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# Surgical Management of Scoliosis in Jehovah's Witness Patients: One Institution's Experience

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## Abstract

**Introduction:** Blood loss is a major cause of morbidity in scoliosis surgery. Jehovah's Witnesses pose a unique challenge, as their religious convictions restrict them from receiving blood products. There is a paucity of literature regarding blood conservation protocols in pediatric Jehovah's Witness patients undergoing scoliosis surgery.

**Methods:** Ten consecutive Jehovah's Witness patients under 21 years of age, who underwent posterior spinal fusion for scoliosis between 1995 and 2013, were retrospectively evaluated. Medical charts were used to assess curve type and magnitude, blood conservation techniques used, operative time, estimated blood loss (EBL), hemoglobin levels and postoperative complications.

**Results:** Diagnoses included 5 idiopathic, 3 syndromic, and 2 neuromuscular scoliosis. An average of 11.5 levels were fused with 58% curve correction. The mean operative time was 325 minutes. Commonly employed blood conservation techniques were electrocautery (100%), cell saver (70%), supplemental iron (70%), and epinephrinesoaked gauze (60%). Anti-fibrinolytics were consistently used in 4 cases since 2010, and the bipolar sealer device in 5 cases since 2007. Hemodilution and hypotensive anesthesia were used in 2 and one case, respectively. EBL was 544 ml. No surgery was aborted due to blood loss. The preoperative and nadir postoperative hemoglobin levels averaged 14.1 and 9.8 g/dL, respectively. There were 4 postoperative complications, which were unrelated to blood loss. At a mean 4-year follow-up, all patients were stable.

**Conclusion:** Posterior spinal fusion can be safely performed in standard fashion in the pediatric Jehovah's Witness population. The variety of blood conservation techniques has increased over recent years. More aggressive techniques such as hemodilution and hypotensive anesthesia are not always imperative for efficacious surgery. Our institution is currently establishing a blood conservation protocol for spinal deformity surgery.

## Introduction

Blood loss is a major cause of morbidity in pediatric scoliosis surgery, with post-operative transfusion rates reported to be as high as 37 to 85% [1]. Jehovah's Witnesses pose a unique challenge to the spinal deformity surgeon, as their religious convictions restrict them from receiving blood products under any circumstance.

There are over 7 million Jehovah's witnesses worldwide [2]. The objection of Jehovah's Witnesses to receiving blood products originates from biblical passages which imply that transfusing blood is equivalent to "eating" it [3] and that it will lead to eternal damnation [4]. They do not accept the transfusion of whole blood, packed red blood cells, white cells nor plasma, nor do they accept their own pre-donated blood because it involves a temporary discontinuation from their circulation. Generally acceptable to the Jehovah's Witness population, however, is the use of crystalloids, colloids and starch, as well as perioperative autologous blood if it maintains a continuous circuit, such as in the case of a cell saver. Fractions of blood components, such as clotting factors and albumin are usually up to the individual's discretion when accepting or refusing transfusion of these products [5].

Numerous blood conservation techniques in spinal surgery have been described in literature. Preoperative strategies include optimization of hematocrit levels with iron supplements or erythropoietin. Intra-operative strategies are numerous and they include proper patient positioning (avoiding abdominal compression by allowing the abdomen to hang free), hypotensive anesthesia, hemodilution and the use of anti-fibrinolytic agents. Additionally, the use of electrocautery or bipolar sealer devices can minimize blood loss, as well as utilizing cell saver. Postoperatively, limited blood draws and cautious use of drains have also been described as effective blood management strategies.

Although each of these strategies has been shown to be efficacious in minimizing intraoperative blood loss, there is a paucity of literature regarding the utilization and effectiveness of these blood management tools when they are used in the pediatric Jehovah's Witness patient undergoing surgery to address scoliosis. Thus, the objective of this study is to retrospectively evaluate one institution's experience with the management of blood loss in adolescent Jehovah's Witness patients undergoing scoliosis surgery over a 20-year period.

## Materials and Methods

### Study design

Following approval from the Institutional Review Board, charts were retrospectively reviewed using medical records to identify Jehovah's Witness patients who underwent spinal fusion for scoliosis at the Cleveland Clinic between 1995 and 2013. Patients were included if they were less than 21 years of age at the time of surgery and refused blood products due to religious preferences.

Electronic medical records were utilized to gather the data in

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| Scoliosis type | Sex | Age at surgery | Comorbidities | Blood conservation techniques used | Intraop complications | Postop complications | Length of f/u |
|---|---|---|---|---|---|---|---|
| AIS | F | 13 | None | Electrocautery, epinephrine, cell saver, hypotensive anesthesia | None | None | 14 years |
| AIS | M | 15 | None | Electrocautery, epinephrine, cell saver | None | None | 6 months |
| AIS | F | 14 | None | Electrocautery, epinephrine, supplemental iron, erythropoietin, thrombin soaked gelfoam | None | Infection > 4 yrs | 6 years |
| AIS | M | 19 | None | Electrocautery, supplemental iron, cell saver, Aquamantys, Amino-caproic acid | None | None | 2 months |
| AIS | F | 12 | None | Electrocautery, epinephrine, supplemental iron, cell saver, Aquamantys, Amino-caproic acid | None | Superficial Wound Drainage | 1 year |
| Syndromic | M | 18 | Congenital heart disease, restrictive lung disease | Electrocautery, epinephrine, supplemental iron | None | None | 7 years |
| Syndromic | M | 21 | Neurofibromatosis type 1 | Electrocautery, supplemental iron, cell saver, Aquamantys, Hemodilution | None | None | 3 years |
| Syndromic | F | 14 | Prader-Willi syndrome | Electrocautery, epinephrine, supplemental iron, cell saver, Aquamantys, Hemodilution, TXA | None | T3 Pedicle Screw Loosening | 4 months |
| Neuromuscular | M | 14 | Cerebral Palsy | Electrocautery epinephrine | Baclofen Pump Damage | Bacteremia with Post op Fevers | 6 years |
| Neuromuscular | F | 12 | Di George syndrome, interrupted aortic arch, sub aortic stenosis, bicuspid aortic valve | Electrocautery, Cell saver, supplemental Fe, erythropoietin, Amino-caproic aci | None | None | 2 years |

**Table 1:** Patient characteristics, blood conservation techniques used and complications.

patients treated since 2004. Electronic radiographic images were also used to collect measurements in all patients who underwent surgery after 2004. For data collection prior to this year, paper medical records were utilized, as well as plain full length standing films for obtaining Cobb measurements.

Patient variables assessed were age, gender, height, weight, associated comorbidities, diagnosis, preoperative and postoperative major curve magnitude (Cobb angle), as well as mean deformity correction percentage ([Postoperative/ Preoperative Cobb angle] × 100). The length of stay and follow-up were also determined. Surgical variables assessed were primary surgeon, number of levels corrected, blood conservation techniques employed, intraoperative estimated blood loss (EBL), intraoperative recycled blood volume, use of a postoperative drain, hemoglobin levels (preoperative, immediate postoperative, pre-discharge and nadir levels) and complications (intraoperative and postoperative).

## Results

### Patient variables

A total of 10 patients met the criteria for inclusion in the study. The mean age of the study population was 15 years (range, 12-21). This included five males and five females. Five patients carried a diagnosis of adolescent idiopathic scoliosis (AIS), while there were three patients with syndromic scoliosis (one Prader-Willi, one neurofibromatosis and one patient with congenital heart and lung disease), and two patients with neuromuscular scoliosis. The patient characteristics are summarized in Table 1. The mean height of the study population was 164 cm (range, 142-180 cm). One patient did not have any record of height measurement. The average weight was 55 kg (range, 35-72 kg). The mean preoperative curve magnitude was 68 degrees (range, 48-112 degrees), the mean postoperative curve magnitude was 28 degrees (range, 10-62 degrees), and the mean deformity correction percentage was 58%.

### Surgical variables

Posterior spinal fusion was performed in all 10 patients by one of three pediatric orthopedic surgeons. The spinal fusion was performed in standard fashion through a posterior midline incision; no minimally invasive techniques were employed in any of the patients. All of the patients were placed in prone position on a Jackson table, allowing their abdomen to hang free. An average of 11.5 levels (range, 8-14) was fused. Seven patients were given supplemental iron preoperatively, while 2 patients were given recombinant human erythropoetin. Electrocautery was used for hemostasis in all 10 patients. Other commonly used blood conservation techniques during surgery included the use of cell saver (7 patients) and epinephrine-soaked gauzes (6 patients). Anti-fibrinolytics (aminocaproic acid or transexamic acid) were consistently used in the four cases since 2010. The bipolar sealer device (Aquamantys) was also used consistently in the five cases since 2007. Hemodilution was used in two cases, and hypotensive anesthesia was used in the oldest case, which occurred in 1995. A subcutaneous drain was used in only one patient. Drains were not employed in the rest of the patients (Table 2).

The average intraoperative EBL was 544 ml (range, 200- 1500 ml) and the average operative time was 325 minutes (range, 175-428 minutes). One patient did not have any record of intraoperative EBL, intraoperative recycled blood or operative time (Table 3). Preoperative hemoglobin levels averaged 14.1 g/dL, and nadir postoperative levels averaged 9.8 (7.1-12.7 g/dL). In no circumstance was a surgery aborted due to blood loss. There were 4 postoperative complications, although none were definitively related to blood loss (Table 1). These complications included one AIS patient with superficial wound drainage, one patient with Prader-Willi syndrome who suffered T3 pedicle screw loosening, and one patient with neuromuscular scoliosis who had intraoperative baclofen pump damage a complicated postoperatively by bacteremia. Another AIS patient had a late onset of infection 4 years postoperatively. At an average follow-up of four years (2 months-14 years), all patients were stable, showing no problems associated with anemia.

## Discussion

Over the past two decades at our institution, there has been an increasing trend in the variety of blood conservation techniques utilized in Jehovah's Witness patients undergoing scoliosis surgery (Figures 1 and 2). The varying combinations of techniques can be attributed

| Blood conservation technique | n | % |
|---|---|---|
| Electrocautery | 10 | 100% |
| Cell saver | 7 | 70% |
| Aquamantys | 5 | 50% |
| Supplemental iron | 7 | 70% |
| Erythropoietin | 2 | 20% |
| Epinephrine | 6 | 60% |
| Thrombin soaked gel foam | 1 | 10% |
| Aminocaproic acid | 3 | 30% |
| Transexamic acid | 1 | 10% |
| Isovolemic hemodilution | 2 | 20% |
| Hypotensive anesthesia | 1 | 10% |
| Drains | 1 | 10% |

**Table 2:** Blood Conservation techniques used.

| | |
|---|---|
| Intraoperative EBL (average ml) | 544 (200-1500) |
| Intraoperative recycled blood volume* (average ml) (n=7) | 609 (140-1000) |
| Operative time (average minutes) | 325 (175-428) |

*The intraoperative recycled blood volume includes cell saver and blood received through hemodilution (in certain patients).

**Table 3:** Operative time and blood loss.

to the introduction of modern methods of blood conservation, surgeon preference and patient profile. The ten patients in this study comprised a heterogeneous group of individuals ranging from healthy adolescents with idiopathic scoliosis to patients with significant underlying comorbidities. The fact that none of the ten patients suffered complications due to intraoperative blood loss demonstrates that spinal fusion for scoliosis can be safely performed in a standard surgical fashion.

Our average intraoperative blood loss of 544 ml is similar to the lowest average blood loss reported in literature for posterior spinal fusion for scoliosis, which ranges from 500 to over 2500 ml. The patient with the highest blood loss (1500 ml) was a female with AIS who underwent a T4-L4 fusion. Her preoperative hemoglobin was 14.1 g/dl, falling to a nadir of 10.4, postoperatively. The lowest nadir postoperative hemoglobin level was 7.1 g/dl in a patient with congenital heart and lung disease. This patient had the highest preoperative hemoglobin (19.9 g/dl), and had received preoperative supplemental iron. Previous studies on patients refusing transfusion have shown that hemoglobin levels as low as 6 or 7 g/dl can be tolerated by an otherwise healthy individual [6,7]. However, even in patients with cardiac disease but without acute myocardial infarction or unstable angina, there is evidence suggesting the "restrictive transfusion" strategy to be safe [8,9]. These results suggest that postoperative phlebotomies could be stopped once hemoglobin levels trend upwards, particularly in this group of patients who cannot tolerate having any more of their blood drawn for the purpose of documenting hemoglobin levels. Blood conservation protocols should be enforced to not subject these individuals to excessive blood draws, since most patients are expected to have a spontaneous increase in their hemoglobin by the second postoperative week.

Drains were generally not used in our series, with the exception of one patient. This patient was the female with AIS who suffered the highest intraoperative blood loss in our series. The only immediate postoperative superficial wound infection of our series also occurred in this patient. There is a lack of consensus within the orthopedic community with respect to the use of drains, and there is also little scientific evidence for or against its implementation [10,11]. However, drained patients have been shown to receive more postoperative transfusions than patients without drains after spinal fusion for AIS, especially those with both superficial and deep drains [11]. It is likely that the avoidance of drain usage in the majority of these patients in our series may have played an additional role in preventing postoperative hemoglobin levels from decreasing even further than the lowest nadir hemoglobin level of 7.1 g/dl. Our general philosophy regarding drain use at our institution is that if meticulous hemostasis can maintain a dry surgical field, then use of drains can be obviated.

Cell saving refers to the autotransfusion of blood shed intraoperatively with the use of devices that filter and reinfuse red blood cells. Because the device and patient are in continuous circuit, Jehovah's Witness patients generally accept this method of conservation. Cell saver was employed in 7 of our 10 patients, with consistent use in the last 5 patients of our series. At our and other institutions, at least 250 cc of blood must be collected to wash and process the blood for approximately a third of its return to the patient. There has been controversy regarding its "added value" [12-14] due to these minimum blood loss requirements, as well as inconsistencies in reports on cell saver reducing the rate of transfusion. However, these studies referred to more limited lumbar procedures, in contrast to the more extensive posterior spinal fusion performed in our series of scoliosis cases, which involved an average of 11.5 levels and longer operative times with higher risk of increased blood loss, in a population in which blood transfusion was not an option.

In recent years, newer methods of blood conservation such as the bipolar sealer device (Aquamantys®) have become a consistent addition to our surgical regimen. The bipolar sealer device uses radiofrequency energy combined with saline irrigation to cause coagulation of soft tissue and at relatively cooler temperatures than standard electrocautery. Recent studies have demonstrated the efficacy of this device in lowering total perioperative blood loss [15,16]. The bipolar device has not replaced electrocautery entirely, however, as the latter continues to be an indispensible standard tool for controlling blood loss during surgical dissection.

Furthermore, anti-fibrinolytic agents such as Transexamic Acid (TXA) and aminocaproic acid have been shown to decrease intraoperative blood loss and transfusion rates, as evidenced by recent systematic reviews and meta-analysis studies [17-19]. Most of the studies have been small, single-center and prospective or retrospective in nature. Recently, a prospective randomized trial involving 125 patients with AIS showed that both TXA and aminocaproic acid reduced intraoperative blood loss when compared with saline solution [19], although they did not find a decrease in transfusion rates. However, in the Jehovah's Witness population where transfusion is not an option, reducing intraoperative blood loss is the primary goal. We

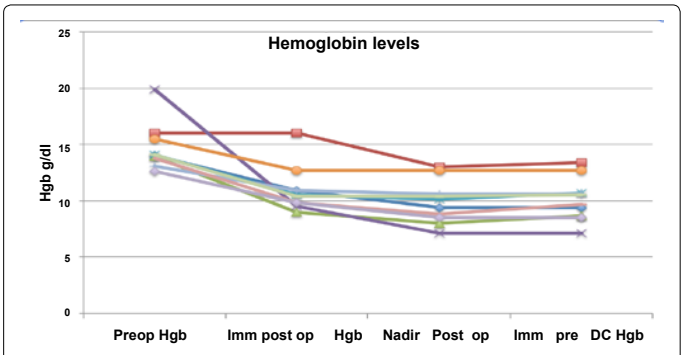


**Figure 1:** Preoperative and postoperative hemoglobin (Hgb) levels for all 10 patients. The lowest nadir Hgb value was 7.1 g/dL.

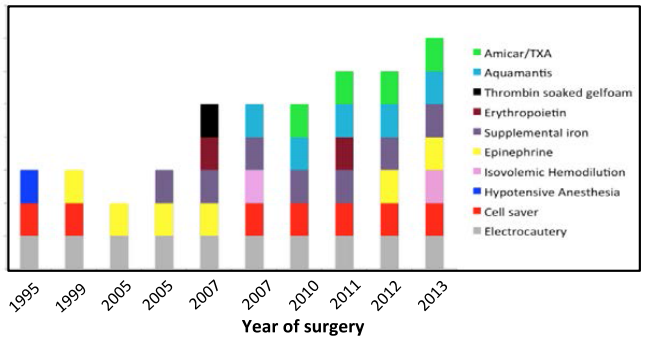


**Figure 2:** The different blood conservation methods used in each patient and the year are depicted.

have subsequently employed these agents in most of our patients with scoliosis who had no contraindications for their use.

Acute normovolemic hemodilution involves a controlled preoperative extraction of blood, which is then replaced with colloid or crystalloid to maintain normovolemia [20]. This reduces hemoglobin loss during surgery, and the pre-extracted blood can be reinfused as needed. For Jehovah's Witnesses, this is generally an acceptable method of blood conservation as long as the blood is maintained in a continuous closed circuit. Hemodilution was used in 2 patients in our series, in 2007 and 2014, respectively. Although described as a relatively safe and effective method to decrease red blood cell mass, hemodilution is not devoid of potential risks, such as morbidity from over-extraction of blood preoperatively [21-24]. The anesthesiologist must therefore consider relatively higher preoperative hemoglobin levels and patient comorbidities when indicating hemodilution as a blood salvage procedure.

Hypotensive anesthesia using different hypotensive agents has also been described as part of blood conservation protocols during scoliosis surgery. The accepted mean arterial pressure during spine surgery is 50-60 mm Hg [25], and there is some evidence of its effectiveness in reducing blood loss [26]. In our series, only one patient was submitted to this blood conservation technique, in 1995. However, there are risks involving its use, particularly spinal cord ischemia during spinal instrumentation and reduction maneuvers [27,28], especially if combined with hemodilution [26]. In our institution, for all posterior spinal fusions, the blood pressure is lowered to a mean arterial pressure of 60-70 during the dissection portion of the case, then it is gradually increased during spinal instrumentation and the remainder of the procedure. Both hemodilution and hypotensive anesthesia have been shown to decrease the need for perioperative blood transfusion in prior studies [12,20,21,23,29,30]. However, the results from our series illustrate the trend in which modern blood conservation techniques have largely replaced these more aggressive methods.

Our study has some obvious limitations. Definitive conclusions about the efficacy of particular blood conservation techniques cannot be reached due to the small number of patients in this study. The retrospective nature of this study and the fact that it relies on older paper charts also limits our ability for data retrieval. Additionally, the heterogeneity of the patient population and the diverse use of blood management strategies make direct comparison of techniques very difficult.

Our study highlights the lack of unanimity when it comes to choosing blood conservation techniques in scoliosis surgery by the surgeon and anesthesiologist alike. Numerous publications analyze individual blood conservation methods, but very few institutions mention the use of a protocol for scoliosis surgery, much less for patients who refuse transfusion of blood products. This only reinforces the need to establish protocols in this population, beginning in the preoperative phase by the anesthesia and surgical team to optimize the patient's tolerance for blood loss. These blood conservation techniques can, in fact, be applied to all spine patients in order to reduce the number of blood transfusions given.

Future research directions should include standardizing blood conservation protocols for spine surgeries, although cost-effective analyses would be necessary, especially with modern techniques, which are not without a high cost.

## Conclusion

Posterior spinal fusion can be successfully and safely performed in a standard fashion in the pediatric Jehovah's Witness population using a variety of blood conservation measures. Performing major surgery in this population is a complex undertaking due to potential for catastrophic complications if a large amount of blood loss occurs. Many anesthesiologists and surgeons hesitate when faced with the challenge of having to perform surgery on these patients because of the significant risk. However, we have shown that it is possible to perform major surgery, such as posterior spinal fusion, in patients who refuse blood transfusions without compromising safety. Though necessary in some situations, aggressive techniques such as hemodilution and hypotensive anesthesia are not imperative for efficacious surgery. Our institution is currently establishing a blood conservation protocol to help surgeons avoid blood transfusions.

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