Original Article

Perioperative concerns in pediatric patients undergoing different types of scoliosis correction surgery: A retrospective observational study

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Abstract

Background: Advances in scoliosis surgery have now made it possible for younger patients to be taken up for scoliosis correction. **Objectives:** To ascertain the patient profile, perioperative complications and need for intensive care management in children undergoing posterior fusion and instrumentation (PF), anterior release (AR), and growth rod (GR) insertion surgery. **Patients and Methods:** After taking parental consent, data were collected retrospectively for 33 patients who underwent 37 procedures (four patients had both anterior and posterior procedures) on 2 days of the week mainly from August 2008 to February 2010 at a tertiary care institution. **Results:** Children undergoing GR surgery were younger (8.1 ± 2.1 years) than patients undergoing AR (12.9 ± 1.7 years) or posterior fusion (14.2 ± 2.2 years). AR children had a significantly higher Cobb's angle and more rigid curves. ($P = 0.057$) Associated congenital abnormalities especially neurological were commoner in the GR children. Surgical duration and blood loss was significantly more for PF (2207.5 ± 1224.13 ml) than GR (456 ± 337.5 ml), or AR (642.85 ± 304.72 ml), ($P = 0.0002$). PF patients needed Intensive care unit (ICU) care mainly due to the blood loss and prolonged surgery (35%). AR performed via thoracotomy was associated with the need for mechanical ventilation in 28.6%. The GR patients had major intraoperative hemodynamic events and 20% needed ICU care. **Conclusions:** Post-operative ventilation may be required in 20-35% patients undergoing procedures for scoliosis correction. Despite GR insertion involving lesser blood loss; younger age, congenital abnormalities, positioning, and surgical manipulation resulted in life threatening events in these patients.

Key words: Anesthesia for scoliosis surgery, growth rod insertion surgery, perioperative complications

Introduction

Scoliosis surgery performed to correct the abnormal curvature of the spine was traditionally performed in adolescents and involved doing a permanent fusion of the vertebral column with insertion of instruments (rods in hooks or pedicle screws) to help maintain the re-alignment post-surgery.[1,2]

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Advances in scoliosis surgery have now made it possible to treat younger pre-adolescent children with congenital scoliosis by using growth rods (GR) to stabilize the spine without permanently fusing it.[3]

The aim of this retrospective observational review was to assess the patient profile, co-morbidities, perioperative complications and need for post-operative ventilator support in children with scoliosis undergoing anterior release (AR) surgery, posterior fusion with instrumentation (PF) or GR insertion (non-fusion surgery) in our tertiary care hospital in India over a period of 1½ years.

Surprisingly no such data is available which can help in planning and allocating resources such as ICU beds for the post-operative management of these patients.

Materials and Methods

After taking parental consent, data were collected retrospectively

for 33 patients who underwent 37 procedures (4 patients had both anterior and posterior procedures) on 2 days of the week mainly from August 2008 to February 2010. Three patients undergoing AR were taken up for posterior instrumentation on a day of the week other than those included in this review.

The surgery performed depended on the surgical indications and decisions of the surgeons. The intra-operative anesthesia technique and post-operative management was left to the discretion of concerned anesthesia consultants. Independent anesthesiologists noted pre, intra, and post-operative details.

Depending on the procedure performed, patient data were analyzed as growth rod insertion or GR group, anterior release or AR group and posterior fusion and instrumentation group.

Results

The demographic data has been outlined in Table 1. Children undergoing non-fusion spine surgery (GR or Shilla procedure) were younger (8.1 ± 2.1 years) as compared to patients undergoing AR (12.9 ± 1.7 years) or PF surgery (14.2 ± 2.2 years). The number of vertebral segments involved were similar between the groups, however, children requiring AR had a significantly higher Cobb's angle as compared to patients undergoing the other two procedures ($P = 0.057$) [Table 1].

The association of scoliosis with kyphosis, double major curves or rigid curves was higher in patients undergoing AR (57.1%) as compared to other two procedures (GR insertion 20%, PF 30%).

Children undergoing GR surgery were more likely to have congenital scoliosis (90%) than those who underwent AR (57%) or PF (35%).

Associated congenital abnormalities were more common in GR patients (50%) as compared to patients undergoing the AR (30%) or PF (40%). Neurological abnormalities (tethered cord, diastomyelia or split cord, Arnold-Chiari malformation,

cisterna magna) were more common than cardiac abnormalities (aortic regurgitation, mitral valve prolapse, coarctation of the aorta, minimal thickening of the aortic valves with left ventricular hypertrophy). None of the patients had moderate-severe pulmonary artery hypertension on echocardiography.

Pulmonary function tests were performed for all except one adolescent (PF) and 4 young children (GR surgery) who were unable to cooperate. All others had restrictive lung disease, with diminution in forced vital capacity (FVC) and preserved peak expiratory flow rates (PEFR) [Table 2].

Induction of anesthesia was by the intravenous route in all except for the 4 young children (GR group) who received inhalational induction.

Intubation was difficult (grade III Cormack–Lehane laryngoscopic view) in two patients, one girl with Klippel-Fiel syndrome who had a short neck (GR), the other a boy with the rigid cervico-dorsal kypho-scoliosis (PF). In both these patients intubations were facilitated by using an elastomeric bougie.

Overall difficulty in internal jugular vein (IJV) cannulation was observed in 20% children, i.e., difficulty in localizing IJV or in threading guide-wire requiring more than two attempts by a skilled anesthesiologist, using the anatomical landmark technique. The anatomical landmark technique was used as ultrasound was not available at the time of the review. A peripherally inserted central catheter (PICC line) was common in children undergoing GR surgery. Difficult

Table 2: Pulmonary function tests

Parameters	Group I (GR)	Group II (AR)	Group III (PF)
PFT done/not done (*n*)	6/4	7/0	19/1
FVC (%)	59.17±13.35	61±25.61	71.95±21.57
FeV1/VC (%)	100.17±19.02	100.14±9.3	97.63±14.40
PEFR (%)	97.33±61.27	85±32.90	92.47±22.29

GR=Growth rod, AR=Anterior release, PF=Posterior fusion and instrumentation, PFT=Pulmonary function tests, FVC=Forced vital capacity, PEFR=Peak expiratory flow rates

Table 1: Demographic data

Groups	Group I (GR)	Group II (AR)	Group III (PF)
No. of patients (*n*)	10	7	20
Age (years)	8.1±2.13	12.86±1.68	14.25±2.2
Weight (kg)	22.3±8.56	35.14±0.58	39.1±7.92
Sex (M/F)%	20:80	43:57	40:60
Vertebrae involved (*n*)	8.4±3.17	9.57±5.83	9.75±3.48
Cobb's angle (degrees)	55.5±9.55	92.57±32.90	77.6±23.95
Scoliosis: Severe scoliosis (%)	80:20	43:57	70:30
Congenital: Idiopathic: Secondary scoliosis (%)	90:10:0	57:43:0	60:35:5
Associated congenital abnormality-none: Neurological: Cardiac (%)	50:40:10	70:15:15	60:25:15

GR=Growth rod, AR=Anterior release, PF=Posterior fusion and instrumentation

radial artery cannulation, defined as requiring more than two attempts for cannulation by a skilled anesthesiologist was observed in 20% patients.

Eleven patients underwent neurophysiological monitoring. Eight patients underwent somatosensory evoked potential (SSEP) monitoring, whereas, motor evoked potential (MEP) monitoring was carried out in three patients. Total intravenous anesthesia was used in four patients, balanced general anesthesia was used in the rest, and seven patients received a combination of inhalational agent (0.6-0.8 inspired isoflurane concentration) and propofol infusion (100-150 mcg/kg/min). In patients undergoing MEP monitoring, muscle relaxant use was restricted, guided by neuromuscular transmission monitoring.

Intraoperative and post-operative analgesia was mainly provided using fentanyl infusion. Two patients in the PF group were administered morphine infusion. The opioid infusions were supplemented with paracetamol and NSAIDs for 3-4 days post-surgery. The patients were managed in a high dependency unit during this time and oxygen supplementation, monitoring of heart rate, respiratory rate, oxygen saturation, and intermittent non-invasive blood pressure was carried out.

Intraoperative parameters have been outlined in Table 3.

Discussion

The duration of the procedure, blood loss, and perioperative complications were significantly more with the posterior fusion and instrumentation (PF) surgery [Table 3]. This is because the surgical procedure is extensive. It involves decorticating laminae, destroying facet joints and spinous processes of 10-14 abnormal vertebrae forming the scoliotic curve to facilitate spine fusion. In adolescent patients with severely deformed, rigid curves, the surgery can involve resection of hemivertebrae, ribs that form the rib hump and even the entire vertebral bodies (vertebral column resection).[4]

This fact accounted for 45% of the PF surgery patients in the present series developing massive blood loss and hemodynamic signs of hypovolemia. Consequently, the intra-operative requirements of packed red blood cells, plasma and (FFPs),

starch and crystalloid insfusion were significantly more in this group as compared to others despite all patients being administered tranexamic acid (10 mg/kg IV bolus followed by 1 mg/kg/h infusion).[5] Of the seven patients requiring post-operative ventilatory support in this group, 4 needed ICU care mainly due to prolonged surgery and massive blood loss.

In procedures such as GR insertion or Shilla's procedure the growth potential of the spine is preserved and decortication and fusion of the all the vertebrae forming the scoliotic curve is not carried out. In Shilla's procedure only the apex of the curve involving 2-3 vertebrae is fused. The remaining spine is allowed to grow in a controlled fashion so that the child can achieve full height and thoracic capacity.[3]

In addition, the instrumentation varies;, in PF, bilateral pedicle screws are inserted into multiple vertebrae along the scoliotic curve, tungsten-steel rods are fitted in the heads of these screws and the scoliotic curve straightened intra-operatively by controlled distraction or straightening of the rods. This procedure results in considerable force being applied in the operative area.[6]

In GR surgery, the pedicle screws are inserted in 1-2 vertebra above and below the scoliotic curve and GRs are inserted and fixed in these screws. Gradual straightening of the rods is used to correct the spinal curvature. On an average only 50% of the curve is corrected during the initial surgery, subsequently the rods are distracted by a centimeter or so every 6 months to a year to keep up with the child's growth.[3]

Therefore, GR surgery involves limited cutting, instrumentation, and blood loss. Despite this fact three children undergoing this procedure developed severe hemodynamic complications. One developed hypotension on being turned prone, another developed severe bradycardia on vertebral column distraction, which responded to atropine and gentler surgical handling. The third developed severe bradycardia on vertebral column manipulation, which initially responded to atropine, but on manipulation of the other side, patient developed ventricular tachycardia (VT) and transient cardiac arrest that necessitated turning her supine for resuscitation. Echocardiography following the event revealed left ventricular hypertrophy in this child.

Table 3: Intraoperative parameters

Parameters	Group I (GR)	Group II (AR)	Group III (PF)	*P* value
Duration of anesthesia (min)	298.5±80.14	285.71±117.9	472±114.8	0.0001
Duration of surgery (min)	228±70.9	197.14±59.0	375.75±93.7	0.0000
Blood loss (ml)	465±337.5	642.86±304.7	2207.5±1224.1	0.0001
PRBC Transfused (ml)	360±388.6	400±374.2	1265±732	<0.05

GR=Growth rod, AR=Anterior release, PF=Posterior fusion and instrumentation, PRBC=Packed red blood corpuscles

Soliman *et al.* reported similar severe hypotension requiring postponement of surgery in 2 out of 12 pediatric patients who were turned prone for scoliosis surgery.[7] One of these children similar to our patient developed VT needing resuscitation. Repeat surgery with transoesophageal echocardiography revealed left ventricular hypertrophy and markedly decreased left ventricular end diastolic and systolic volumes. Decreased ventricular distensibility in the prone position[8] combined with the compression of the inferior vena cava was postulated to be the reason for the observed hemodynamic instability.[8-11]

In another observational study carried out in 80 adults and children undergoing posterior fusion, Bernard *et al.* found that vertebral manipulation in the prone position was associated with 51 episodes of sudden fall in mixed venous saturation that occurred at least once in 35 patients.[6] Twenty of these episodes were associated with a 15% fall in blood pressure that necessitated stopping, modifying the manipulation, administering atropine for bradycardia (seven patients) or vasopressors for hypotension (three patients). These hemodynamic events were attributed to the compression of the heart against the sternum-rib cage and to decreased venous return caused by the stretching of the inferior vena cava during the surgical manipulation in the prone patients.

In addition to the GR surgery patients, one patient undergoing PF and three patients undergoing AR developed episodes of bradycardia (heart rate 45, 48, 56 beats/min) and hypotension (systolic 60-70 mmHg) on vertebral column distraction that necessitated either temporary cessation of the surgical stimulus or atropine administration. The responses in GR children may have been exaggerated because they were younger, with smaller thoracic cavities and more congenital anomalies (left ventricular hypertrophy disregarded on a cursory pre-operative echocardiography). After these episodes, the rolls that were used for supporting patients prone were changed to foam rolls that were softer and less rigid.[11]

As patients undergoing AR have higher Cobb's angles and more rigid curves, they required a thoracotomy and anterior mobilization of the abnormal vertebra for a three dimensional correction of the deformity.[12,13] All the above may contribute to post-operative respiratory complications and need for ventilatory support observed in these patients.[14]

In this series two such patients were observed. One was a 12 year old (Cobb's angles of 110°) with poor preoperative effort tolerance and pulmonary function tests (PFT) suggestive of severe restrictive lung disease (FVC 18%, FeV1/VC ratio 106%, peak expiratory flow rates (PEFR) 34%), with no prior history or signs of chest infection. However, on thoracotomy patches of consolidation and caseous matter

were seen in the lung (no evidence of tuberculosis was found on post-operative analysis). Saline lavage of the thoracic cavity at the end of surgery resulted in severe bradycardia, hypotension and a transient cardiac arrest. The hemodynamic parameters stabilized on atropine administration. The patient was mechanically ventilated in the ICU and extubated 3 days later.

The second patient had a good effort tolerance (Cobb's angle 136°, FVC 41%, PEFR 69% of predicted) and underwent both de-tethering of the cord and AR in the same sitting. This resulted in a prolonged procedure (6.5 h), massive blood loss and hypothermia. She was electively ventilated but could be extubated only on the 8th post-operative day.

Therefore, provision of post-operative ventilatory support in the ICU is essential for patients with high Cobb's angles undergoing AR surgery, even though the procedure and blood loss may not be as extensive as observed with PF. Surprisingly both the above mentioned patients did not need ventilatory support after PF surgery.

An under-developed thoracic cage and subclinical myopathy could be the reason a patient with a Cobb's angle of 70° (PF surgery) who was initially ventilated following prolonged surgery and massive blood loss, could not be weaned off the ventilator despite multiple attempts. He went on to develop pneumothorax, and ultimately was weaned off on the post-operative day (POD) 13 after being tracheostomised. This may also be the reason for an 11 year old with no identifiable syndrome or myopathy undergoing GR insertion developing a strained respiratory pattern following fentanyl administration. She was managed using the non-invasive continuous positive airway pressure (5 cm H_2O) for 3 days, opioids were avoided and ketorolac supplemented for pain, her subsequent hospital course was uneventful.

A 12-year-old boy undergoing PF was found to be drowsy and unresponsive on the 2nd post-operative evening. Cerebrospinal fluid was seen to be oozing from the surgical wound and computed tomography (CT) scan showed dilatated ventricles. He was administered acetazolamide and taken up for emergency revision of the ventriculo-peritoneal shunt. His pre-existing shunt had probably got displaced with straightening of the spinal curvature. He made an uneventful recovery thereafter. Therefore, careful monitoring in the post-operative period is essential as unexpected complications can occur at any time.

Two PF patients were found to have developed paraplegia in the immediate post-operative period despite SSEP monitoring. In one patient, the articular facet of the 8th thoracic vertebra was found to be impinging on the upper lamina on CT scan),

and an immediate wide laminectomy resulted in partial recovery of lower limb motor function (3/5 left, 5/5 right). In the second patient, no obvious cause was visible on CT scan. Despite the performance of a de-compressive laminectomy, the patient (congenital scoliosis) did not regain motor power and died suddenly on POD 21 probably due to the massive pulmonary thrombo-embolism.

SSEP monitoring identifies injuries of the dorsal (sensory) part of the spinal cord alone. This can result in a patient developing motor weakness and paraplegia despite a normal SSEP trace.[15] This led to monitoring of the MEPs in the subsequent patients in our series. A combination of MEP and the SSEP monitoring is preferred and planned for future cases as it would help better in detecting inadvertent spinal cord damage.[15]

Two patients (PF and GR) developed post-operative epigastric pain, which was found to be gastritis on investigation. However, superior mesenteric artery syndrome can have a similar presentation following scoliosis surgery and a high index of suspicion should be maintained as early diagnosis and surgical intervention can be lifesaving.[16]

To conclude posterior fusion surgery was associated with more blood loss, perioperative complications, 35% patients needed ventilatory support. AR performed via thoracotomy in patients with more rigid curves was associated with the need for mechanical ventilation due to respiratory insufficiency in 28.6% patients. The young age, congenital anomalies of GR patients made them susceptible to major intra-operative hemodynamic events (20% needed ICU care). Limitations of the review were the small sample size and the fact that patients operated only during a certain period were included in the series.

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