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Klein, Norma Jean

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Neurological Complications Associated with Epidural Analgesia in Children: A Report of 4 Cases of Ambiguous Etiologies

Mark J. Meyer, MD,* Elliot J. Krane, MD,† Kenneth R. Goldschneider, MD,‡ and Norma J. Klein, MD§

The safety and utility of pediatric epidural analgesia is well established, but the risk of permanent neurological injury is unknown and largely must be extrapolated from adult literature. In this article we present a series of 4 cases of long-term or permanent neurologic complications associated with epidural analgesia. Possible mechanisms of injury and implications for practice are discussed. (Anesth Analg 2012;115:1365–70)

Until recently, practitioners of pediatric anesthesiology used risk information derived from adults when considering epidural analgesia and when obtaining informed consent. Risk factors, however, may not apply from one population to the other. As for adult-focused literature, both recent and older literature suggests a low rate of serious complications associated with performing pediatric epidural anesthesia.

The reluctance of many practitioners to announce their failures and complications limits understanding of the true incidence of complications, and reduces the ability to understand and possibly correct underlying mechanisms and risk factors. In the interest of transparency, and to add to the collective experience, we present 4 cases of long-term or permanent neurologic injury after routine epidural catheter placements. The following cases occurred within the practices of the authors or were reviewed by an author acting as an expert witness of now-closed medical malpractice actions pertaining to these cases. Our IRB granted an informed consent waiver. All data were deidentified in accordance with the Health Information Privacy and Portability Act.

CASE REPORTS

Case 1

A 23-month-old female with an urogenital sinus deformity and solitary kidney presented for cystoscopy, vaginoscopy, and surgical repair of the urogenital sinus under general anesthesia. This child had previously undergone uneventful anesthetics for cystoscopies and vesicostomy placement. After IV induction of general anesthesia, the airway was secured with an endotracheal tube, and the patient was positioned in the right lateral decubitus position. After IV induction of general anesthesia, the airway was secured with an endotracheal tube, and the patient was positioned in the right lateral decubitus position. After a single successful attempt, the epidural space was located with an 18-gauge Tuohy needle, using continuous loss-of-resistance to preservative-free normal saline with a glass syringe at the L3 to 4 interspace. Loss of resistance was noted at 1.6 cm, the expected depth for a child of this age, and a 20-gauge epidural catheter was advanced without difficulty to the depth of 3.5 cm past the epidural needle tip. After removal of the Tuohy needle, aspiration of the catheter was negative for the presence of blood or cerebrospinal fluid (CSF). Injection of a 1.5 mL (0.1 mL/kg) test dose of lidocaine 1.5% with 1:200,000 epinephrine was negative for ST-segment, heart rate, or arterial blood pressure changes. The catheter was secured and the patient returned to the supine position, and later to the dorsal lithotomy position, in preparation for cystoscopy and vaginoscopy. During preparation for the endoscopies, the epidural catheter was injected with 4 mL of bupivacaine 0.25% with 1:200,000 epinephrine in a fractionated fashion.

On the basis of unanticipated findings during the endoscopies, the larger reconstruction of the urogenital sinus was deferred to a future date. The epidural catheter was therefore removed intact at the end of the surgical procedure; the patient awoke from anesthesia and was transferred to the postanesthesia care unit (PACU), then to the postsurgical ward. Five hours after the completion of the procedure, the parents and nurse noted that the patient was unable to sit up. The on-call anesthesiologist evaluated the patient and found flaccid paralysis and absent sensation to pinprick stimulation of both lower extremities. An emergent magnetic resonance image (MRI) was performed of the lumbar and thoracic spine, and neurosurgical consultation was requested simultaneously. The MRIs revealed no hematoma, abscess, mass, or trauma to the spinal cord or dura, but there was an increased signal abnormality of the conus medullaris consistent with ischemia or venous hypertension (Fig. 1). A short course of dexamethasone was begun, and the patient was transferred to the pediatric intensive unit for further monitoring. The following day there was no change in the clinical examination: flaccid paralysis of the lower extremities and weak hip flexor activity. At this time, the child was irritable and sensory examination was inconsistent in the lower extremities. A repeat MRI on this day demonstrated spinal cord ischemia and swelling extending from the T10 level to the conus medullaris. No gross anatomic abnormalities were found,

From the *Department of Anesthesia, Cincinnati Children’s Hospital Medical Center, Cincinnati, OH; †Lucile Packard Children’s Hospital, Stanford University School of Medicine, Stanford, CA; ‡Division of Pain Management, Cincinnati Children’s Hospital Medical Center, Cincinnati, OH; §Department of Anesthesiology, University of California, Davis, Davis, CA.

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Address correspondence to Mark J. Meyer, MD, Cincinnati Children’s Hospital Medical Center, 3333 Burnet Avenue, MLC 2001, Cincinnati, OH 45220-3039. Address e-mail to Mark.Meyer@chmc.org.

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and genetic and hematologic evaluations were unrevealing for syndromic and prothrombotic states.

Over the next few weeks, the child underwent a rehabilitation program with subtle improvement in motor function, but flaccid paralysis persisted below the L1 level. Transient neuropathic pain (suggested by allodynia in the lower extremities) was treated with gabapentin during the hospitalization. An MRI performed 2 weeks after the injury indicated resolution of cord edema and decrease signal in the area of injury (Fig. 2). Twelve months after the injury, there was no further recovery of motor function.

**Case 2**

A 12-year-old female with ulcerative colitis presented for a proctocolectomy with ileoanal anastomosis after failed medical therapy with high-dose steroids and immunosuppressants. Her medical history was significant for tetralogy of Fallot (repaired in infancy) and autoimmune hepatitis of unknown etiology. On physical examination she had a cushingoid appearance with body mass index of 27. After induction of general anesthesia, an epidural catheter was inserted using a midline approach at the T12–L1 interspace after 2 attempts with an 18-gauge Touhy needle using loss-of-resistance to air. Test dosing with 3 mL of 1.5% lidocaine with 1:200,000 epinephrine was negative for heart rate, ST-segment, or arterial blood pressure response. Bupivacaine 0.25%, 7 mL, was injected into the epidural catheter without a change of vital signs. The patient was placed in lithotomy position using knee crutch supports. An epidural infusion of bupivacaine 0.1% with fentanyl 5 μg/mL was maintained between 10 to 14 mL/hr. Bupivacaine 0.25% in 4- to 7-mL boluses were also periodically administered as needed for increases in heart rate and blood pressure. Her blood pressure ranged from 142/60 to 85/45 mm Hg, central venous pressure 3 to 22 mm Hg, and heart rate 78 to 128 beats per minute (bpm) throughout the anesthetic. Trendelenburg positioning, at times steep, was used intermittently throughout the procedure. Overall blood loss was 1200 mL. Fluid replacement was 6500 mL isotonic fluid, 1000 mL hydroxyethyl starch (Hetastarch™), and 500 mL of red blood cells. Medications used on the surgical field included lidocaine with 1:1000 epinephrine and cephazolin. Total operative time was 13 hours. Emergence was uneventful, and the patient was alert and pain-free in the immediate postoperative period.

Five hours after emergence from anesthesia, the bedside nurse noted that the patient was not moving her lower extremities. The epidural infusion was stopped. Over the next 8 hours, the patient’s sensory block regressed to the lower lumbar dermatomes accompanied by abdominal pain. On physical examination, vibratory, pressure, and proprioceptive sensations were intact in the lower extremities. However, lower-extremity flaccidity persisted with absence of anal wink. Neurosurgical consultation was obtained, and the epidural catheter was removed in preparation for MRI of the spine. T-1 and T-2 weighted images showed increased signals consistent with ischemia in the anterior regions of the spinal cord at L1 to 2 and T5 to 7, a low-density signal in the upper portion of the thoracic epidural space, as well as lipomatosis of the epidural space (epidural lipomatosis, EDL). No physical trauma to the dura or cord was seen. The patient underwent an exploratory T5–L1 laminectomy the next day. Sensory-evoked potentials were present but depressed, and motor-evoked potentials were absent in both lower extremities. Epidural fat to 1 cm in thickness was noted throughout the length of the spine, though the epidural space did not appear to be tense or under pressure. The patient has not regained

**Figure 1.** Magnetic resonance imaging 7 hours after removal of epidural catheter demonstrating ischemia of the conus medullaris.

**Figure 2.** Magnetic resonance imaging 2 weeks after injury with resolution of edema.
bowel or bladder function and remains confined to a wheelchair.

**Case 3**

A 12-year-old boy presented for inpatient rehabilitative treatment of complex regional pain syndrome after outpatient therapy failed to reduce his right leg pain. Initially, a right-sided lumbar sympathetic catheter was placed. After 4 days, the site appeared erythematous with whitish discharge. The catheter was removed, and an epidural catheter was placed on the second attempt (blood returned via the catheter on the first attempt). Loss-of-resistance to saline was found at 4.5 cm at L3 to 4, and the catheter was threaded 4.5 cm past the needle tip. An initial loading dose of 9 mL of 0.1% bupivacaine with 1 μg/mL of clonidine was given in a 2-part bolus after negative test dosing with 3 mL of 1.5% lidocaine with epinephrine 1:200,000. A delayed onset of a light sensory block was noted. A continuous epidural infusion was initiated using 0.1% ropivacaine and clonidine 1 μg/mL infused at 6 mL/hr with modest pain reduction. Sacral anesthesia was noted, with sensory blockade in the L4-S1 distribution. While not reported at the time, the patient began to have urinary dribbling, though no bowel incontinence. An increase in pain resulted in changing the solution to 0.125% ropivacaine with clonidine 1 μg/mL. On the fifth day of the epidural infusion, to improve the quality of analgesia, the patient was moved to a monitored bed, and over 2 hours the following therapy was performed: the epidural analgesia was augmented with 14 mL of 3% chloroprocaine over 15 minutes. This intensified the block around the pelvis, as well as the left leg, with modest analgesia of the right leg. Therefore, the catheter was removed and another placed on first attempt at the L4 to 5 level. When no further block was obtained after a bolus of 7 mL of 0.5% bupivacaine, the patient was transferred to the fluoroscopy suite, where an epidurogram was performed, showing correct epidural placement and appropriate spread of contrast in the epidural space (Fig. 3, A and B).

The catheter was used to infuse the following infusates: 0.125% ropivacaine with 1 μg/mL clonidine at 8.5 mL/hr, which was changed the following day to 0.15% bupivacaine with fentanyl 2 μg/mL at the same rate for 24 hours, then to 0.1% bupivacaine with butorphanol 4 μg/mL at 6.3 mL/hr. All medications were preservative-free. These infusions produced sympathectomy but inadequate analgesia, so the catheter was removed uneventfully. During these 3 days, the patient developed urinary incontinence, reporting that he could not feel the urge to void, or the onset of flow. There was neither back pain nor motor block below the mid-thighs. He remained constipated, as he had been throughout his hospitalization before the placement of the second epidural catheter. Twenty-four hours later, the left leg numbness resolved, but the pelvic anesthesia and incontinence remained. A neurological examination showed that his cremasteric reflexes and anal wink were absent; he had anesthesia to touch and pinprick in symmetrical distribution of L1 and S2 to 4, oddly sparing L2 to 5. An MRI was performed, which showed inflammatory changes in some nerve roots of the cauda equina, and lumbar plexus, but no trauma, blood, abscess, or vascular lesion.

![Figure 3. Epidurogram demonstrating correct spread of contrast in (A) lateral view and (B) anteroposterior view. The epidural catheter is poorly visualized on reproduction.](image)

Dexamethasone was administered for 24 hours, and when no improvement was seen, high-dose methylprednisolone was administered for 5 days. Erythrocyte sedimentation rate, complete blood count, and C-reactive protein level were within normal limits. Over the following month, incontinence partially resolved, and the cremasteric reflex returned on the left side. Two months later, the cremasteric reflex was present bilaterally, but the anal reflex remained absent. Bowel function was normal despite diminished sensation with evacuation. Urodynamic studies were normal, including some sensation of abdominal discomfort when the bladder was distended, and he had the ability to retain urine. A repeat MRI showed partial resolution of the nerve root changes. At 6 months, the patient had return of patchy sensation in the right groin. Lower-extremity motor function remained normal throughout this event, and the pain related to his complex regional pain syndrome remained stable. After 8 months, he had full sensory and motor recovery in the areas affected by the epidural.

**Case 4**

An 11-year-old male was scheduled to undergo surgical correction of a pectus chest wall deformity under combined general and thoracic epidural anesthesia. After the uneventful induction of general anesthesia and intubation of the trachea, the patient was turned to the lateral decubitus position, and a thoracic epidural catheter was inserted on the first atraumatic attempt at the T7 to 8 interspace, and an epidural catheter was threaded 3 cm into the space. Neither blood nor CSF returned from the needle or upon aspiration of the catheter, and a test dose of 4 mL 1.5% lidocaine containing 1,200,000 epinephrine did not indicate vascular injection. However, 5 minutes after the injection of the test dose, his blood pressure decreased to 56/24 mm Hg, which was attributed at the time to the effect of the large test dose in a dehydrated fasted child. After restoration of the blood
pressure to normal values with fluids and by reduction of volatile anesthetics, a further anesthetic dose of 5 mL 0.25% bupivacaine with 1:200,000 epinephrine was administered. Again, his blood pressure decreased to 58/22 mm Hg with heart rate maintained at 100, which was corrected by administration of fluids, ephedrine, and by reduction of inhaled anesthetic doses.

In the PACU, the patient was awake and pain-free with an arterial blood pressure of 103/63 mm Hg, and a continuous infusion of 0.1% bupivacaine in saline was started at 8 mL/hr. The nursing assessment revealed sensory levels at T6 on the left side and T7 on the right. Forty-five minutes after arrival in the PACU, the patient reported pain, and his anesthesiologist administered a further 5 mL of 0.25% bupivacaine with 1:200,000 epinephrine through the epidural catheter with the patient in Trendelenberg in an attempt to produce blockade of higher dermatomes. Seven minutes later, the patient became unresponsive and apneic, requiring bag/mask mechanical ventilation to maintain oxygen saturation.

The epidural infusion was discontinued and the catheter removed, producing a small amount of clear fluid at the skin site. This fluid was glucose positive, suggesting that it was CSF from an inadvertent intrathecal placement of the catheter.

Twenty minutes later, the patient resumed spontaneous ventilation and recovered consciousness. His blood pressure was well maintained throughout this episode, with the lowest recorded value 78/25 mm Hg. Two hours after arrival in the PACU, the child was pain-free. He had a sensory block at T6 to 7, was unable to move his legs and began to report surgical pain. For the next 3 days his lower extremities recovered only partial neurological function, and on the third postoperative day a neurological consultation documented left lower-extremity weakness and areflexia, normal right lower-extremity strength, indicating a pattern consistent with an incomplete Brown-Squard syndrome from injury to the left hemiscord. A MRI scan documented enhanced signal intensity from the T4 to 5 interspace to T10 centrally in the cord, fitting a vascular infarction pattern. The patient’s left lower-extremity paresis did not resolve.

**DISCUSSION**

These 4 cases illustrate severe permanent or longstanding neurological injury after uncomplicated placement of epidural catheters in children. In each of these cases the neurological result was devastating, and 3 cases resulted in sizeable medical malpractice claims and settlement despite the absence of proof of medical negligence. Furthermore, all 4 catheters were placed by experienced pediatric anesthesiologists in institutions where epidurals are performed regularly. None of the cases reported here had clinical or radiographic evidence of direct trauma, abscess, or hematoma, leaving no clear explanation of etiology. The rate of epidural complications in children is not known. Before 1995, the literature of long-term complications of pediatric epidurals comprised a single case series of 5 neurologically injured patients. In 1995, the Survey of French-Language Society of Pediatric Anesthesiologists released complication rates after 17,837 epidural blocks by caudal (n = 15,013), sacral (n = 293), lumbar (n = 2396), and thoracic (n = 135) epidural approaches. There were transient neurological complications in 2 of these blocks, but no permanent neurological complications. Since then, only isolated case reports have been published. Epidemiologic data as presented in the National Pediatric Epidural Audit from the United Kingdom reported epidural complications. Of the 10,633 pediatric epidurals, there were 6 events of neurological injury. Five had resolved by the time of discharge from the hospital, and the last one had resolved by 1 year after the event. Most recently, the Pediatric Regional Anesthesia Network (PRAN), a consortium of 14 pediatric anesthesia departments in the United States collecting detailed prospective data on all regional anesthetics performed by anesthesiologists at the participating centers, reported complications associated with 14,917 regional nerve blocks in children performed by anesthesiologists. Of these, they described 6127 single-injection epidural blocks (of which 6011 were caudal injections) and 2946 placements of epidural catheters. There was 1 case of transient neurologic injury (allodynia), and no cases of permanent neurologic injury. Therefore, combining the data reported by the French, United Kingdom, and American series, there were 9 transient neurological complications associated with 37,543 epidural blocks (2 per 10,000) and no permanent neurological injuries.

Reports of neurologic injury from epidural techniques in adults reveal mechanisms of injury that include mechanical injury from needle or catheter trauma to neural or vascular structures, compression from masses as in hematoma or abscess formation, spinal cord infarction due to hypotension or prothrombotic states, and toxicity from medications injected into the epidural space. In these cases, cord trauma, hematoma, and abscess were not found on MRIs. Epidural butorphanol has received much clinical study in both children and dogs without evidence for neurologic compromise; however, butorphanol has been found to be neurotoxic on intrathecal administration in sheep. While the urinary symptoms and saddle anesthesia were present before the administration of butorphanol in case 3, a secondary or additive toxic effect cannot be excluded. Alternative mechanisms of injury are speculative and include vascular injuries from anterior spinal artery syndrome (ASAS) or other alteration in cord bloodflow. From case reports, ASAS has been associated with intraoperative hypotension, vasculopathy, and positioning.

An additional possible mechanism, which may be unique to children, relates to the effects of the hydrostatic pressure created by the injection of the test dose, initial loading dose, or infusions into the epidural space. High peak pressures during injection into the epidural space, and sustained pressures upon completion of the injection, have been recorded using a pressure transducer in adult and pediatric patients. The pressures transduced in the epidural space of children are higher than pressures transduced in adult epidural space. Sustained pressures in pediatric patients who underwent a slow rate of injection have consistently higher residual epidural pressures than do sustained pressures in adults. A rapid rate of injection may also
increase epidural pressures when measured with a pressure transducer.\textsuperscript{20} The effect of transient increases in epidural space pressure within the medullary canal resulting in decreased cord perfusion may be relevant as a mechanism of injury, especially in children, as it has been suggested to be in adults.\textsuperscript{18} Perhaps pediatric patients are more susceptible to this mechanism of injury because they have lower spinal cord pressure pressures than do adults. The use of epinephrine-containing solutions was a common adjunct in all 4 cases reported above. The Belgian case series had several possible risk factors to consider, including large volumes and use of epinephrine.\textsuperscript{4} It is possible that hydrostatic forces, in conjunction with even mild vasocstriction could play a role in creating an ASAS in an otherwise healthy pediatric patient. What the dose response of epinephrine is regarding spinal cord ischemia is unknown. There is no evidence to support discontinuing the use of single test doses of epinephrine-containing solution in the absence of a more reliable method to identify placement of the catheter in the intravascular space. The Tsui technique, fluoroscopy, and ultrasound can identify the anatomical location of the catheter but cannot identify intravascular placement. As there is justification for the use of a single dose of epinephrine as a test dose, there is little justification for its use in a loading dose or continuous infusion. The conservative approach would be to use other means of confirming placement, should multiple test doses be otherwise required, and to avoid using epinephrine beyond its role in test dosing.

Preexisting spinal canal pathology is a recognized risk factor for adult patients undergoing epidural analgesia.\textsuperscript{22,23} In prior reports in the literature concerning adults, the preexisting pathology has included spinal stenosis, disk herniations,\textsuperscript{20} osteoarthritis,\textsuperscript{24} facet joint cyst, vertebral fractures, thoracic meningioma, poliomyelitis, and obesity.\textsuperscript{21} A clinical profile of back pain, lower extremity weakness, sensory deficits, abnormal reflexes, and incontinence has been linked to a compartment-like syndrome in the epidural space. There are no case reports directly implicating EDL in concert with the spinal cord, nerve roots, vessels, or even facet joints, which normally allow egress of fluid placed in the epidural space. Not all patients with EDL are symptomatic,\textsuperscript{25} and MRI findings do not necessarily correlate with the clinical presentation.\textsuperscript{26} Therefore, anesthesiologists may need to be vigilant in the preoperative period in evaluating patients for spinal cord pathology, including a history of steroid administration, because it may be associated with EDL.

It is important to underscore the principle that neurologic findings out of the ordinary in a child receiving epidural anesthesia or analgesia should prompt investigation of the source of the findings. Although most common, enhanced local anesthetic effects will not always be responsible for unusual findings. Most often, investigation is by physical examination, followed by MRI of the spine.

In summary, this is a series of 4 cases of transient or permanent central nervous system injury in children who underwent placement of epidural catheters and in whom imaging studies excluded mechanical needle or catheter injury to the spinal cord or nerve roots. The causal relationship between the epidural catheter placement or epidural anesthetic drugs and the subsequent injury is speculative at this time, but in all but case 3, imaging studies were consistent with a vascular injury to the cord, while case 3 was suggestive of neurologic toxicity. In case 4, probable accidental intrathecal catheter placement may have resulted in total spinal anesthesia with subsequent episodes of hypotension, leading to spinal cord infarction, although direct neurotoxicity of local anesthetic to the spinal cord or epinephrine-induced vasospasm of the circulation of the cord cannot be excluded. Practitioners should remain alert to otherwise unexplained hypotension as a sign of possible intrathecal injection of local anesthetic when performing epidural analgesia in the context of general anesthesia. A sudden decrease in arterial blood pressure after the test dose suggests that the catheter position should be double-checked. As to the role of epinephrine-related ASAS, authors have speculated on this for years. Unfortunately, it is our best weapon against intravascular injection.

The conclusions to be drawn from these experiences are as follows: (1) ischemic injuries to the spinal cord may occur in children during epidural anesthesia, but spontaneous infarction of the spinal cord also may occur in patients who experience hypotension absent epidural anesthesia; (2) collection of outcome data for large numbers of children undergoing epidural anesthesia is necessary and desirable to define the magnitude of risk, thought at this time to be quite small; toward that end, the PRAN continues to accumulate data in North America and to enroll new participating sites, with case numbers of approximately 35,000 in their database; and (3) further laboratory and clinical investigations are desirable to define the pressure–volume relationship of the epidural space, and the effect of transient epidural hypertension on spinal cord bloodflow and perfusion, to guide clinicians in choosing an appropriate local anesthetic volume and rate of injection, as well as the safety of adjuvant-containing local anesthetic solutions in the developing central nervous system.

**DISCLOSURES**

**Name:** Mark J. Meyer, MD.  
**Contribution:** This author helped analyze the data and write the manuscript.  
**Attestation:** Mark J. Meyer approved the final manuscript.  
**Name:** Elliot J. Krane, MD.  
**Contribution:** This author helped analyze the data and write the manuscript.  
**Attestation:** Elliot J. Krane approved the final manuscript.  
**Name:** Kenneth R. Goldschneider, MD.  
**Contribution:** This author helped design the study, analyze the data, and write the manuscript.  
**Attestation:** Kenneth R. Goldschneider approved the final manuscript.  
**Name:** Norma J. Klein, MD.  
**Contribution:** This author helped conduct the study, analyze the data, and write the manuscript.  
**Attestation:** Norma J. Klein approved the final manuscript.  
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