benefits of spinal opioid analgesia with less risk of undetected myocardial ischemia.

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Epidural Abscess Associated with Epidural Catheterization: A Rare Event? Report of Two Cases with Markedly Delayed Presentation

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Epidural abscess is a rare condition, with an incidence of approximately 0.2 to 1.2 per 10,000 hospital admissions per year.[1] The incidence of epidural abscess associated with placement of epidural catheters is unknown, but considering the few published reports, apparently is very rare.[2–5] In addition, in these reports the abscess formation generally was acute in onset, occurring soon after epidural catheter placement. We report two cases of epidural abscess formation after placement of epidural catheters for pain management. In both, the manifestation of the abscess did not occur until nearly 1 month after catheter insertion.

Case Reports

Case One. A 71-yr-old man was referred to our Pain Clinic for the treatment of severe burning pain associated with a resolving acute herpes zoster infection involving the T5–T6 dermatome. His acute lesions were mostly healed, but he was taking oxycodone and acetaminophen with codeine without pain relief.

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His past medical history was unremarkable, and he was taking no other medications. His physical examination was remarkable for a well-healed herpes zoster scar on his left posterior chest wall. There were no active lesions and no evidence of infection over his spine. He was counselled for placement of a thoracic epidural catheter for injection of local anesthetic and steroid for pain control.

An epidural catheter was inserted under sterile conditions at the T6–T7 interspace, midline position, using a loss-of-resistance technique without difficulty. The catheter was advanced 3 cm into the epidural space and secured with a sterile transparent dressing. The dressing was changed daily and bacteriocidal ointment placed at the exit site. The catheter was injected through a micropore filter with 5 ml 0.25% bupivacaine (freshly drawn from a preservative-free vial) on four occasions over a 26-h period to provide analgesia and sympathetic blockade. In addition, with the first injection, 120 mg methylprednisolone acetate was added to the local anesthetic solution. The patient had complete resolution of his pain, and the catheter was removed intact.

The patient returned 4 days later with the same pain he had had previously, although it now was less severe. A second epidural catheter was inserted under sterile conditions at the T5–T6 interspace without difficulty and covered with a sterile transparent dressing. Prophylactic antibiotic (cephradine 500 mg by mouth, four times per day) was administered for 10 days according to our routine for epidural catheters that remain in place for more than 24 h. Two times per day he received injections of 0.25% bupivacaine (total dose 5 ml) drawn and administered from single-dose vials in a sterile fashion. Injections were made by several different residents. The patient received a total of ten separate injections. The catheter was removed on the 3rd day with no evidence of infection at the entry site. The patient returned the following week with only mild burning pain over his anterior chest wall; this pain was well controlled with topical capsaicin cream.

Three weeks later (31 days after insertion of the first catheter) the patient returned to our clinic with mild burning pain; more significant, however, was his complaint of a severe headache, stiff neck, fever to 101.5° F, and right-sided flank pain. He denied dysuria or cough. He was not tender over the site where the epidural had been previously placed, and the site was clean and no evidence of erythema or discharge. No neurologic deficits were noted. He was immediately sent to the emergency room, where a lumbar puncture was performed, revealing white blood cells too numerous to count, increased protein, and decreased glucose. No organisms were seen on Gram's stain. His urinalysis was normal. He was admitted for treatment of aseptic meningitis.

Because of the history of the prior epidural puncture, a chest computed tomography (CT) scan was ordered. The scan revealed a large epidural abscess from T5–T9. The patient was taken to the operating room for emergent decompression and drainage of the abscess. A T5–T9 laminectomy was performed, and a large amount of purulent material drained. Also noted was significant granulation tissue. Cultures at the operative site were positive for *Staphylococcus aureus.* The operation was otherwise uncomplicated, and the patient was treated with intravenous antibiotics for 21 days. He was discharged home with complete resolution of infection and with no neurologic deficits.

Case Two. A 20-yr-old woman was referred to our Pain Clinic from the Neurology Service with the tentative diagnosis of reflex sympathetic dystrophy (RSD). She had a 1-week history of progressive burning pain in her left hand. There was no history of trauma. However, she had awakened from a nap with a "numb" hand, which progressed to the current painful state over a few days. On physical examination her left hand was cool and edematous with a 2–3° F temperature difference compared to her right hand. The hand was extremely tender to light touch, and the patient displayed marked guarding and limited motion.

A diagnosis of RSD was made, and a stellate ganglion block was performed with 10 ml 0.25% bupivacaine without difficulty. The patient had 70–80% improvement in pain, but the relief lasted for only 12–18 h. She was then given an intravenous regional guanethidine block, again with significant pain relief for 3–4 days. She refused repeat intravenous regional block because of intense pain associated with application of the tourniquet. She then consented to placement of a cervical epidural catheter for repeat injections of local anesthetic to provide a more sustained sympathetic block and facilitate physical therapy.

After informed consent, an epidural catheter was inserted under sterile conditions at the C6–C7 interspace using the hanging drop technique to locate the epidural space. The catheter was advanced 3 cm into the epidural space without difficulty and covered with a sterile transparent dressing. The patient had excellent pain relief with injections of 6 ml 0.25% bupivacaine two times per day from single-dose vials, drawn and administered through a micropore filter. Sterile gloves and a syringe were used, and the tubing connection was swabbed with povidone–iodine. Aggressive physical therapy was continued. The patient received prophylactic antibiotics (cephradine). The catheter site was observed daily for any sign of inflammation or contamination and was removed after 5 days.

Three days later the patient returned with recurrence of pain. She had been receiving prednisone 60 mg/day because of a concern that a viral-mediated disease was the cause of the pain. A second epidural catheter was inserted at the C7–T1 interspace without difficulty using the same technique as before. There was no evidence of infection at the site prior to catheter insertion. The catheter was injected two times per day with 0.25% bupivacaine as before for 5 more days and then was removed. The catheter was injected by several different residents, and a total of ten injections were made. There still was no evidence of infection at the site. Three days later the patient complained of mild tenderness at the insertion site, and a localized cellulitis without drainage was noted. Cervical spine CT scan was normal, as was a triple-phase bone scan. Antibiotics (dicloxacillin 250 mg by mouth, four times per day for 2 weeks) were administered, and within 3 days the site was much improved and showed no tenderness. The patient's pain was markedly decreased, and she continued to improve.

Five weeks after the second catheter was removed (7 weeks after the initial catheter insertion) the patient returned to our clinic complaining of neck pain radiating to her left arm that worsened with cough. She had no headache or meningeal signs, and her temperature was 99° F. Her epidural site was mildly tender, but there was no discharge. Her white blood count was 4.6×10^3. The patient had just discontinued antibiotics 3 days previously (amoxicillin/clavulanate 500 mg by mouth, three times per day) for a urinary tract infection. An indium-labeled white blood cell scan showed increased soft tissue uptake at the lower cervical region. A CT scan showed an extradural mass defect at C5–C6. In the opinion of the neuroradiologist, the finding on CT was most consistent with an epidural abscess. Immediate cervical exploration revealed an epidural–cutaneous fistula with a significant amount of granulation tissue and small amount of purulent material at the C4–C6 level. The site was drained, and the patient was treated with intravenous antibiotics for 3 weeks. Cultures and Gram's stain taken at surgery were negative for organisms but did show a large number of polymorphonuclear leukocytes. The neurosurgeons believed the findings to be consistent with a sterile abscess that had been partially treated with high-dose oral antibiotics taken for the urinary tract infection. The patient recovered completely without any neurologic deficits.

Discussion

Spinal epidural abscesses are rare, as noted by Baker *et al.*[1] in their evaluation of all epidural abscesses reported at Massachusetts General Hospital between 1947 and 1974. They reported 39 cases over that period, and only 1 case was associated with an epidural catheter. Other

reviews of spinal epidural abscesses[6,7] are consistent with the review by Baker *et al.* in terms of incidence, etiology, rapid progression, and prognosis. In those reviews,[1,6,7] epidural abscess formation was most often associated with skin or soft tissue infections elsewhere or with bone or joint infections such as osteomyelitis.

In our Pain Clinic, we have inserted approximately one epidural catheter per month, on the average, over the past 5 yr. Based on the two cases above, the incidence of abscess among patients having epidural catheters placed is 1 in 30 (3%), which is extraordinarily high.

Not only are these two life-threatening infections associated with an outpatient procedure within a 9-month period extremely disconcerting, but also the presentation of each was unusual. The manifestation of the infection was delayed (31 days in case 1 and 5 weeks in case 2), and symptom presentation was not typical for epidural abscess infection.

Possible explanations for the high incidence and unusual, delayed presentation of these two cases could include (but are not limited to) the following.

First, substandard technique must always be considered. This cannot be proven or disproven retrospectively; it only can be emphasized that in our clinic all epidural catheters are inserted with attention to aseptic technique. In addition, a prophylactic antibiotic (cephradine) was given to both patients.

Second, each patient had two separate epidural catheters inserted, with a 3-day "rest" period between insertions. It may be that with the initial catheter insertion the safety barrier was violated, leaving the patient at increased risk with subsequent catheter insertion. Antecedent trauma was associated with epidural abscesses in 15–35% of the cases reviewed in previous reports.[1,6,7] In our cases, antecedent trauma may have increased the risk if there was any infection below the skin that was not detected prior to insertion of the catheter. Although possible, we and others have placed needles through the sites of previous puncture sites without evidence increased infection.

A third and highly likely contributing factor is a decreased host response secondary to concomitant steroid administration.[8] Danner and Hartman[7] noted that steroid administration adversely affected outcome, but they did not cite it as a predisposing factor. Both of our patients received steroids (one through the epidural catheter, the other orally). Although simply receiving steroids should not necessarily be a contraindication to epidural injection, placement of a foreign body (epidural catheter) through a previous insertion site may have been the culminating factor leading to epidural abscess.

Fourth, the first patient presented was being treated for herpes zoster. This disease frequently occurs in patients who are older, have a reduced immune response, or have associated malignant disease,[9–11] especially lymphoma. The activation of herpes zoster lesions appears to be related to depression of cell-mediated immunity.[12] Thus, the patient in case one may have been immunocompromised *via* two different means.

Epidural abscesses generally have an acute onset with rapid progression if not readily recognized and treated. However, in Baker *et al.*'s review,[1] 19 of 39 of the patients were considered to have "chronic" epidural abscesses, and at operation were noted to have significant amount of granulation tissue, as were both patients presented here. The previously reported cases of epidural abscess associated with epidural catheters[2–5] all had very rapid onset and progression of symptoms. The delay in onset of symptoms in our patients may have come about by one of the factors that made them at increased risk, *i.e.*, steroids. In addition, each patient received prophylactic antibiotics, which may have further delayed onset of symptoms and modified the usual clinical presentation of epidural abscess.

How long can epidural catheters be safely left in place? In the several previous reports[2–5] of epidural abscess associated with epidural catheters, the catheters were left in place only 1–4 days, as were the catheters in our patients. On the other hand, Barretto[13] and Strasser *et al.*[14] were unable to culture bacterial growth from aspirate of epidural catheters left in place for 1–10 days. Positive cultures of skin organisms were noted when the catheters were removed. Tunneling of the epidural catheter as reported by Mandaus *et al.*[15] and DuPen *et al.*[16] may even provide additional prevention from infection. DuPen *et al.*[16] reported a series of 350 terminally ill patients in whom long-term epidural catheters were inserted subcutaneously. Their infection rate was 5.4% (1 of 1,702 catheter days). Fifteen (4.3%) of these infections involved epidural space infections. These patients were treated with catheter removal and intravenous antibiotics. No patient required surgery. The earliest infection occurred at 7 days, but in some the onset was on the 457th day. DuPen *et al.* concluded that the onset of infection seemed to be unrelated to duration of catheter placement. All of his patients were immunocompromised with cancer or acquired immunodeficiency syndrome (AIDS).

The newer material and design of the current epidural catheters, the avoidance of the caudal route for placement, the use of a micropore filter, and greater scrupulousness with the aseptic technique probably have reduced the incidence of epidural infections. In addition, the use of continuous infusion instead of intermittent injections obviates the need for frequent manipulation of the catheter system, or "line breakages," and thereby may also prevent infection in this population of patients. Even so, patients continue to be at risk for life-threatening infections, and a high index of suspicion is essential. Epidural abscesses are rare, but they may occur with greater frequency as we

find an increasing number of uses for epidural cathethers in patients who have special conditions placing them at higher risk.

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Anesthesiology
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Refractory Arterial and Intracranial Hypertension in the Intensive Care Unit: Successful Treatment with Isoflurane

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We report a case of refractory arterial and intracranial hypertension in a patient with reduced intracranial compliance and suspected cerebral dysautoregulation after resection of an arteriovenous malformation (AVM). The patient was managed safely and effectively by the prolonged administration of isoflurane.

Case Report

The patient was a 40-yr-old, 70-kg male who was well until the occurrence of a grand mal seizure 30 days prior to the current admission. Neurologic evaluation, including cerebral angiography, revealed a large intraparenchymal AVM in the left posterior frontal region just anterior to the pre-Rolandic gyrus. Past medical history included mild controlled systemic arterial hypertension and cigarette smoking (40 cigarettes daily for many years). His medications at the time of admission were pindolol 5 mg twice daily and diphenylhydantoin 400 mg once daily. He had sustained an aspiration pneumonia at the time of his seizure. However, a recent x-ray of the chest revealed no persistent abnormality, and his lung fields were clear to auscultation. Preoperative blood pressure was 140/90 mmHg.

The patient underwent a craniotomy for excision of the AVM. Induction of anesthesia was accomplished with thiamylal, pancuronium, and fentanyl (10 $\mu g \cdot kg^{-1}$). Anesthesia was maintained with fentanyl by infusion (3 $\mu g \cdot kg^{-1} \cdot h^{-1}$), isoflurane (0.5% end-tidal), and 50% nitrous oxide. Blood gas analysis early in the procedure revealed pH 7.45, arterial carbon dioxide tension (Pa_{CO_2}) 40 mmHg, arterial oxygen tension (Pa_{O_2}) 143 mmHg (fractional inspired oxygen concentration [FI_{O_2}] 0.35). The patient was hemodynamically stable throughout the 12-h procedure. However, the anesthetic course was complicated by bronchospasm and decreasing lung compliance. These were attributed to cigarette use and to the residual effects of the aspiration pneumonitis. At the conclusion of the procedure, peak inspiratory pressure was 40 cmH2O, and Pa_{O_2} was 75 mmHg and FI_{O_2} 0.4. A decision was made to transfer the patient to the intensive care unit (ICU) for mechanical ventilation.

There was concern regarding the possibility of cerebral dysautoregulation (perfusion pressure breakthrough)[1,2] because of the size of the resected lesion. Accordingly, prior to departure from the operating room a Camino intracranial pressure (ICP) monitor (Camino Laboratories, San Diego, CA) was placed in the right frontal lobe, and it was decided to maintain systolic blood pressure at less than 100 mmHg. The choice of threshold was somewhat arbitrary, but represented a

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Key words: Anesthetics, volatile: isoflurane. Blood pressure: hypertension. Brain: arteriovenous malformation; cerebral dysautoregulation; intracranial pressure; perfusion pressure breakthrough.