

# **Perioperative complications in children undergoing selective posterior rhizotomy: a review of 105 cases**

BARBARA M. VAN DE WIELE MD, LORETTA A. STAUDT MSPT,  
EDUARDO H. RUBINSTIEN MD, PHD, MARK NUWER MD  
AND WARWICK J. PEACOCK MD

*Division of Neurosurgery, Departments of Anesthesiology and Neurology, University of California, Los Angeles, California, USA*

## **Summary**

Medical histories for 105 consecutive children who underwent selective posterior rhizotomy (SPR) were reviewed to determine the incidence and clinical significance of adverse events related to anaesthesia and surgery. No intraoperative or postoperative events with potential for lasting morbidity, nor life threatening events, were identified. Intraoperatively, the most common adverse events were moderate elevation of body temperature (13/105) and transient dysrhythmias (8/105). The most frequent postoperative complications were fever, marginal oxygen saturation in the absence of supplemental oxygen, and postcatheterization cystitis. Early surgical complications, such as wound infection, cerebrospinal fluid leak, haemorrhage, and bowel or bladder disturbance were absent in this series. Surgical technique and anaesthetic management are described.

**Keywords:** rhizotomy, cerebral palsy, spasticity, electromyographic response, complications; children

## **Introduction**

In recent years children with cerebral palsy (CP) and spasticity, that interfere with function or daily care, have benefited from selective posterior rhizotomy. This surgical procedure is designed to reduce spasticity by interrupting facilitatory afferent signals from stretch sensitive muscle spindles. Type IA afferents, which make monosynaptic excitatory connections with the alpha motor neuron pools, are a primary source of facilitation. By sectioning selected

posterior (sensory) spinal roots, IA input to the spinal cord is reduced. Only a portion of the rootlets are divided to avoid sensory disturbances. Reduction of spasticity is associated with improved joint range of motion and gait dynamics (1,2).

This retrospective study was undertaken to determine the incidence and clinical significance of adverse perioperative events in children undergoing SPR. Perioperative surgical and anaesthetic complications previously described in children undergoing SPR, e.g. sensory deficit, motor deficit, bowel dysfunction, bladder dysfunction, CSF leak, pulmonary complications, elevated body temperature, problems due to anaesthetic technique; and children with CP, e.g. slow emergence from

*Correspondence to:* Barbara M. Van de Wiele, Department of Anesthesiology, School of Medicine, University of California, Los Angeles, AS-356 Center for Health Sciences, 10833 LeConte Ave, Los Angeles, CA 90024, USA.

**Table 1**  
Diagnosis and functional status

|   | <i>No. of children</i> |
|---|------------------------|
| Diagnosis:                                    |                        |
| Spasticity associated with cerebral palsy     | 102                    |
| Spastic diplegia                              | 62                     |
| Spastic quadriplegia                          | 32                     |
| Spastic paraparesis                           | 6                      |
| Spastic triplegia                             | 2                      |
| Spasticity not associated with cerebral palsy | 3                      |
| Transverse myelitis                           | 1                      |
| Near drowning                                 | 1                      |
| Subarachnoid haemorrhage                      | 1                      |
| Functional status:                            |                        |
| Nonambulatory                                 | 26                     |
| Minimal stepping with support                 | 25                     |
| Independent ambulation with assist device     | 33                     |
| Independent ambulation                        | 21                     |

anaesthesia, problems with intravenous access and positioning due to spasticity, and hypothermia, were specifically examined (3–7). Potential risk factors for perioperative complications were sought (8).

## Patient and methods

This review comprises data collected from the charts of 105 children who underwent SPR at UCLA Medical Center between 1986 and 1991. Institutional approval for confidential chart review was obtained from the Human Subjects Protection Committee of the UCLA Medical Center. Patients studied ranged in age from three to 15 years (mean 5.2 years). A description of the patient population is provided in Tables 1 and 2.

Chart review included examination of all anaesthesia records for evidence of intraoperative anaesthetic or surgical complications. Clinically significant intraoperative deviations in oxygen saturation ( $\leq 85\%$ ), blood pressure (systolic BP  $\leq 70$ ) and cardiac rate (HR  $\leq 60$ ) and cardiac rhythm were evaluated. In 28 patients onset of nerve rootlet stimulation was precisely noted on the anaesthesia record. Anaesthetic requirements and changes in heart rate during nerve rootlet stimulation, were assessed in these 28 patients.

## Anaesthetic technique

Pharmacological premedication was administered to 66 children prior to surgery. Drugs used for

**Table 2**  
Medical, surgical, and anaesthetic history

|  | <i>No. of children</i> |
|--|------------------------|
| Medical history:                             |                        |
| Premature birth                              | 76                     |
| Neonatal mechanical ventilation              | 35                     |
| Intraventricular haemorrhage                 | 20                     |
| Strabismus                                   | 21                     |
| Seizures                                     | 19                     |
| Reactive airway disease                      | 15                     |
| Difficulty swallowing or clearing secretions | 7                      |
| Aspiration                                   | 2                      |
| Receiving anticonvulsant medications         | 14                     |
| Surgical history:                            |                        |
| Prior surgery (105 procedures)               | 68                     |
| Common procedures:                           |                        |
| Orthopaedic procedures                       | 21                     |
| Strabismus surgery                           | 18                     |
| Myringotomy                                  | 12                     |
| Inguinal hernia repair                       | 11                     |
| Ventriculoperitoneal shunt                   | 7                      |
| Anaesthetic history:                         |                        |
| Complications of prior general anaesthetics  | 8                      |
| Prolonged awakening                          | 1                      |
| Postoperative pneumonia                      | 1                      |
| Masseter spasm                               | 1                      |
| Dental damage                                | 1                      |
| Laryngospasm                                 | 1                      |
| Arrhythmia                                   | 2                      |
| Febrile episode                              | 1                      |

premedication included pentobarbitone, meperidine (pethidine), diazepam, midazolam, morphine, chloral hydrate and methohexitone. Anaesthesia was induced by mask inhalation of nitrous oxide (N<sub>2</sub>O), halothane or enflurane (one child), and oxygen (O<sub>2</sub>) in 80% of patients and by intravenous thiopentone in 20%. To facilitate tracheal intubation intermediate acting nondepolarizing muscle relaxants (vecuronium or atracurium), were used in 49 children, succinylcholine was used in 39 children, and pancuronium in two children.

Anaesthesia was maintained with N<sub>2</sub>O and an inhalation agent in 103 cases. In two children anaesthesia was maintained with a N<sub>2</sub>O narcotic technique because of suspected malignant hyperthermia susceptibility. Ventilation was controlled to maintain normocarbia as assessed by end tidal CO<sub>2</sub> monitoring by mass spectrometry. Ninety-one percent of patients received narcotics intraoperatively to supplement inhalation anaesthesia and provide for early postoperative

analgesia. Routine monitoring included electrocardiography (EKG), noninvasive blood pressure measurement, pulse oximetry, and end tidal CO<sub>2</sub>. Temperature was monitored using an oesophageal stethoscope with the temperature probe in the lower third of the oesophagus (Sheridan UC Sonatemp). In the recovery room intravenous narcotics were administered as needed for pain management. Water filled warming blankets and heating lamps were routinely used to maintain body temperature for paediatric cases during the time frame of the study.

### **Surgical technique and intraoperative monitoring**

After induction of anaesthesia, children are positioned prone with bolsters under the upper thorax and pelvis to prevent compression of the abdomen. Surgical drapes are elevated over the legs to allow access to, and visualization of, the lower extremities. The procedure involves an L2–L5 laminotomy with reflection of the upper portion of the sacrum to expose the nerve roots from L2 to S2. The surgical procedure has been described previously, but has been modified over the years to improve efficacy and safety (9–11).

During the procedure posterior spinal roots and their constituent rootlets from L2 to S1 or S2 are electrically stimulated (1). Simultaneously EMG is recorded from the five major lower extremity muscle groups bilaterally. Posterior rootlets associated with hyperactive responses to electrical stimuli of one second duration, at or near the threshold voltage, are divided and the remainder spared. Rootlets associated with incremental, clonic, multiphasic, or very irregular patterns to a steady train of stimuli are cut. Rootlets with responses in muscle groups which are not innervated at the level being tested, for example adductor responses when sacral rootlets are stimulated are usually divided. Responses sustained beyond the one second duration of the stimulus are also considered abnormal. Rootlets associated with absence of response, decremental responses, or squared responses are spared, particularly if the response is limited to the appropriate muscle groups. Suprathreshold voltages are avoided because spread of responses may occur under these conditions. Clinical judgement is

necessary, particularly when responses are equivocal. Excessive deafferentation is avoided and the child's clinical exam is also considered. Several measures are used to ensure that there is no interference with bowel and bladder continence. By operating at the level of the cauda equina, exact spinal levels are more easily determined. Corresponding anterior roots are visible and easily stimulated to confirm the proper identification of nerve root levels. A conservative approach to rootlet division is exercised when S2 levels are tested.

### **Statistical analysis**

Data abstracted from patient records were analysed using Excel statistical software (Microsoft). Changes in oesophageal temperature were calculated from a baseline temperature obtained after induction of general anaesthesia. Heart rate and temperature data were analysed using the Student's two tailed *t*-test for paired data. Data are expressed as mean  $\pm$  SD, with differences considered significant at  $P < 0.05$ .

## **Results: perioperative complications**

### **Intraoperative and recovery room course**

#### *Induction and positioning*

Four children exhibited problems during anaesthetic induction. One had laryngospasm which was successfully treated with succinylcholine; one vomited prior to tracheal intubation, was intubated without difficulty and did not aspirate; one had a transient wide complex tachycardia without hypotension; and one had masseter spasm after succinylcholine. Problems with positioning or difficulty establishing intravenous lines due to contractures were not noted. One child sustained a small abrasion of the eyelid which did not require treatment, and one patient was inadvertently extubated, prior to surgical incision, during placement of a pharyngeal pack.

#### *Anaesthetic technique*

In one of the two patients maintained with a pure N<sub>2</sub>O narcotic technique, EMG background activity was very high during nerve rootlet stimulation, despite generous narcotic doses (alfentanil

580  $\mu\text{g}\cdot\text{kg}^{-1}$  over 4.7 h) and midazolam and droperidol supplementation. Modification of anaesthetic technique to accommodate neurophysiological testing, by increasing or decreasing the inhalation agent administered, was recorded in 14 patients. The mean concentration of volatile agent used during the first half hour of nerve rootlet stimulation was  $1.38 \pm 0.49\%$  isoflurane and  $0.91 \pm 0.22\%$  halothane in the subset of cases in which onset of nerve rootlet testing was specifically noted on the anaesthesia record. Residual neuromuscular blockade was reversed pharmacologically, prior to nerve rootlet stimulation, in two individuals. One had received an intubating dose of pancuronium. In the other, neuromuscular blockade was maintained with incremental doses of vecuronium until immediately prior to nerve rootlet testing.

### Respiration

One child, with a history of reactive airway disease, had 'mild wheezing' intraoperatively. This episode of bronchospasm occurred as anaesthetic depth was reduced in anticipation of completion of the procedure. It was treated and resolved with increased inspired concentration of halothane and intravenous aminophylline. This individual was ultimately extubated without incident, spontaneously breathing on 1% halothane and oxygen. No other intraoperative problems related to ventilation and no instances of hypoxaemia (defined as oxygen saturation  $\leq 85\%$ ) were noted.

### Heart rate and rhythm

Cardiovascular changes noted during nerve rootlet stimulation included modest tachycardia relative to baseline, transient bradycardia and transient dysrhythmia. An 11.9% increase in heart rate (mean of values recorded q 5 min) was observed during the half hour after onset of nerve root stimulation, as compared to the half hour preceding nerve rootlet stimulation ( $117.2 \pm 13.4$  vs  $105.3 \pm 16.7$ ,  $P < 0.05$ ).

In four children, an association between nerve rootlet stimulation and haemodynamic changes or dysrhythmia was specifically noted on the record by the anaesthesiologist. Abrupt transient decreases in heart rate and blood pressure were noted during nerve rootlet stimulation in three children. In two of

these, a three year old child and a  $4\frac{1}{2}$  year old child, heart rate decreased to less than 60 beats per min and blood pressure decreased to 75 systolic. Atropine was administered to one of these two children. Another child anaesthetized with halothane developed premature atrial contractions and premature ventricular contractions during nerve rootlet stimulation with return to normal sinus rhythm after treatment with lignocaine, discontinuation of halothane, and maintenance with isoflurane. Two additional children had dysrhythmia (bigeminy and nodal rhythm) intraoperatively most likely during the period of nerve rootlet stimulation although specific notation of the association is lacking. Both children were anaesthetized with halothane. The nodal rhythm reverted to normal sinus rhythm after atropine. In the child with bigeminy normal sinus rhythm was reestablished after lignocaine administration, and replacement of halothane by isoflurane for maintenance of anaesthesia.

Two children had transient dysrhythmia not associated with nerve rootlet stimulation. These included transient wide complex tachycardia associated with normal blood pressure on induction of anaesthesia with halothane, and bradycardia after extubation. The latter was not associated with reversal of neuromuscular blockade nor hypoxaemia and resolved after administration of atropine.

### Body temperature

A tendency for body temperature to decrease after induction of anaesthesia and to increase gradually after surgical incision was noted. Comparison of the initial temperature, obtained after induction and the last temperature, obtained prior to emergence, revealed a mean increase of  $0.54 \pm 0.87^\circ\text{C}$  during the surgical procedure ( $P < 0.05$ ). Comparison of the lowest temperature measured after surgical incision and the last temperature obtained prior to emergence revealed a mean increase of  $1.06 \pm 0.67^\circ\text{C}$  ( $P < 0.05$ ). There was a weak correlation between change in oesophageal temperature and surgical time.

Intraoperative oesophageal temperature  $\geq 37.9^\circ\text{C}$  was recorded in 17 children,  $\geq 38^\circ\text{C}$  in 13 children and  $\geq 38.5^\circ\text{C}$  in six children. Interventions to moderate increases in body temperature, including turning off warming blankets, rectal acetaminophen (paracetamol),

cooling blankets, ice packs, decreasing room temperature and discontinuing airway humidification devices, were reported in 12 cases.

At the end of the surgical procedure, oesophageal temperature was greater than 34°C in all children, 28 children were mildly hypothermic (oesophageal temperature <36°C), and oesophageal temperature was less than 35°C in 11 children.

### *Emergence and extubation*

One patient vomited during emergence, while the tracheal tube was still in place, but did not aspirate. One had laryngospasm after extubation which resolved with continuous positive airway pressure by mask. Three children had prolonged awakening following termination of anaesthesia. One of these patients was anaesthetized with N<sub>2</sub>O and alfentanil because of suspected malignant hyperthermia. In this patient, suboptimal conditions during nerve rootlet stimulation led to droperidol and midazolam supplementation which may have contributed to prolonged emergence. One child was noted to have a 'croupy' cough after extubation and was treated with cool mist once in the recovery room.

### *Surgical complications*

No intraoperative surgical complications were noted. Operating time (incision to placement of surgical dressing) averaged 4.4 ± 0.7 h. Surgical blood loss averaged 8% of estimated blood volume. None of the patients studied required intraoperative blood transfusion.

## **Postoperative course**

### *Postoperative fever*

Low grade fever occurred commonly in the first 48 h after SPR. A maximum temperature (axillary) of 38.5°C or more was noted in 68% of patients in the first 24 h after surgery and in 62% of patients in the second 24 h. From 48 to 72 h after surgery, such temperature increases were much less frequent (10%). One hundred and one patients had Foley catheters placed after induction of anaesthesia. Of these, six female and four male patients (10%) developed

urinary tract infections postoperatively. All were successfully treated with antibiotics.

### *Airway and ventilation*

Early in the postoperative course, but after discharge from the recovery room, nine individuals required supplemental oxygen to maintain optimal oxygen saturation and four had stridor which was treated with vaponephrine (racemic adrenaline). Of the nine patients who required supplemental oxygen, eight had a history of premature birth, four had required intubation and ventilation as neonates, four had a history of bronchopulmonary dysplasia and one had reactive airway disease. Another patient, also with a history of reactive airway disease, was treated for postoperative bronchospasm with aminophylline. One child was noted to have a 'croupy' cough. Twenty-one patients had postoperative chest roentgenograms. Of these, 14 were within normal limits, six revealed atelectasis, and one revealed a possible right upper lobe infiltrate. The latter roentgenogram was obtained on postoperative day three when the patient, a six year old with spastic quadriplegia and severe developmental delay, spiked a fever to 39°C. The patient was started on intravenous antibiotics and defervesced. Postoperative mechanical ventilation or reintubation was not necessary in any of the patients.

### *Bowel function*

All patients were treated with intravenous narcotic analgesics as necessary in the paediatric intensive care unit and with oral narcotic and other analgesics after transfer to the ward. At some time during hospitalization, constipation was noted in six individuals. Three patients achieved resolution after initial laxative intervention and three were discharged on laxatives. Another patient, who was clinically asymptomatic, had the appearance of an ileus on abdominal x-ray obtained on the fifth postoperative day. The child was also discharged on laxatives.

### *Surgical complications*

No instances of wound infection, dural leak, haemorrhage, altered sensation of the lower

**Table 3**  
Perioperative complications

|  | <i>No. of children</i> |
|--|------------------------|
| Intraoperative:                                      |                        |
| Elevated temperature ( $T \geq 38^{\circ}\text{C}$ ) | 13                     |
| Dysrhythmia  | 7                      |
| Hypotension ( $\text{BP} \leq 60$ )                  | 1                      |
| Laryngospasm   | 2                      |
| Bronchospasm   | 1                      |
| Inadvertent extubation                               | 1                      |
| Emesis   | 2                      |
| Eyelid abrasion                                      | 1                      |
| Masseter spasm                                       | 1                      |
| Recovery:  |                        |
| Prolonged awakening                                  | 3                      |
| Postintubation croup                                 | 1                      |
| Postoperative:                                       |                        |
| Urinary tract infection                              | 10                     |
| Persistent nausea and vomiting                       | 2                      |
| Constipation   | 6                      |
| Ileus  | 1                      |
| Supplemental oxygen*                                 | 9                      |
| Stridor  | 4                      |
| Bronchospasm   | 1                      |
| Postintubation croup                                 | 1                      |
| Pneumonia  | 1                      |
| Incisional haematoma                                 | 1                      |

\* Required to maintain optimal oxygen saturation.

extremities or motor deficit, or bladder dysfunction, were evident prior to discharge from the hospital. Perioperative complications are summarized in Table 3.

## Discussion

### Perioperative anaesthetic and surgical complications

In the present series of 105 children the majority of adverse perioperative events were of minor clinical significance, transient in nature and without sequelae. Children with a history of neonatal lung disease due to prematurity or perinatal mechanical ventilation commonly exhibit some degree of residual pulmonary dysfunction, particularly airway hyperreactivity (12–14).

Seventy-two percent of the children in our series had a history of premature birth, and 33% had required mechanical ventilation as neonates. Thus perioperative complications related to underlying pulmonary pathology would be anticipated in this

patient population. Severe intraoperative respiratory complications, particularly aspiration and bronchospasm, occurred less frequently in this series than in previous published reports regarding patients undergoing SPR (3,4). The low incidence of perioperative bronchospasm in this series questions a recommendation that children undergoing SPR, who are at risk of bronchospasm, be routinely placed on aminophylline perioperatively (3,4). Prior reports also suggested an association between nerve rootlet stimulation and intraoperative bronchospasm (4) that was not apparent in the present series.

Bladder dysfunction was not evident at time of discharge in any of the 105 patients studied, supporting the efficacy of a conservative approach to nerve rootlet division at the S2 level. EMG monitoring of the external anal sphincter (pudendal nerve), was performed in four patients in this series. When stimulation of the posterior nerve rootlets at the S2 level results in anal sphincter muscle contraction, the rootlets are left intact regardless of ensuing response in lower extremity musculature. This technique, currently used at our institution, is thought to provide a further safeguard against bladder dysfunction.

### Anaesthetic technique

In the present series, with few exceptions, SPR was performed using inhalation anaesthesia, which did not compromise nerve rootlet testing. In lightly anaesthetized children, background spontaneous EMG activity is high, complicating analysis of reflex responses. As a result, the depth of anaesthesia during SPR is 'titrated' to a low level of background EMG. Use of isoflurane facilitates making rapid changes in anaesthetic depth.

Riegle and colleagues have noted severe muscle spasms during electrical stimulation of nerve rootlets in children anaesthetized, without inhalation agents, using nitrous oxide and propofol (6). Similarly, in the present series, conditions for analysis of response to electrical stimulation of nerve rootlets were markedly suboptimal in one of two patients anaesthetized with a pure nitrous oxide-narcotic technique. However, narcotic supplementation of inhalation anaesthesia, *per se*, does not appear to alter the response to electrical testing, if a comparable low background EMG activity is achieved.

Advantages of intraoperative narcotic supplementation include analgesia and suppression of the cough reflex, allowing for a smooth emergence from anaesthesia. Theoretically, coughing and straining during emergence could elevate lumbar CSF pressure and threaten dural closure.

Children with spastic CP are not at increased risk of succinylcholine induced hyperkalaemia (15). However, we have noted exaggerated muscle movements and muscle spasms, and rigidity due to muscle spasms may suggest malignant hyperthermia. Riegler and coauthors based on similar observations, concluded that succinylcholine is relatively contraindicated in this setting (6).

Although succinylcholine was used in 37% of patients in this series without apparent complication, prudence suggests limiting its use except for specific indications. To facilitate intubation and avoid the risk of altering EMG response to nerve rootlet stimulation, intermediate acting nondepolarizing neuromuscular blocking agents are a reasonable alternative.

### Cardiovascular response to nerve root stimulation

Because electrical stimulation activates not only proprioceptive, but also nociceptive and chemoreceptive afferents, some degree of cardiorespiratory change is expected during testing of the dorsal rootlets. Low intensity stimulation of large myelinated fibres has been shown to elicit bradycardia and hypotension in experimental animals (16). This may explain the transient episodes of bradycardia observed in three of the patients in this series. Animal studies have also demonstrated that high intensity stimulation, despite adequate anaesthetic depth, excites fine fibre afferents and initiates marked sympathetic responses (16).

### Intraoperative body temperature

Warming measures are routinely used in children to prevent hypothermia during general anaesthesia. The incidence of modest intraoperative hyperthermia in this series may be due to the combined effects of increased metabolic heat production, due to lower extremity muscle activity during nerve rootlet stimulation, and warming measures used, such as

warming blankets, warming lights and increased room temperature.

These data confirm a previous report of increased intraoperative temperatures during SPR and bolster the argument that aggressive warming measures be curtailed in this patient population (6). Interestingly, hyperthermia in response to emotional stress and exaggerated febrile response to infectious processes, possibly related to a defect in central control of body temperature, have been reported in children with severe disabilities due to CP (17).

### Postoperative fever

Low grade temperature elevations occur commonly after anaesthesia and surgery (18,19). Causes, excluding infection, include trauma to tissue, atelectasis, depression of tracheobronchial cilia with stasis of secretions, release of leucocyte toxins, resetting of the hypothalamic thermostat, and dehydration (20). In the present series of patients, postoperative fever (defined here as a temperature greater than or equal to 38.5°C) was common in the first 48 h following SPR. Febrile episodes, in the absence of confirmed aetiology, were usually attributed to atelectasis or chemical meningitis by the intensivists following the patients postoperatively.

### Conclusion

In the present series of children, adverse events with potential for lasting morbidity were absent. Anaesthetic technique and depth of anaesthesia influence muscle activity during nerve root testing in children undergoing SPR. Optimal conditions require communication between the neurophysiological monitoring team and the anaesthesiology team. Nerve root stimulation and muscle contraction also affect autonomic function. Potential elevation of body temperature intraoperatively warrants continuous assessment of body temperature and moderation of warming measures accordingly. A high index of suspicion for preexisting pulmonary disease and borderline postoperative respiratory function is indicated.

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