The anesthesia management of Harrington rod-spinal fusion procedure for idiopathic scoliosis

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Harrington rod instrumentation with spinal fusion has proven to be of great value in correcting idiopathic scoliosis—which is not only physically unattractive but a cardiorespiratory crippler as well. The author details the pre- and intra-operative anesthetic considerations necessary for these cases, emphasizing such areas as positioning, fluid and blood replacement, and obtaining adequate muscle relaxation.

The scoliotic child who presents for surgical correction by Harrington rod-spinal fusion is a poorer risk patient than most pediatric patients we routinely work with. They require an extensive preoperative work-up by the orthopedist, pediatric staff, and anesthetist. Intraoperative care must be precise and detailed.

The first hours of recovery and early postoperative care are critical. Postoperative complications are many and need to be watched for.

The purpose of this article is to discuss the various aspects of anesthetic management for the scoliotic child, his pathology, his preoperative preparation, course of anesthesia, and early postoperative concerns.

Pathophysiology

The orthopedic deformity of scoliosis has been described and treated for many years. Hibbs began surgical treatment for scoliosis in children around 1914, and became a leader in its correction. The pathology is prevalent in pre-adolescents and adolescents, with females having a four-to-one greater incidence than males. Idiopathic scoliosis, as its name implies, has no known cause. One must treat the resultant lateral curvature in idiopathic scoliosis while the vertebral column is still undergoing growth as the curvature tends to progress quickly during periods of rapid growth.

Donaldson defines scoliosis as “any lateral curve, tilt, or angular deviation of one or more vertebral segments of the spine from the normal straight position.” Scoliosis can be viewed as either functional, that is, a condition that the patient can correct and maintain without intrinsic spinal involvement, or structural, that is, with intrinsic involvement of spinal segments. According to Cobbs’ classification, structural scoliosis can be grouped as (1) osteopathic, (2) neuropathic, (3) myopathic, and (4) idiopathic.

Knowing the etiological factors in your patient’s condition permits a quicker initial treatment whether it be frames, turnbuckle casts, body casts, or surgical instrumentation. It is beyond the focus of this article to go into detail on the various known etiologies, their impact on correctability, and courses of therapy in their amelioration. The reader
is directed to the bibliography for sources describing pathophysiology and treatment for non-idiopathic scoliosis.

Scoliosis has a marked effect on both cardiovascular and pulmonary functions. The degree of spinal curvature has a direct relationship to these effects. Shannon, et al\(^4\) and Risenborough\(^5\), in two separate studies, found that scoliosis is a progressive disease. As it progresses, pulmonary function becomes impaired followed by a cardiovascular work overload with resulting right heart failure. Congenital heart defects resulting from Friedreich’s ataxia, Marfan’s syndrome, or torsion of pulmonary artery and aorta further compromise adequate cardiac function.\(^6\)

The lateral curvature of the thoracic vertebrae creates pulmonary function problems. There is less chest compliance, a restriction on rib expansion, and a resultant decrease in vital capacity (VC) and total lung capacity (TLC). This restriction on chest excursion creates severe problems in most scoliosis patients, particularly those with curves greater than 60°-80°. These children can have as much as 40% reduction in pulmonary function.\(^2\)

The idiopathic scoliosis patient has retained most of his intercostal and diaphragmatic muscular strength, but the overall chest deformity creates enormous work for these muscles. The ribs are not allowed a full range of motion, both anterio-posteriorly and superiorly on deep inspiration.

All parameters of pulmonary function are decreased markedly. The residual volume and physiologic dead space are increased as is the \(V_D/V_T\) with accompanying right to left shunting of unoxygenated blood. Arterial blood gas analysis shows abnormal alveolar gas exchange with signs of hypoxemia and hypoventilation present. The ventilation-perfusion ratio demonstrates a sharp change in tissue perfusion with abnormal ventilation.\(^4,5,7\)

Shannon notes that when patients are examined erect, the perfusion is more uniform throughout the lung fields rather than greater in the dependent portions as expected. In his study group, ventilation of lung tissue was found to be different in 23 zones.

Due to the seriousness of the cardiopulmonary embarrassment, nonsurgical treatment is usually attempted before more elaborate surgical procedures are initiated. In some scoliosis treatment centers, various types of frames, braces, and body casts are used to re-align the spine.\(^1,8,9\) At Durham County General Hospital, Durham, North Carolina, we have found there is no need for these devices prior to surgery in most cases. Body casts and braces are cumbersome and limit accessibility to the anesthetized patient. We believe the best choice of treatment of idiopathic scoliosis is the Harrington instrumentation with spinal fusion.

Briefly, the Harrington rod procedure consists of placement of a slender threaded rod along the patient’s dorsal spine bilaterally. The rod on the concave side produces distractive forces while the other rod gives compression with hooks on the inferior articular processes of the vertebrae.

When the forces of distraction and compression are suitably applied and the instrumentation found to be tight, a spinal fusion is carried out over the decorticated spinous processes and rods. The usual donor site for the graft is the pelvic ilium. Our surgical procedure closely follows that described by Harrington in his 1962 work\(^10\) and his later reports.\(^11\)

**Preoperative evaluations**

Preoperative evaluation studies are essential in preparation of the pediatric scoliosis patient for surgery. CBC with differential, prothrombin time, partial thromboplastin time studies, and electrolyte panel (SMAC-20) are routine blood tests. Eight units of whole blood are typed and cross-matched for surgery. Routine urinalysis is done. Some patients, particularly adolescents, have arterial blood gases done. All have pulmonary function studies to determine
Table 1
Preoperative evaluation studies

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| Chest x-ray | VC, TLC, and residual lung capacities.

A 12-lead electrocardiogram is done and read by a cardiologist. He examines the patient and prepares a consultation note detailing any cardiovascular problems and suggests intraoperative and postoperative care. A pediatric consultation is also requested. Chest x-rays and spinal films are taken and read by a radiologist.

Anesthesia work-up

The anesthesia work-up begins with a thorough interview with the patient and his parents. The patient’s pertinent medical history is explored, including a review of the major systems: cardiovascular, respiratory, and renal. Past drug allergies and current medications are noted. Previous anesthesias are discussed and any sequels noted.

An important part of the anesthesia interview is the development of a good rapport with the patient and his parents. They are often anxious, unsure of their decision and of the surgical risks involved. They need much psychological support and someone with whom they can verbalize concerns and place trust. We discuss our anesthesia plan with them and review the preoperative time schedule. Procedures such as IV’s, cardiac monitoring, and anesthesia induction are briefly explained. As a result of these efforts, our scoliosis patients are more at ease and are better able to tolerate unpleasant procedures in the operating room.

Premedication is usually left up to the surgeon and his staff. Diazepam (5-10 mg) IM 1-hour prior to induction has been most successful. The combination of meperidine-promethazine or secobarbital have been of benefit in selected patients. An anticholinergic drug is given to patients up until the age of 10 or 12. If indicated, atropine is given to adolescents in the operating room prior to induction.

On the morning of surgery, the anesthesia team reviews all the laboratory data, x-ray reports, consultations, and interview material to draw up a course of anesthesia for the pediatric scoliosis patient.

We have found a conventional approach of inhalation agent (Fluothane®, enflurane), N₂O-O₂, depolarizing relaxant (succinylcholine) with thiopental for induction to be a simple, easily managed anesthetic plan for most of our patients. Balanced anesthesia of narcotics (meperidine, Innovar®-fentanyl), long acting non-depolarizing relaxant (D-tubocurarine or pancuronium) and N₂O-O₂ with thiopental for induction adds flexibility to our anesthetic armamentarium, and has proved to be as suitable as conventional inhalation agents.

Next, the following pieces of equipment and supplies are gathered for use. These include:

- anesthesia machine with circle filter and CO₂ absorber
- EKG monitor
- arterial pressure monitor with transducer

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heparin flush solution (NaCl 500 cc with 1000 units heparin)
- blood warmer with pressure pump
- oxygen analyzer
- Williams bacterial circuit filter
- sterile disposable cuffed endotracheal tubes
- esophageal stethoscope with temperature probe
- blood pressure cuff of appropriate size
- pillows and arm rests for prone position

On arrival in the operating room, the patient is prepared in the usual fashion. A no. 16-gauge intracath is introduced into the left hand or forearm. After baseline vital signs are obtained, a sleep dose of thiopental (200-300 mg) is given, followed by succinylcholine (.5 mg/kg for adequate muscle relaxation. A cuffed Murphy orotracheal tube is introduced.

After breath sounds and chest expansion are checked, the patient is placed on a positive pressure volume ventilator with tidal volume of 10 cc/kg. Esophageal stethoscope and temperature probe are placed for monitoring. A no. 18-gauge intracath is placed in the right radial artery and attached to a pressure transducer and monitor bank. A no. 14-gauge intracath is also inserted in the right forearm for blood transfusion. Anesthetics are given according to the anesthetic plan decided upon earlier.

The patient is then carefully turned to the prone position. Particular attention is paid to proper positioning of the patient. Parallel foam rubber pads are placed in the center of the table with the patient’s body resting on them with main support from the shoulder to the anterior iliac crest. The legs are flexed slightly, and the arms are folded at shoulder level on a large support board that is well padded. After proper positioning is completed, the transfusion of the first unit of blood is begun.

Intraoperative considerations

There are four areas one must pay close attention to during the surgery.

One area has been discussed, proper positioning in the prone position. This cannot be over emphasized. Keeping pressure off the midline of the chest and abdomen allows for better venous return, decreased venous oozing, and decreased blood loss. The anterior bony prominences must also be protected as well as eliminating positions that strain nerve plexuses.5,12

Blood loss and and fluid maintenance are critical considerations for Harrington rod-spinal fusion procedures. These patients have a normal blood volume of 65-75 cc/kg, depending on age. One must remain 200-250 cc ahead of the blood loss throughout the operation. If blood loss exceeds replacement volumes, the surgery should be momentarily stopped and the difference in blood volume made up.12

Gardener13 notes that most of the bleeding occurs as a result of soft tissue losses, not decortication of bone. Harrington’s research notes an average estimated blood loss (EBL) of 840 cc while Gardner finds the EBL to average 1825 cc (1650 cc-2050 cc) or 44% of patient’s initial blood volume. The patient must be kept normovolemic and normotensive. It is maintained in that state only with careful observation of blood loss and prompt whole blood replacement.

Keeping the patient normovolemic requires ongoing assessment of blood loss and replacement levels. The blood loss must be checked in the wall suction (with deduction of irrigation fluids used), in the wound often packed off with sponges, sponges used, and the drapes for adequate estimation. Weighing sponges is one accurate determination of blood loss, but it requires a circulator’s complete attention. Weigh a dry sponge, record it’s weight and weigh each of the wet sponges as quickly as possible. We allow 1 mg/cc of blood in the sponge.

A second method offers more simplicity, is quicker, and more accurate. For each 4x4 saturated sponge, we allow 10 cc blood loss; and for each lap tape,
we allow 100 cc if saturated. This measurement is somewhat subjective, yet we find our estimates are accurate; and postoperative hematocrits are slightly below preoperative values. The patient is normovolemic or slightly hypovolemic. No overloading of the circulation has been observed by this method in more than 200 cases.2

Due to multiple transfusions, all blood is filtered through a microaggregate filter (Johnson and Johnson Co.) and is warmed to body temperature before reaching the patient’s circulation. Warming the blood helps maintain the patient’s body heat and prevents temperature drops of 90°-91° F. Microemboli are also eliminated by low-porosity blood filtration.

The third consideration is to maintain your patient under light general anesthesia by inhalation agents or narcotics with succinylcholine or long-acting relaxants. We have had marked success with low concentrations (.5-.8%) of Fluothane® or meperidine IV (1 mg/lb/4 hrs). A group of orthopedists at Children’s Hospital in Boston have reported awakening their patients during surgery to check for neurologic sequelae.14 We, however, maintain our patients throughout the case under light general anesthesia and awaken them only at the end of the case.

The fourth point of intraoperative care is the completion of surgery and the body cast application. Once the skin incision is closed and dressed, the posterior body cast is applied. At this point, two factors must be considered: the patient must not move, buck, or strain when turned to supine, and he must be awake after the cast is completed so neurological assessment can quickly be made. If a non-depolarizing relaxant is used, a maintenance dose should be repeated 30-45 minutes prior to turning the patient.

Once turned, the patient is adequately suctioned, is extubated apneic, and then reversed with a prostigmine-atropine mixture. If a succinylcholine drip has been used as a relaxant, the drip must be increased just before turning. The patient is extubated in the supine position. At this time, the succinylcholine drip is stopped, and the patient is ventilated by mask. It is essential that the patient does not buck or cough on the orotracheal tube as any movement could possibly dislodge the rods. The anesthetic agents are turned off.

After the complete body cast has been applied, the patient is awake enough to cooperate and obey commands; and the neurological examination is carried out. He is then moved to the recovery room for observation and later transferred to surgical intensive care for 48-72 hours.

Postoperative complications
In the early postoperative period, several severe complications can occur. As a result of excessive spinal column correction, nerve palsies and even paraplegia can result. Treatment involves a speedy return to surgery and removal of the rods. Hypovolemia, resulting in hypotension, is a direct result of inadequate blood replacement and an indirect result of a developing hematoma in the wound.

These patients continue to ooze blood for 24 hours or more and postoperatively may require an additional unit of whole blood. A hematocrit is done in the recovery room to further assess fluid replacement needs.2 Care must be exercised in medicating patients with analgesics. Most narcotics, especially meperidine or morphine, can depress the respiratory drive of these children. One must be judicious in the use of narcotics.6,15,16

Conclusion
Surgical treatment of the scoliosis patient is a graphic illustration of team planning, management, and follow-up care. It is a combination of the major resources in a hospital: the staffs of the laboratory, x-ray department, and operating room; orthopedists and anesthesiologists. Thorough pre-planning and detailed, conscientious anesthetic man-
agement are essential. A successful correction is the great reward for the time and effort put forth by the entire team.

REFERENCES
(2) Coonrad, R. W., MD. 1977 Personal Communications.

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Randel Keith Temples, CRNA, BSN, is a 1973 graduate of Wake Forest University, and 1975 graduate of the University of North Carolina at Chapel Hill School of Nursing. This paper was written at the time he was a senior student at Durham County General Hospital School of Anesthesia for Nurses, Durham, North Carolina, and was submitted for publication at the recommendation of the Chairman of the Department of Anesthesiology, Michel Bourgeois-Gavardin, MD. Mr. Temples is currently a staff nurse anesthetist at Moses Cone Hospital in Greensboro, North Carolina.