Anesthetic management of parturients with pre-existing paraplegia or tetraplegia: a case series

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ABSTRACT
With improvements in management and rehabilitation, more women with spinal cord injury are conceiving children. Physiologic manifestations of spinal cord injury can complicate anesthetic management during labor and delivery. Patients who delivered at Mayo Clinic, Rochester, Minnesota between January 1, 2001 and May 31, 2012 with a history of traumatic spinal cord injury were identified via electronic record search of all parturients. Eight patients undergoing nine deliveries were identified. Six deliveries (67%) among five patients (63%) involved a trial of labor. Among these deliveries, three (50%) occurred vaginally, all with successful epidural analgesia. Trial of labor failed in the remaining three patients, and required cesarean delivery facilitated via epidural (n=1), spinal (n=1) and general anesthesia (n=1). Three patients (33%) underwent scheduled cesarean delivery via epidural (n=1), spinal (n=1), and general anesthesia (n=1). Four patients having five deliveries had a history of autonomic hyperreflexia before pregnancy. One patient had symptoms during pregnancy, two patients had episodes during labor and delivery, and three patients described symptoms in the immediate postpartum period. These symptoms were not reported by any patient without a history of autonomic hyperreflexia. Neuraxial labor analgesia may have a higher failure rate in patients with spinal cord injury, possibly related to the presence of Harrington rods. Postpartum exacerbations of autonomic hyperreflexia are common in patients with a history of the disorder.

Keywords: Spinal cord injury; Autonomic hyperreflexia; Neuraxial anesthesia; Labor analgesia; Pregnancy

Introduction
In the USA, 12,000–20,000 individuals sustain a new spinal cord injury (SCI) each year.\textsuperscript{1} With improvements in acute management and rehabilitation, there are an increasing number of pregnancies in the spinal cord injured population, with 14\% of these women becoming pregnant at least once.\textsuperscript{2} Spinal cord injury is associated with complications including chronic urinary tract infections (UTI), decubitus ulcers, thrombophlebitis, anemia, decreased respiratory reserve, and autonomic hyperreflexia (AH).\textsuperscript{3} In addition to these complications, pregnancy adds additional risks as it is associated with anemia, decreased respiratory reserve, a hypercoagulable state and increased risk for thrombophlebitis and UTI. Labor pains may not be perceived in patients with an injury above T10, which puts these patients at risk for unperceived delivery.\textsuperscript{4} Furthermore, pain during labor and delivery may stimulate an AH exacerbation in women with SCI.\textsuperscript{5} If unrecognized, AH can cause devastating complications during pregnancy such as intracranial hemorrhage, hypertensive encephalopathy and death.\textsuperscript{6}

Although many case series exist in the obstetric and rehabilitation literature,\textsuperscript{5,7–9} only a few case reports\textsuperscript{3,10–18} and one case series of three patients\textsuperscript{8} focus on the obstetric anesthetic management of patients with paraplegia or tetraplegia for labor and delivery. This case series describes nine pregnancies in eight parturients with paraplegia or tetraplegia.

Methods
Following Mayo Clinic Institutional Review Board approval, all patients admitted to the Labor and Delivery Unit at Mayo Clinic Hospital, Rochester, Minnesota from January 1, 2001 to May 31, 2012 were retrospectively identified from the unit’s birth log. Clinical notes were queried within all electronic medical records for the following free-text terms: SCI, paraplegia, paraparesis, quadriplegia, quadriparesis, AH, autonomic dysreflexia, meningocoele, spina bifida, spina bifida occulta, transverse myelitis and tethered cord. In addition, records were searched for the following...
International Classification of Disease (ICD) nine code prefixes: 344, 740, 741, 742, 756, and 952. These codes describe paralytic syndromes, anencephalus and similar anomalies, spina bifida, other congenital anomalies of the central nervous system, other congenital musculoskeletal anomalies and SCI without evidence of spinal bone injury, respectively.

The medical records of identified patients were then manually reviewed for details of their central nervous system pathology. Patients were excluded if there were no neurologic deficits at the time of delivery or they had lower motor neuron disease without evidence of upper motor neuron involvement. Demographic data including maternal age, American Society of Anesthesiologists physical status classification, parity and gestational age at delivery, as well as the patient’s obstetric, medical and neurologic history, were recorded. Delivery data were extracted, including the type of delivery, type of labor analgesia, postpartum care and complications. All notes in the records, including outside records and reports, were included in the review. All patients had consent-for-research authorization on file.

Injury severity and extent were classified according to the American Spinal Injury Association (ASIA) Impairment Scale. The ASIA classification for each patient was determined via information in the medical record. The scale was developed to create standards for neurologic classification of SCI and categories are described as follows:

- **ASIA A**: complete injury with no sensory or motor function preserved in the sacral segments S4–5.
- **ASIA B**: preserved sensation but no motor function below the neurological level and extends through the sacral segments S4–5.
- **ASIA C**: motor function preserved below the neurological level and the majority of key muscles below the neurological level have a muscle grade <.3.
- **ASIA D**: motor function preserved below the neurological level and the majority of key muscles below the neurological level have a muscle grade ≥.3.
- **ASIA E**: patient with normal sensory and motor function.

ASIA A refers to a complete injury and ASIA B–D refer to incomplete injury. The ASIA scoring system grades muscle strength on a scale of 0–5, where 0 is total paralysis and 5 refers to normal active movement with full range of motion against full resistance.

**Results**

Eight patients with SCI undergoing nine deliveries were identified during the study interval. Obstetric and anesthetic management for all deliveries are summarized in Fig. 1. Obstetric history, details of SCI, AH history, deep vein thrombosis (DVT) management, and neonatal outcome are summarized in Table 1. Anesthetic management and intrapartum obstetric management is described in Table 2. Of note, all patients had acquired SCI before pregnancy, with a median time from injury to time of delivery of 13 years [range 2–19 years]. A history of AH episodes was noted in four patients having five deliveries. Delivery numbers described below pertain to delivery numbers as described in Table 1.

The patient having Delivery 2 presented with spontaneous rupture of membranes and epidural placement was not successful. She described episodes of AH occurring before pregnancy but none episodes during pregnancy. The anesthesia and obstetric team recommended...
cesarean delivery (CD) under general anesthesia to prevent AH from developing during labor and delivery. General anesthesia was induced with thiopental 5 mg/kg. The patient received intravenous labetalol 5 mg and esmolol 15 mg to treat a blood pressure of 152/102 mmHg immediately following intubation. She did not describe any symptoms of AH during the peripartum period.

Deliveries 3 and 4 occurred in the same patient. She had a history of episodic headaches and flushing consistent with AH before pregnancy. There was no record of AH events during pregnancy. For her first delivery (Delivery 3), after successful external cephalic version, an epidural was placed and medications infused as described in Table 2. Labor progressed without complication until just before vacuum assisted delivery, when she complained of a headache with a maximum blood pressure of 186/128 mmHg. She received epidural 3% 2-chloroprocaine 5 mL and intravenous hydralazine 5 mg. There was a decrease in blood pressure to 137/94 mmHg and subsequent resolution of her symptoms. The patient also noted headaches on postpartum day 3 which were similar to past AH episodes. No blood pressure measurements were recorded during these periods. With her second pregnancy (Delivery 4), an epidural catheter was placed before an external cephalic version. She complained of a headache when intravenous oxytocin was administered during induction of labor but this was not accompanied with an increase of blood pressure. Neuraxial medications given for the version and labor are detailed in Table 2. No further episodes of AH during the peripartum period were recorded.

The patient having Delivery 5 had episodic AH episodes before pregnancy but none were noted during pregnancy. Before labor induction, an epidural was inserted and an epidural infusion started. The epidural was subsequently augmented for CD. There was no record of AH during delivery. However, at a postpartum visit the patient described multiple episodes of AH during the first few days postpartum. She stated the symptoms quickly resolved without intervention. Blood pressures at those times were not recorded.

The patient having Delivery 6 had three admissions for AH during pregnancy. She presented with symptoms of headache, blurred vision, piloerection and palpitation, with or without hypertension. She was prescribed oral labetalol for AH control until late pregnancy and was the only patient in this series taking medications during pregnancy to reduce the risk for AH. She had an epidural placed and medications were given before amniocentesis to determine fetal lung maturity. When the results of the amniocentesis were obtained, the decision was made to deliver via CD for prevention of AH. The maximum blood pressure recorded was 172/90 mmHg during epidural placement. In the postpartum period, she was monitored in the intensive care unit for...
<table>
<thead>
<tr>
<th>Delivery</th>
<th>Initial delivery plan</th>
<th>Management of delivery</th>
<th>Indication for CD</th>
<th>Neuraxial management</th>
<th>Invasive arterial pressure monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Elective CD: spinal anesthesia</td>
<td>Elective CD: spinal anesthesia</td>
<td>Urethral sling</td>
<td>Spinal 10% procaine 0.7 mL + 1% tetracaine 0.7 mL</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>VD: epidural analgesia</td>
<td>Spontaneous rupture of membranes Scheduled CD: GA as unable to place epidural</td>
<td>History of AH</td>
<td>Epidural: 0.125% bupivacaine + 2 µg/mL fentanyl 10 mL bolus followed by 12–15 mL/h; additional boluses of 3% 2-chloroprocaine &amp; 0.125% bupivacaine</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>ECV VD: epidural analgesia</td>
<td>Induced labor</td>
<td>NA</td>
<td>Epidural: 0.125% bupivacaine + 2 µg/mL fentanyl 10 mL bolus followed by 12–15 mL/h; additional boluses of 3% 2-chloroprocaine &amp; 0.125% bupivacaine</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>ECV VD: epidural analgesia</td>
<td>Induced labor</td>
<td>NA</td>
<td>ECV: 3% 2-chloroprocaine 15 mL Epidural: 2% lidocaine 10 mL followed by 0.125% bupivacaine + 2 µg/mL fentanyl at 10 mL/h</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>VD: epidural analgesia</td>
<td>Induced labor</td>
<td>Failure to progress</td>
<td>Epidural: 0.125% bupivacaine + 2 µg/mL fentanyl 10–20 mL/h CD: 2% lidocaine, fentanyl 100 µg, morphine 2 mg 25 mL Postop analgesia: 0.125% bupivacaine + 2 µg/mL fentanyl 10 mL/h for 16 h</td>
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</tr>
<tr>
<td>6</td>
<td>Elective CD: epidural anesthesia</td>
<td>Elective CD: epidural anesthesia</td>
<td>Breech</td>
<td>Amniocentesis: 2% lidocaine 10 mL followed by 0.125% bupivacaine + 2 µg/mL fentanyl 10 mL/h CD: 2% lidocaine 20 mL Postop analgesia: 0.125% bupivacaine + 2 µg/mL fentanyl 10 mL/h for 32 h</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>VD</td>
<td>Induced labor</td>
<td>Non-reassuring fetal heart trace</td>
<td>Spinal: 0.75% hyperbaric bupivacaine 1.6 mL, fentanyl 20 µg, hydromorphone 100 µg</td>
<td>No</td>
</tr>
<tr>
<td>8</td>
<td>VD</td>
<td>Spontaneous labor</td>
<td>Failure to progress</td>
<td>Spinal: 0.5% bupivacaine 5 mg, fentanyl 20 µg</td>
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</tr>
<tr>
<td>9</td>
<td>VD: epidural analgesia</td>
<td>Induced labor</td>
<td>NA</td>
<td>Epidural: 0.125% bupivacaine + 2 µg/mL fentanyl 10 mL, 1% lidocaine 5 mL followed by 0.125% bupivacaine + 2 µg/mL fentanyl at 10 mL/h</td>
<td>No</td>
</tr>
</tbody>
</table>

CD: cesarean delivery; VD: vaginal delivery; ECV: external cephalic version; AH: autonomic hyperreflexia. *Deliveries 3 and 4 were the same patient.
24 h and the epidural was removed on the third postpartum day. After the epidural was removed, the patient described short episodes of AH. No blood pressure recordings were performed during any episodes and all resolved without intervention.

Three patients (33%) in this series had a history of venous thromboembolism and received anticoagulation during pregnancy. Two of these patients (Deliveries 6 and 8) were receiving low-molecular-weight heparin (LMWH) and one (Delivery 9) was treated with fondaparinux as she had a history of heparin-induced thrombocytopenia (HIT). Two patients (Deliveries 8 and 9) had an inferior vena cava filter in place. The two patients prescribed LMWH were switched to unfractionated heparin upon hospital admission and this was stopped before induction of labor or CD. Fondaparinux was discontinued in the patient with HIT 24 h before induction of labor and >72 h had elapsed between her last dose and the placement of her epidural catheter. All three patients had neuraxial anesthesia without bleeding complications. Bridging therapy with LMWH or fondaparinux was planned in two patients (Deliveries 6 and 9) until appropriately anticoagulated, at which point warfarin was initiated. The remaining patient (Delivery 8) was discharged on LMWH. No patient had recurrent thromboembolism during the peripartum period. The patient having Delivery 5 did not have a history of thromboembolism and was not using anticoagulants before delivery but was discharged home on a two-week course of prophylactic subcutaneous unfractionated heparin.

All patients had a history of recurrent UTI and were receiving prophylactic antibiotics during pregnancy. One patient (Delivery 5) developed a suprafascial wound dehiscence following CD but no signs of wound infection were noted. One patient (Delivery 7) had a prolonged hospital stay of 19 days with transfer to inpatient rehabilitation to improve her functional independence and assist in the transition to providing childcare to her newborn.

The rate of preterm birth before 37 weeks of gestation was 11% (1 of 9). Two infants (22%) were admitted to the Level II Nursery after birth (one for prematurity, low birth weight, and initial poor respiratory effort; one for initial respiratory depression). Mean neonatal weight was 2936 g [range 2280–3810 g]. Otherwise, neonatal outcomes were unremarkable.

Discussion

Cross et al. reported 22 patients with SCI who had 33 deliveries and only mentioned the type of anesthesia. We report the largest series of cases specifically describing the peripartum anesthetic management of patients with SCI. Six deliveries involved a trial of labor, resulting in three vaginal deliveries and three CDs. All three vaginal deliveries utilized epidural analgesia. The remaining six deliveries were via CD, with two patients receiving epidural anesthesia, two spinal anesthesia and two general anesthesia.

Sixty-seven percent of the pregnancies in this series resulted in a CD. This is higher than the overall national average of 32.8% reported by the Centers for Disease Control in 2011. It is also not consistent with previously published studies in patients with SCI which reported CD rates of 29–43%. Additionally, a retrospective review of patients without SCI who had Harrington rods for scoliosis correction had a CD rate of 38%. In our study, the indications for CD included breech presentation (n=1), history of urethral sling procedure (n=1), induction of labor resulting in failure to progress in labor (n=1) and non-reassuring fetal heart tracing (n=1), spontaneous onset of labor resulting in failure to progress in labor (n=1) and a history of AH in a patient who preferred CD (n=1). Of the six patients who underwent trial of labor in our study, five had labor induced. This high rate of induction may have contributed to our CD rate. Another contribution to this increased rate included AH as an indication for CD in one patient. It is important to note that the American College of Obstetricians and Gynecologists considers AH an indication for CD only when “AH during labor cannot be controlled by any means.”

Patients with SCI at the level of T6 or above are at risk for developing AH. Common triggers for AH result from sensory or painful stimulation below the level of the spinal cord lesion. Reflex motor outflow from the lateral horn causes spasm of pelvic viscera, arteriolar spasm resulting in hypertension, pilomotor spasm and diaphoresis. These reflexes are inhibited by outflow from higher centers in patients without SCI. The resultant hypertension is sensed by receptors in the aortic arch, carotid sinus and cerebral vessels, often causing reflex bradycardia through intact vagus nerves. Additionally, afferent outflow from the carotid sinus and aortic arch stimulates the vasomotor center, leading to vasodilatation in the head and neck. These regions are diaphoretic, warm and red while the remainder of the body is cool and dry.

The four patients without previous AH episodes did not manifest symptoms during the peripartum period. Of the four patients who had a history of AH before pregnancy, three had symptoms consistent with AH peripartum. One patient experienced AH during epidural placement and one experienced AH during the second stage of labor. In addition, all three patients noted AH symptoms in the postpartum period. No blood pressure measurements were recorded during these episodes, which emphasizes the need to educate staff about the risks of AH in SCI patients with a history of the disorder. All postpartum episodes resolved spontaneously and no interventions were needed.
Neither, awareness that AH is common in the postpartum period may influence obstetric and anesthesia providers to elevate the level of postoperative monitoring in high-risk patients. In patients deemed to be at very high risk for postpartum AH, maintenance of neuraxial anesthesia should be considered. In our series, one patient (Delivery 6) had multiple antepartum admissions for AH control. As such, she was deemed to be at high risk for postpartum episodes and was admitted to the intensive care unit for close hemodynamic monitoring. Further, her epidural infusion was continued for three days following delivery.

Although four patients experienced peripartum symptoms of AH, they did not have any permanent sequelae from the events. However, AH can be devastating as the sudden rise in blood pressure can cause retinal hemorrhage or fatal cerebral and subarachnoid hemorrhage. Previous reports have estimated that 60–80% of pregnant SCI women with lesions at T6 or above experience AH during uterine contractions with labor. Possible causes of postpartum AH symptoms include postsurgical pain, urinary bladder distension or uterine contractions. However, in patients with a higher SCI, lactation can also be a potential trigger.

Two patients had a level of injury of T4 or above. Therefore, the stimulation with lactation would be below the level of the spinal insult and could theoretically trigger AH.

One patient (Delivery 2) had a CD via general anesthesia to prevent AH. An elevated blood pressure was recorded during intubation and was treated with antihypertensive medications. We did not identify any circumstances where additional techniques, such as instillation of tracheal lidocaine, opioid administration, or preemptive treatment with antihypertensive medications, were used to blunt the hemodynamic responses to tracheal intubation. The airway and trachea are innervated by cranial nerves that should still be intact in all of the subjects of our investigation. Thus, afferent sensory stimulation during airway management should reach the brain unimpeded, limiting the potential for intubation to trigger AH.

Treatment of AH during labor can be managed in many ways. Prevention is ideal and inhibiting afferent impulses with neuraxial blockade has been successful: SCI is not a contraindication to its use. Previous case reports and series have recommended epidural anesthesia as an effective method to prevent AH.

Epidural meperidine has been reported to be successful, however, epidural fentanyl failed to control AH. Management of AH with intravenous anxiolytics and hydralazine is, however, often ineffective.

In our series, the patients who had epidural analgesia for labor received a continuous infusion of 0.125% bupivacaine with fentanyl 2 μg/mL to prevent AH. Some patients may have received patient-controlled epidural analgesia in addition to a continuous infusion. Other techniques can be used. Combined spinal–epidural (CSE) analgesia has the benefit of a subarachnoid bolus of medication for sacral coverage with subsequent epidural analgesia for the duration of labor. An intrathecal catheter would provide reliable analgesia in patients with a history of back surgery. In patients considered to be at high risk of postpartum episodes, vigilant monitoring and continued neuraxial analgesia should be considered. The placement of an intrathecal catheter may be advised in the case of an inadvertent dural puncture.

Invasive arterial monitoring of blood pressures should be considered in patients at risk for AH during the peripartum period. In this series, an arterial line was placed in three deliveries for hemodynamic monitoring at the discretion of the anesthesiologist. This decision should be based on the patient's history and severity of AH as well as the consistency of the noninvasive blood pressure cuff to obtain accurate blood pressure readings.

We were unable to deduce from the records how the level of block was determined in our patients, but possible ways include assessing for loss of reflexes and hemodynamic changes. Patients with AH are at risk of catheter dislodgement during an AH episode secondary to diaphoresis and traditional taping may not be adequate for securing an epidural catheter. The anesthesiologist may consider suturing the epidural catheter in place or using a liquid adhesive.

Pregnancy increases the risk of thromboembolism. Three patients had a history of DVT and anticoagulation was continued during pregnancy without DVT recurrence. All three received neuraxial anesthesia without complications. Adherence to the American Society of Regional Anesthesia and Pain Medicine (ASRA) guidelines for anticoagulation during neuraxial blockade should be followed. Specifically, the ASRA guidelines recommend that performance of neuraxial block in patients who recently received or will soon receive fondaparinux should be limited to controlled conditions similar to those of clinical trials (e.g., single needle pass, atraumatic placement, avoidance of indwelling catheters). However, one subject in our series (Delivery 9) received epidural analgesia in the setting of fondaparinux that was discontinued 72 h before block placement. This patient did not exhibit evidence of a spinal hematoma although signs and symptoms may be masked in patients with complete SCI.

Among our eight patients, seven had a history of spinal surgery and five had rod instrumentation. Epidural placement was unsuccessful in the patient having Delivery 2 who had previously undergone Harrington rod instrumentation. The patient having Delivery 8 also had Harrington rod instrumentation; she received a spinal block for labor analgesia as the anesthesiologist was concerned about difficult epidural placement.
When her labor failed to progress, she receive general anesthesia for the CD. In patients who have undergone spinal surgery, known complications include inability to identify the epidural space, subdural injection, accidental dural puncture, multiple attempts before catheter insertion and vascular trauma. One retrospective review reported 16 parturients with Harrington rod instrumentation for scoliosis correction. Among these 16, there were nine epidural catheter insertions and four were complicated by failure to identify the epidural space, intravascular puncture, dural puncture, failure to obtain analgesia or the need for multiple attempts before successful insertion. The increased incidence of failure and complications is theorized to occur as a result of ligamentum flavum injury during surgery. During healing, the epidural space may be partially or totally obliterated and this may interfere with the spread of local anesthetic in the epidural space, resulting in a patchy or failed block. The placement of an intrathecal catheter in the patient with Delivery 8 may have resulted in the avoidance of general anesthesia. In addition to difficult epidural placement in this population, there is the theoretical risk of infection of hardware and it may be advisable to avoid fused or adjacent levels of the back. Investigation into a patient’s surgical history, as well as assessment of her scar, is necessary before neuraxial blockade.

This study has all the inherent limitations of a retrospective case series, including charting omissions and uncertainty of reasons for management decisions. There is the possibility of missing clinically significant events that may not have been documented. During postpartum AH episodes, there was no documentation of vital signs at the time of symptoms. Finally, the group of patients is small, limiting conclusions that can be drawn.

Noting that the medications and doses given to the patients in this series are summarized in Table 2, recommendations for management of chronic SCI patients can be summarized as follows:

- SCI patients should be seen for antepartum anesthetic consultation before presenting for delivery. Their history of possible AH and spinal surgery, if performed, should be reviewed by a multidisciplinary team. Besides obstetricians and anesthesiologists, this team may also include representatives from maternal fetal medicine, physical medicine and rehabilitation, neurosurgical or orthopedic spine surgery, urology, and in severe AH cases, cardiology. Based upon whether a trial of labor is planned, appropriate analgesia, anesthesia, and intrapartum and postpartum monitoring should be discussed.
- Early neuraxial analgesia should be considered in patients in labor with SCI who are at risk for AH. We recommend the use of epidural analgesia, CSE, or intrathecal catheter placement for the prevention of AH.
- Because the goal of neuraxial labor analgesia is to block afferent noxious stimuli from reaching the spinal cord, local anesthetics should be used. Narcotic-only neuraxial techniques have not been effective at minimizing noxious stimuli from reaching the spinal cord.
- In insensate patients, the height of the block may be difficult to accurately assess. As such, we recommend close hemodynamic monitoring until the block is established.
- Loss of deep tendon reflexes in the lower extremities and the abdominal wall can estimate the level of a neuraxial block in insensate patients.
- Close hemodynamic monitoring during labor is paramount for patients with SCI, especially those with AH. Continuous intra-arterial blood pressure monitoring should be considered.
- For CD, a surgical plane of anesthesia should be obtained via neuraxial anesthesia or general anesthesia with meticulous hemodynamic monitoring for AH.
- Neuraxial epidural anesthesia, as well as close hemodynamic monitoring, should be continued into the postpartum period in patients at high risk for AH.

Chronic SCI impacts multiple organ systems and complicates peripartum obstetric and anesthetic management. Epidural analgesia may be useful to attenuate AH but does not completely eliminate risk, especially during the second stage of labor. In addition, episodes of AH were common in the postpartum period in our population. With appropriate planning, along with vigilant obstetric and anesthetic management, patients with SCI can experience childbirth with minimal risk.

References