Case Report

Open Access Journal of
Biomedical Science
ISSN: 2690-487X

Perioperative management of Adolescent Idiopathic Scoliosis: Posterior Spinal Fusion of 14 Segments with A Foreseen Blood Loss of 2000ml (57% of Total Blood Volume of the Patient) Without Transfusion

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ABSTRACT

Adolescent Idiopathic Scoliosis (AIS) is a disease of the spinal column that affects up to 3% of pediatric patients at puberty. In most cases it can be managed conservatively and only a minority develop severe deformities which compromise neurological, pulmonary, cardiac and psychosocial function, requiring surgical management. The main complications of this highly complex operation, which needs careful planning and preparation, is excessive blood loss needing transfusion, and neurological injury. We present the case of a 15-year-old male who underwent a bloodless 14 spaces, instrumented posterior spinal fusion without any complications. All the pillars and means of patient blood management (PBM) and meticulous minimally invasive (MISS) surgical technique were applied to achieve a successful result. The dissemination of the management of complex cases like the one we describe, may help other teams worldwide when faced with similar challenges.

KEYWORDS: Adolescent idiopathic scoliosis; Posterior spinal fusion; Patient blood management; Acute hypervolemic hemodilution; Controlled hypotension; Tranexamic acid; Intraoperative cell salvage; Allowable blood loss; Restrictive transfusion trigger; Perioperative iron supplementation

INTRODUCTION

Adolescent Idiopathic Scoliosis (AIS) is a disease of the spinal column characterized by a three-dimensional deformity (coronal, sagital and axial). It has an incidence of 2-3% of the pediatrics population between the ages of 10 and 18 years old, and its treatment is internationally standardized depending on the degrees of the curves, their timeline progression and spinal maturity. The management of curves that have reached a pre-established severity (Cobb angle greater than 40º and have not responded to treatment with an orthesis) is surgical: an instrumental arthrodesis to correct the deformity and prevent deterioration of pulmonary and cardiac function. The most frequent complication of the operation is excessive blood loss. Different surgical and anesthetic techniques have been developed to reduce it. In the case report we present, we combined all the approaches of Patient Blood Management (PBM), starting at the moment of indication of surgery and continuing until the definitive discharge of the patient, to perform a procedure with a foreseen 57% total blood volume (TBV) (2000ml) loss, without recurring to allogenic blood product transfusion. Specific anesthetic and minimally invasive surgical techniques (MISS) were used [1-5].

CASE DESCRIPTION

We present 15 years old (50kg, 160cm, body mass index 19,5 kg/m2, total body surface 1.49m2), Latino male with AIS of the thoracolumbar spine (T2-L4) with curves of 78º and 42º

Quick Response Code:

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Received: January 22, 2022 **Published:** February 14, 2022

How to cite this article: Hanna PC, Patricia SM, Perioperative management of Adolescent Idiopathic Scoliosis: Posterior Spinal Fusion of 14 Segments with A Foreseen Blood Loss of 2000ml (57 % of Total Blood Volume of the Patient) Without Transfusion. 2022- 4(1) OAJBS.ID.000397.
DOI: 10.38125/OAJBS.000397

respectively, associated with a moderate restrictive - obstructive respiratory insufficiency (FEV12,11L (61,5%), FVC 2,74L (62,5%), with a positive bronchodilator test (increase in FEV1 of 11,8% (250ml), whose instrumented posterior spinal fusion (PSF) of 14 segments was performed at our hospital (a national reference center) in March 2021. In May 2019, the patient who was 13 years old at that time, developed a 40º thoracic curve which was initially treated with a permanent plaster brace for 6 months. By November 2019 the curve had progressed to 60º and a new permanent plaster brace was applied. It was ill fitting and badly tolerated by the patient, causing him constant discomfort, and it was changed after three months. At this stage the thoracic curve had progressed to 72º and a 30º lumbar curve developed. The patient was again braced for 6 months. At the next checkup in September 2020,

The curves progressed to 78º and 42º respectively. The patient´s orthopedic surgeon recommended to continue with conservative management until the patient turned 16 years old and reached skeletal mature, and then to be operated. The family sought a second opinion as the patient was severely limited in his physical and psychosocial development and was breathless with mild exertion which prevented him from participating in activities with his peers. He had pain when remaining in the same position for a period of time and had difficulties with daily hygiene as he lived in a hot climate (Figure 1,2).

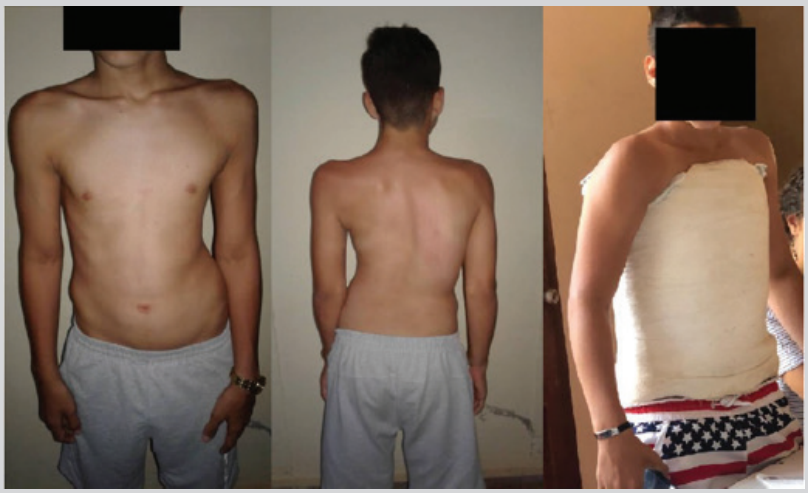

Figure 1: Photos of the patient at presentation to our hospital.

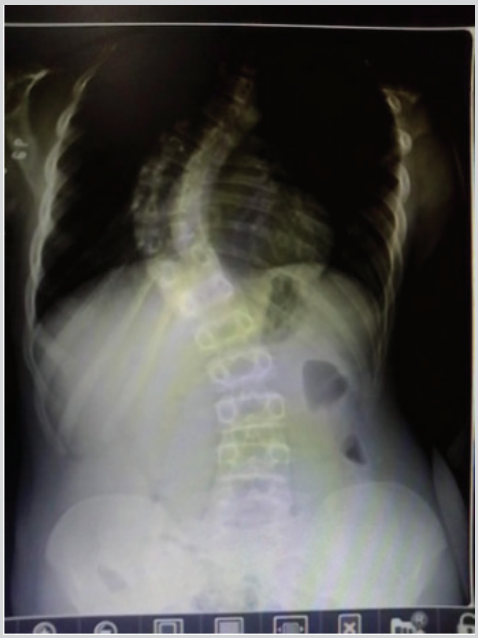

Figure 2: X-rays of the patient at presentation to our hospital.

When the patient presented at our hospital in January 2021, the orthopedic surgeon in charge deemed the futility of the brace and indicated preferrential surgical treatment. The thoracic curve progressed to 100º, the patient had dispnoea with mild exercise and great discomfort and limitations because of the brace. He was placed on the waiting list and went through the first preanesthetic assessment. Of significance was a hemoglobin (Hb) 12,6g/dl, hematocrit (Hct) 38%, microcytosis, hypochromia and a total protein count of 5 g/dl. Respiratory function tests revealed a moderate restrictive-obstructive component to his limitations which responded well to bronchodilators [5-10].

Echocardiography and cardiac function testes were normal. We initiated PBM with oral Ferrous Sulphate 105 mg daily (to be taken on an empty stomach with a glass of orange juice 30 minutes before breakfast), supplementation with a multivitamin complex, vitamin B12, Folic Acid and a puffer of Salbutamol (inhalation suspension 100mcg/dose) as needed.

Recommendations were also given to increase the overall caloric and protein intake and the patient was given instructions for prerhabilitation exercises. There was a delay with the waiting list because of the COVID pandemic situation, with cancellation of physical presence consultations and all surgical procedures, except emergency and oncologic operations. Three months later, in March 2021, the patient came back for a second preanesthetic assessment (two weeks prior to his operation). He was tolerating the oral iron supplementation with no digestive issues and was using the bronchodilator two to three times a day. The blood test revealed Hb 15,7g/dl, Hct 45,6%, Fe 126mcg/dl, Fe saturation index 36%, Transferrin 277mg, Ferritin 43ng/ml, Vitamin B12 442pg/ml, Folic Acid 5,65ng/ml. The rest of the consultation results were satisfactory.

The patient was scheduled for a 14 vertebrae instrumental arthrodesis via posterior approach with autologous and donor

bone grafts and Ponte osteotomies. We calculated the foreseen intraoperative blood loss according to the orthopaedic surgeon´s predictions based on his 25-year experience with these operations: 80 +/- 40 ml per vertebral space fused and up to 150ml for each Ponte osteotomy (approximately 2000ml total). On the day of the operation a combination of Total Intravenous Anaesthesia (TIVA) (induction with Midazolam, Fentanyl, Atracurium and Propofol, maintenance with Propofol, Fentanyl and Remifentanyl, without muscle relaxant to permit neurophysiology monitoring) and a Morphine spinal for postoperative analgesia (due to an impossible lumbar puncture by the anesthesiologist, this was administered by the surgeon under direct vision during the operation:

Morphine Chloride 3mcg/kg (total dose 150mcg). Antibiotic prophylaxis was administered with Cefazolin 1g IV at induction and repeated after 4 hours during the operation. This was continued at 8 hourly intervals for the first 48 hours postoperative. Preemptive analgesia was provided with the administration of IV Dexamethasone 8mg and Dexketoprophen 50mg. Full standard ASA monitorization was applied. After induction, and while the neurophysiology monitoring was being placed, acute hypervolemic hemodilution (AHH) was slowly started with 2000ml of Gelafundin®.

Central venous access was secured by cannulation of the right internal jugular vein; the right radial artery was cannulated for close hemodynamic monitoring and frequent blood tests. Bladder catheter was inserted for fluid balance control and a nasogastric tube was placed to empty the gastric chamber. The patient was placed in prone position on a special scoliosis operating table, taking care to protect all the pressure points and decompress the abdomen in order not to cause excessive filling of the epidural veins which would increase the intraoperative bleeding. Head (3kg) and lower limb (5kg) traction was applied and the table was placed in a mild Trendelenburg position.

Strict normothermia was observed during the whole procedure by employing convective air blankets to exposed body parts and warmed IV fluids. Core temperature was monitored throughout surgical time. The first blood test was done before incision revealing Hb 13,2 g/dl and Hct 42% which reflected the results of the AHH. The fluid repositions and maintenance continued at the anaesthesiologist´s discretion (Lactated Ringer solution 2000ml). Intravenous Tranexamic Acid (TXA) was administered as a loading dose of 15mg/kg and continued with a 2mg/kg/h infusion for the duration of the operation. The OrthoPAT® (Haemonetics), an autologous cellsalvage and transfusion system, was set in place [10-17].

After skin incision (T2 to L4), subperiosteal dissection of the paravertebral muscles to the tips of the transverse processes of all the vertebrae to be fused was performed under controlled hypotension (mean arterial pressure (MAP) 55mmHg).

Once the curve correction stage was reached, the patient was returned to normal MAP (65-75mmHg) to prevent ischemia of the neural tissues during distraction, rotation and stretching manoeuvres of the corrective screws and rods which were done under continuous neurophysiology monitoring (somatosensory evoked potentials, motor evoked potentials, screw placement potentials). Before closure, 1 g of Vancomycin was mixed together with the bone graft shreds and distributed directly over the open operating field. Another blood test revealed Hb 11,2 g/dl, Hct 36%.

An atmospheric pressure drain was placed. At the end of the procedure which lasted 7 hours, a third blood test revealed Hb 10,2g/dl and Hct 33%. The anaesthesiologist reinfused the blood recuperated by the OrthoPAT® (350ml). The patient was placed in the supine position and extubated before transfer to the Pediatric Critical Care Unit (PCCU). A loading dose of postoperative analgesia with Paracetamol 1g and Metamizol 2g IV was administered. There were no intraoperative complications.

On admission to the PCCU the patient was hemodynamically stable and in sinus rhythm. Respiratory mechanics were correct with 100% SpO2 with Ventimask® O2 at 6L/min. The patient was fully conscious and had no pain. Post OrthoPAT® blood infusion test revealed Hb 12,6g/dL, Hct 36,4%. The following 24 hours were uneventful. Analgesia was continued with IV Paracetamol and Metamizol. On discharge from the PCCU at 24 hours postoperative Hb was 11,8 g/dL and Hct 35,9%, drain yield 170ml. He was transferred to the childrens´ orthopedic ward for further care.

The first dose of Patient Controlled Analgesia (PCA) with Morphine was required at 36 hours postoperative when patient mobilization was initiated. The drain was withdrawn at 48 hours with a 200 ml yield. The patient started early deambulation. The postoperative period was satisfactory, except for continued serohematic oozing from the lower third of the incision which required reinforcement with surgical stapling. There were no hemodynamic, respiratory, infectious or neurological complications. The patient was discharged home on day 8 with oral analgesia (Paracetamol and Metamizol). Blood workup before discharged revealed Hb 9,3g/dl. A single dose of IV Ferrous Carboxymaltose 1000mg (20mg/kg) was administered.

On day 12 the patient presented to the Emergency Department because of sustained bleeding from the lower third of the wound. His Hb dropped to 8,9g/dl (nadir) and he felt tired, weak and dizzy when standing up, with no syncopal episodes or breathlessness. He was admitted for surgical revision of the bleeding and bed rest. There were no signs of infection. When the wound was clean and the bleeding had stopped the patient was discharged home. Another dose of IV Ferrous Carboxymaltose (1000mg) was administered. On a revision visit two weeks later he was subjectively well, sitting and deambulating without pain, the wound looked clean and was healing well. Staples were removed. Blood test was Hb 11,1g/dl and Hct 35,4%, Iron 62mcg/dL, Transferrin 227mg/dL, Ferritin Saturation Index 19%, Total Iron Transport Capacity 320mcg/dL and Ferritin 838ng/mL (Figure 3).

The patient was instructed to avoid sports for three months and was advised to start aerobic exercise after that. Contact sports were to be delayed six months. He was scheduled for follow up in 6 months. The surgical results were surgically and esthetically satisfactory, and the patient and his family were very happy with the outcome (Figure 4,5).

DISCUSSION

AIS is a frequent disease of the pediatric population1,2,3. Most cases are managed conservatively with active observation. In progressive cases bracing is applied. When the pathological angles progress rapidly and significantly, surgical management is indicated. Different operative techniques and instrumentations are in use depending on the surgical team´s training. The most frequent complication of extensive AIS surgery is excessive perioperative blood loss, requiring transfusion in up to 70% of the

cases4. Attempts have been made to standardise the estimation of and predict the perioperative blood loss 5-8. An exact formula is elusive as many factors are involved. The ultimate volume differs depending on the surgical and anaesthetic teams´ techniques and experience.

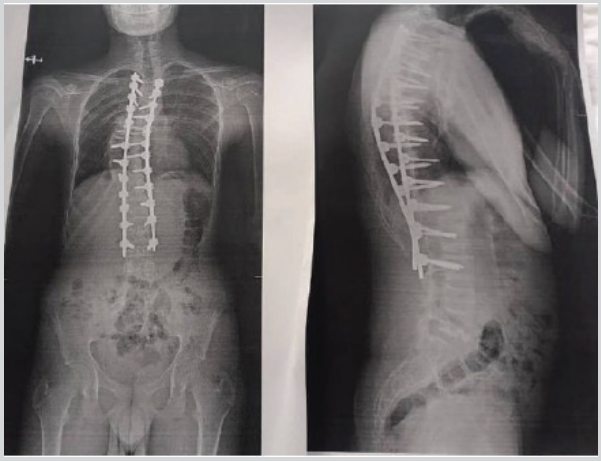

Figure 3: Control X-rays on discharge.

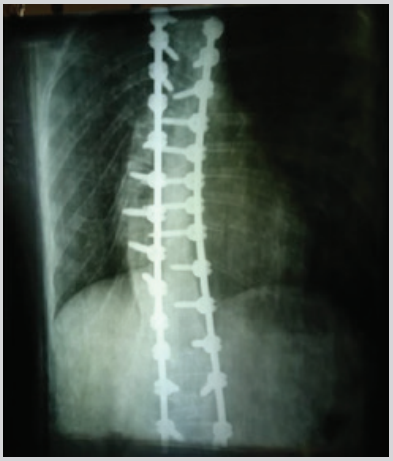

Figure 4: 7 months follow up X-ray.

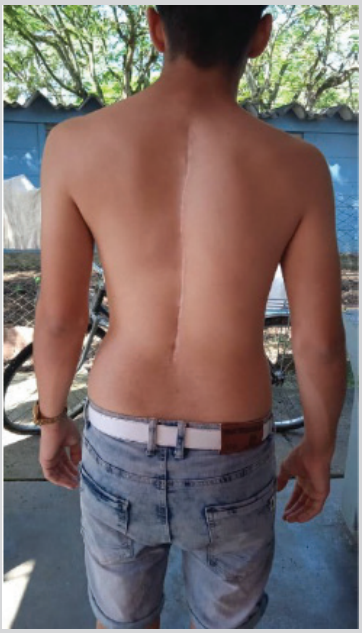

Figure 5: 7 months follow up photo.

The RBC transfusion rate is higher in males, lower preoperative Hb, greater deformity angles, larger numbers of vertebrae to be fused and duration of the operation. Our patient had all of the risk factors. Knowing this and planning appropriately can help avoid blood product transfusion. It is well known that although blood transfusions are lifesaving in many cases, this however comes with a high price (immunomodulation side effects, metabolic disorders, induced coagulopathy, increased surgical site infections, pulmonary complications, increased length of hospital stay and overall costs per case, as well as complications associated with transfusion errors, adverse reactions and the possibility of infective agent transmission)9-14. PBM addresses all these issues and was scrupulously applied by our team as soon as the patient was placed on the waiting list for surgery. We had 3 months of preparation time and we used all techniques available pre, intra and postoperatively.

Careful calculation of the predicted perioperative blood loss, taking into consideration hemorrhagic complications and possible contingencies. Perioperative red blood cell (RBC) mass optimization15 with oral and IV iron supplementation. The use of bone marrow stimulating agents such as human recombinant erythropoietin was considered but deemed unnecessary in this case.

a) Restrictive RBC transfusion trigger (in healthy ASA I pediatric patients a Hb nadir of 7g/dl, depending on anemia tolerance, can be accepted).

b) AHH16-20 to decrease the RBC loss by lowering the Hct of the blood lost from the operating field. Clinical studies support improved hemodynamic stability and optimization of central venous pressures in patients who undergo this technique under general anesthesia. AHH promotes an increased heart preload, improves the rheological properties of the circulating blood and coagulation is not affected when the technique is done properly. Employing gelatins in the process maintains the effects for an estimated t½ of 6 hours, which is appropriate for the duration of the surgical procedure.

c) Hyperfibrinolysis that develops during the surgery due to extensive bone and muscle tissue trauma.

d) Controlled hypotension during the dissection phase to decrease the blood lost during the bloodiest stage of the operation. It is important to return the patient to normotension during the traction and torsion stage to prevent possible ischemic damage to delicate neural tissues. The controlled hypotension technique has been

e) Shown to safely and significantly decrease autologous transfusion rate26,27.

f) Proper patient positioning on the operative table (decompressing the abdomen to avoid epidural vein engorgement, applying protection to pressure sites and placing the table in moderate Trendelenburg to favour adequate venous drainage and prevent the blood pooling in the operative field).

g) Maintain of normothermia with convective air blankets and warmed IV fluids to prevent hypothermia induced coagulopathy during prolonged surgery times (in our case7 hours duration).

h) The use of intraoperative cell salvage 28-30 with a system like the Harmonics OrthoPAT® system which is able to recuperate up to 70% of the blood in the intraoperative field, wash and concentrate the blood recovered and make it safe for returning it to the patient via the IV route.

i) Careful hemodynamic and bispectral index monitoring to aid appropriate anaesthetic dosage.

j) Neurophysiological monitoring to prevent possible neurological complications

k) Meticulous hemostatic surgical strategy, MISS and experienced surgeons 31,32. At our institution, the use of expensive OrthoPAT® technology is authorized for surgical procedures where the foreseen blood loss exceeds 30% of the total blood volume (TBV) of the patient as only then does it become cost effective compared to autologous blood product transfusions. In our case we calculated our patient´s TBV by using the 70ml/kg estimation (adolescent 50kg male: 3500ml TBV). The predicted blood loss was 2000ml, corresponding with 57% of TBV. We calculated the allowable blood loss (ABL) for a minimal Hb of 7g/dl according to the formula:

ABL = TBV · (preop Hb – nadir Hb) / preop Hb

Where TBV = 3500ml

Preop Hb = 15,7g/dl

Nadir Hb = 7g/dl

The ABL result was 1940ml.

We took into consideration the reinfusion of RBC recuperated from the operative field by the OrthoPAT® to allow for a margin of hemorrhagic complications and contingencies. Finally, 350ml of concentrated RBC was generated and reinfused at the end of the operation when Hb of 10,2 g/dl was reached, raising the post infusion Hb to 12,6g/dl. PBM was continued until the definite discharge of the patient. Because of persistent wound serohematic discharge, the patient´s Hb decreased leading to mild anaemia symptoms but never reaching the preestablished transfusion trigger. IV iron supplementation was used to speed up the recovery of RBC mass and aid in symptom tolerance.

CONCLUSION

With careful planning and conscientious application of PBM strategies, we were able to perform this complex and high-risk surgical procedure without recurring to autologous RBC transfusion. The experience of the managing team and continued close communication between surgeons and anesthesiologists makes bloodless surgery of difficult AIS cases possible. The reporting and dissemination of Case Studies such as this one, may help in the management of similar situations by other teams at health institutions worldwide.

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