surgery, with inevitable further compromise to the coagulation system, as shown by the uneventful course of our patient. If perioperative bleeding occurs in these patients during their cardiac surgery, its cause and therapeutic approach should be no different from those of patients with normal secondary hemostasis.

Surface activation of F XII is an essential requirement for many in vitro assays used for coagulation monitoring in cardiac surgical patients. Such tests are unable to assess clinical hemostasis and heparin activity in F XII-deficient patients, because in vivo alternate modes of activation can compensate for the defect. In the absence of a clinically feasible method to assess surgical anticoagulation rapidly in these patients, heparin must be given according to weight-based protocols, and a normal dose-response relationship must be assumed. Measuring heparin concentrations during and after CPB could assist in the maintenance of anticoagulation and its reversal in the F XII-deficient patient.

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Epidural Opioid Analgesia Does Not Obscure Diagnosis of Compartment Syndrome Resulting from Prolonged Lithotomy Position

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Extensive genitourinary or gynecologic surgery often requires prolonged anesthesia and the lithotomy position. Many anesthesiologists prefer to conduct these cases under combined epidural and general anesthesia and then to use epidural analgesia for postoperative pain. A rare complication of prolonged lithotomy position under general anesthesia is lower-extremity compartment syndrome. It has been suggested that postoperative epidural analgesia may obscure symptoms of compartment syndrome and delay diagnosis and treatment. We report two cases of patients who underwent prolonged genitourinary surgery while in the lithotomy position under combined general and epidural anesthesia. Postoperatively, while receiving intermittent epidural morphine, both patients developed readily diagnosed unilateral compartment syndrome requiring fasciotomies.

CASE REPORTS

Case 1. A 52-yr-old, 85-kg woman, ASA physical status 2, with carcinoma of the bladder underwent a radical cystectomy with urinary...
diversion. Anesthesia was managed using general anesthesia (oxygen/nitrous oxide/isoflurane) and intermittent epidural anesthesia with 2% lidocaine via an L3–L4 catheter. Lithotomy position, using stirrups, was maintained for 10.5 h. Two hours before the end of the procedure the epidural catheter was injected with 5 mg morphine. The patient was awake and responsive at the end of the procedure.

The patient’s initial postoperative analgesic requirements consisted of epidural morphine, 5-mg boluses, every 8 h for the first 48 h. She complained of only mild incisional pain when coughing or moving. At 12.5 h postoperatively, the patient first complained of “numbness” and “muscle spasm” in her right lower extremity, not relieved by the epidural injections. Examination revealed decreased sensation to pin-prick below the knee, and “all extremities appeared tight and swollen.” Compartment pressures measured in the right lower extremity were as follows: anterior, 85 mmHg; lateral, 60 mmHg; superficial posterior, 70 mmHg; and deep posterior, 36 mmHg. The arm–ankle index was 0.7. Pressures measured in the left leg were normal, 20 mmHg.

At 18.5 h after the original surgery the patient underwent four compartment lower-extremity fasciotomies on the right leg. Examination intraoperatively revealed no necrotic tissue. Subsequent delayed primary closure was performed 4 days later. Six weeks later, the patient was able to ambulate with an external leg brace but still had some sensory and motor deficit.

Case 2. A 17-yr-old, 40-kg girl, ASA physical status 2, who as an infant had had a urodermal sinus tumor requiring an anterior pelvic exenteration, underwent a reconstructive urologic procedure to form a urinary continent reservoir, ileal vagina, and orthotopic neourethra. Anesthesia was managed with combined general anesthesia (oxygen/isoflurane) and continuous epidural anesthesia with an infusion of 0.0625% bupivacaine via an L3–L4 catheter. The lithotomy position, using well-padded solid molded steel leg holders, was maintained for 11.5 h. Two hours before the end of the procedure the epidural catheter was injected with 2 mg epidural morphine. The bupivacaine infusion rate was decreased and discontinued 0.5 h before the end of surgery. The patient was awake and responsive at the end of the procedure and complained of decreased sensation in both legs and discomfort. Examination revealed a bilateral lower-extremity sensory block noted to be greater on the right side than on the left. She was reassured that this was a residual effect of her epidural bupivacaine infusion and was given an additional 1 mg epidural morphine. Six hours postoperatively, she complained of mild bilateral decreased leg sensation and was given 2.5 mg of epidural morphine. At 12 h, the patient complained of increasing left leg pain, not relieved by two 25-μg doses of epidural fentanyl. Examination revealed bilateral edematous and warm legs with peripheral pulses. The left leg was more swollen than the right, and there was pain on passive stretch of tibialis anterior and extensor hallucis longus muscles. All four compartment pressures in the left lower extremity were increased (69–71 mmHg), whereas pressures in the right leg were normal (13–19 mmHg). Sixteen hours after surgery, the patient underwent emergency fasciotomies of four compartments of the left leg under epidural anesthesia. Muscle necrosis was evident, and debridement of the superficial posterior compartment was done 3 days later. Delayed closure of the wound requiring skin grafting was done 8 days postoperatively. At discharge, the patient was able to walk with crutches and at 12 weeks postoperatively was able to walk unassisted, with a slight limp.

**Discussion**

Compartment syndrome is defined as a symptom complex that is caused by elevated pressure of tissue fluid in a closed osseofascial compartment of the limb and that interferes with circulation to the myoneural components of the compartment. The cause of the injury, as it relates to patient position, is a primary decrease in perfusion due either to direct external pressure or to a decrease in local perfusion pressure. This ischemia results in tissue membrane damage and leads to leakage of fluid through capillary and muscle membranes. With arterial reperfusion, the damaged membranes continue to leak and aggravate edema formation and thus increase the pressure in the closed osseofascial compartment. These changes are both time- and pressure-dependent, such that a minimal decrease in pressure over a prolonged period of time can result in injury.

Compartment syndrome is a well-recognized complication of extremity trauma and a much rarer complication of intraoperative position. It was first described as a complication of the lithotomy position in a healthy 38-yr-old man after a urethrostaplasty lasting 6.5 h. More recent case reports include those of a healthy 30-yr-old woman undergoing reanastomoses of the fallopian tubes while in lithotomy position for 6 h and a 23-yr-old man with ulcerative colitis undergoing a 7-h procedure for ileostomy closure, also while in the lithotomy position. In addition, unilateral compartment syndrome has been described in the nonoperative leg after femoral nailing in two cases in which the patients were in the hemilithotomy position for 5.75 and 6.0 h.

Prolongation of the lithotomy position may predispose the patient to compartment syndrome in several ways. Leg perfusion may be decreased by elevation of the limb above the heart, excessive local pressure from improper placement of the legs in the holders, external pressure from equipment or personnel, or excessive dorsiflexion of the foot. Other intraoperative factors may include hypotension, hypothermia, and vasoconstriction, hypovolemia, and compression of the pelvic vessels associated with surgery. The effects of the regional sympathetic block associated with intraoperative epidural anesthesia are not known. Predisposing patient factors include unusual body habitus complicating positioning, preexisting vascular disease, and extremity trauma. Postoperative factors include the use of occlusive dressings and any persisting intraoperative factors.

Diagnosis is made with reference to “the six Ps”: 1) pain, out of proportion to the clinical situation; 2) paresthesia, in peripheral nerve distribution; 3) paresis and pain on passive stretch of muscles; 4) pink skin color; 5) presence of pulse, until the compartment pressure exceeds arterial inflow pressure; and 6) pressures greater than 30–40 mmHg in each osseofascial compartment. Deep venous thrombosis, arterial injury, and peripheral nerve injury are included in the differential diagnosis. A high index of suspicion and early measurement of compartment...
pressure is recommended. This applies especially to the 
obtunded patient.

In recent cases in which hemilithotomy position was 
maintained for 6.0 h, diagnosis of postlithotomy-position 
compartment syndrome was made in the nonoperated 
extremity in the immediate postoperative period.7 The 
diagnosis has also been made as late as 24 h postoperatively 
after a urethroplasty was performed in lithotomy position 
for 6.5 h.4 None of the seven cases reviewed involved the 
use of intraoperative or postoperative peridural local anes-
thetics or narcotics, and three of the seven diagnoses 
were made later than 12 h postoperatively.

Delayed diagnosis on the eighth postoperative day in 
an orthopedic case has been described. This involved a 
patient in whom surgery on an extremity had been per-
formed and in whom an epidural infusion of 0.125% bu-
pivacaine was used for 4 days postoperatively.2 In the sec-
ond case presented here, the complaint of bilateral de-
creased leg sensation, involving the right leg more than 
the left, was attributed to a residual sensory block from 
the intraoperative use of a bupivacaine infusion. The lat-
eralization of the pain, which increased in the left leg, the 
side of the compartment syndrome, was not found until 
12 h later. It is possible that residual bupivacaine block, 
present 6 h postoperatively, when the patient was com-
plaining of mild bilateral decrease in sensation, was ob-
suring the development of the unilateral compartment 
syndrome.

The initial therapeutic maneuver for the treatment of 
excessive limb pain in both cases was to reinject the epi-
dural catheter with either morphine or fentanyl. In nei-
ther case did this relieve the symptoms, and repeat physical 
examination, consideration of the diagnosis of compart-
ment syndrome, and subsequent measurement of compart-
ment pressures was made 12–14 h postoperatively. 
Because compartment syndrome is a reperfusion injury, 
its signs and symptoms may not be immediately apparent 
and may develop insidiously. Residual lower extremity 
sensory block due to intraoperative epidural local anes-
thetics may interfere with early detection of subtle sensory 
changes, and its use should be considered carefully during 
or after a prolonged procedure with the patient in the 
lithotomy position.

In summary, we have presented two cases of patients 
who developed unilateral compartment syndrome after 
prolonged lithotomy position and whose diagnosis was 
not obscured by the use of postoperative epidural mor-
phine. We believe that there is no contraindication to the 
use of epidural morphine for postoperative pain in these 
patients, but a high index of suspicion must be maintained 
for patients at risk for the development of compartment 
syndrome.

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