Eur J Orthop Surg Traumatol (2015) 25 (Suppl 1):S219–S223
DOI 10.1007/s00590-015-1624-3

ORIGINAL ARTICLE

Eliminating the use of allogeneic blood products in adolescent idiopathic scoliosis surgery

Mark J. Berney[1] · Peter H. Dawson[1] · Margaret Phillips[1] · Darren F. Lui[1] · Paul Connolly[1]

Received: 19 September 2014 / Accepted: 18 March 2015 / Published online: 27 March 2015

Abstract
Purpose The aim of this study was to compare transfusion requirements in patients before and after the introduction of tranexamic acid as standard in patients undergoing spinal surgery for idiopathic scoliosis in a national orthopaedic hospital.
Methods A retrospective chart review of 56 idiopathic scoliosis patients who underwent posterior spinal instrumentation and fusion between 2009 and 2013 at our institution. Preoperative, intraoperative, and postoperative data were measured.
Results Patients who received tranexamic acid as standard ($n = 31$) showed a trend towards a decrease in transfusion requirements compared with those who received no tranexamic acid ($n = 25$). These patients had a statistically significant decrease in operative time (223 vs 188 min, $p = 0.005$), and estimated intraoperative blood loss was reduced by nearly 50 % in the tranexamic acid group. They also had an associated reduced decrease in haemoglobin between preoperative and postoperative levels (4 vs 5 g/dL, $p = 0.01$).
Conclusions Since February 2012, no patient has required intraoperative or postoperative allogeneic blood product transfusion in this hospital. The routine use of antifibrinolytic medications in patients undergoing surgery for adolescent idiopathic scoliosis has effectively eliminated the need for allogeneic blood products.

Keywords Adolescent idiopathic scoliosis · Antifibrinolytic agents · Blood loss · Blood transfusion

✉ Peter H. Dawson
peterhughdawson@gmail.com

Mark J. Berney
markjberney@gmail.com

Margaret Phillips
magsphillips@cappagh.ie

Darren F. Lui
darrenflui@gmail.com

Paul Connolly
paulconn@gmail.com

[1] Cappagh National Orthopaedic Hospital, Finglas, Dublin 11, Ireland

Introduction

Adolescent idiopathic scoliosis (AIS) is the most common form of scoliosis, affecting 2–4 % of adolescents [1]. While the incidence of scoliosis is equal between the sexes, females have a tenfold increased risk of curve progression. The majority of patients diagnosed with AIS will not develop significant clinical symptoms [2]. However, in those with progressive disease, severe deformity of the spine can cause respiratory compromise [3]. These patients can also suffer significant emotional distress secondary to the cosmetic problems associated with the disease [4].

Treatment options for patients with AIS include conservative management with regular observation or the use of a spinal brace. However, for those with more severe disease, surgical intervention is indicated to correct the spinal deformity and halt curve progression. The principle indication for surgery during adolescence is a thoracic curve that will reach 50° or more by skeletal maturity. The management of other curve patterns are more difficult due to the risk of low back pathology and pain after fusion into the low lumbar spine. However, thoracolumbar curves that will reach 50°–60° at maturity are associated with a marked degree of deformity and potential vertebral

translatory shift, and many surgeons would suggest corrective surgery for such patients [5].

In spinal fusion and instrumentation, the vertebrae are typically accessed by posterior or anterior incision, with the posterior approach being the most common procedure undertaken in AIS patients due to greater curve reduction, reduced operative time, and decreased postoperative stay in those with thoracic scoliosis. Anterior instrumentation is used predominantly for thoracolumbar and lumbar scoliosis [6]. These operations can require prolonged operative times with extensive soft tissue dissection and significant perioperative blood loss [7, 8]. In cases where there has been significant blood loss, blood transfusions have been required with multiple units of allogeneic blood products frequently needed in extreme cases [9]. The risks of transfusion are well documented and can be divided into transfusion-transmissible infections, immunological risks, and mistransfusion. The risk of transmissible infections, including HIV, hepatitis B, and hepatitis C, has decreased dramatically due to increased test sensitivity in recent years. However, immunological reactions and mistransfusions, while rare, are still a significant risk to patients and can be associated with significant morbidity and mortality [10–12]. Massive transfusions also put patients at risk of metabolic abnormalities, dilution of clotting factors, and hypothermia [13, 14]. Any intervention that can minimise the requirement for transfusion would have a significant beneficial effect on this patient cohort.

Tranexamic acid is a synthetic derivative of lysine which exerts its antifibrinolytic effect through the reversible blockade of lysine-binding sites on plasminogen molecules, thereby stopping it binding to fibrin and suppressing fibrinolysis [15]. This leads to stabilisation of fibrin clots and reduced blood loss.

Strong evidence for the effectiveness of tranexamic acid in reducing blood loss and transfusion requirements across a range of surgeries has been demonstrated [16, 17]. Similar results are seen in studies examining the use of tranexamic acid in surgery for adolescent idiopathic scoliosis [18–20].

In May 2011, the anaesthetists at a national orthopaedic hospital introduced the use of tranexamic acid as standard for all AIS patients undergoing surgical correction. This study aims to determine the effect that the introduction of tranexamic acid as standard for patients undergoing posterior spinal instrumentation and fusion has had on the use of blood product transfusions at our centre.

Materials and methods

We performed a retrospective chart review of all patients who underwent surgical correction for AIS at a national orthopaedic hospital between 2009 and 2013. Patients with a non-idiopathic diagnosis were excluded. All patients were American Society of Anaesthesiologists (ASA) physical status classification I or II. Patients were divided into two groups, those who had received tranexamic acid perioperatively and those who received no antifibrinolytic agents. The homogeneity of these two groups was analysed by comparing age, sex, BMI, ASA physical status, autologous blood donation, preoperative Cobb angle, magnitude of Cobb angle correction, number of levels fused, pedicle screw density, and preoperative values for haemoglobin and haematocrit. The primary outcome variable for this study was the number of patients requiring perioperative red blood cell transfusion. Secondary outcomes included change in haemoglobin levels between pre- and post-operation time points, total operative time, length of postoperative stay, and estimated intraoperative blood loss. Intraoperative blood loss was estimated from the surgical suction and auto-transfusion systems and by weighing sponges.

The surgical technique in all cases involved a posterior spinal instrumentation and fusion with pedicle screws. No hooks were used. Morselised bone graft was prepared from locally excised bone. Concurrent anterior release is not practised at our centre.

This was a retrospective study; therefore, it was not possible to set strict transfusion criteria preoperatively. Anaesthesiologists followed common practice guidelines for transfusing patients with allogeneic blood products, pre-donated autologous blood or cell saver transfusion. A cell saver recovered blood during all operations, and where the patient made a preoperative autologous blood donation, 2 units were typically prepared. Criteria for transfusion included low haemoglobin levels, significant drop in systolic blood pressure, or any perceived rapid intraoperative loss of blood. No protocol exists for intraoperative monitoring of haemoglobin, and levels are measured based on the clinical assessment of the anaesthetic team. Postoperatively, haemoglobin is routinely checked in the morning day 1 post-surgery, and patients with haemoglobin levels <8 g/dL and clinical symptoms of anaemia, including dizziness, excessive fatigue, and hypotension, or a haemoglobin level of <7 g/dL, were considered for transfusion. A standard protocol is used for the administration of tranexamic acid at our centre. A bolus of 15 mg/kg is administered at 10 min prior to skin incision, and a continuous infusion is administered at 10 mg/kg/h until skin closure.

The collected data were analysed using descriptive statistics carried out using SPSS software (v16.0, IBM Corporation). A two-sample Student's t test was used for the analysis of continuous variables, and a two-sample z test was used to compare sample proportions. p values were calculated, and a value of <0.05 was considered to be significant.

Results

Fifty-six patients were eligible for admission into the study. Twenty-five patients underwent posterior instrumentation and spinal fusion without receiving any antifibrinolytic agents and the remaining 31 patients received tranexamic acid perioperatively. Table 1 shows the mean values for parameters measured to compare the homogeneity of the two groups. Both groups were comparable with no statistically significant difference between them for any of the parameters measured, with both groups similar in age, sex, BMI, ASA physical status classification, rate of autologous blood donation, preoperative Cobb angle, magnitude of Cobb angle correction, number of levels fused, pedicle screw density, and preoperative values for haemoglobin and haematocrit.

Table 2 demonstrates the outcome findings for the two groups. Eighteen (72 %) of the 25 patients who did not receive any tranexamic acid required transfusions in the perioperative period. Of these patients, 14 received allogeneic blood products. The remainder received either pre-donated autologous blood or cell saver transfusion. All transfusions were commenced in the postoperative period with the exception of three instances where cell saver transfusion was commenced prior to skin closure. Only four (13 %) of the 31 patients who received tranexamic acid required transfusions in the perioperative period, and in all cases, this was from cell saver transfusion commenced in the postoperative period. None of the patients who received tranexamic acid required transfusion with allogeneic blood products or pre-donated autologous blood.

The average operating time was 35 min faster in those patients who had received tranexamic acid (188 vs 223 min, $p = 0.03$). These patients also had a reduced drop in haemoglobin levels when comparing preoperative and postoperative values (4.0 vs 5.0 g/dL, $p = 0.01$). Postoperative length of stay was reduced by almost an entire day in these patients (6.63 vs 5.86, $p = 0.08$); however, this was not found to be statistically significant for this study.

Discussion

The aim of this study was to determine the effect that the standard use of the antifibrinolytic agent, tranexamic acid, would have on transfusion rates for patients undergoing corrective surgery for AIS. Reviewing the data gathered, it is clear that the introduction of tranexamic acid has dramatically reduced the number of patients requiring transfusions, both intraoperatively and in the postoperative course. Prior to May 2011, when tranexamic acid was introduced for these procedures, patients auto-donated typically two units of blood before surgery or were cross-matched for three units due to the high likelihood that a transfusion would be required (72 % of cases required transfusion in the period studied). Transfusions placed these patients at risk of infections and transfusion-associated reactions with associated morbidity and mortality. Autologous and allogeneic donations are also associated with significant cost to the health service provider [21].

Since the introduction of tranexamic acid as standard, our centre has seen an over 80 % reduction in the number of transfusions for AIS patients undergoing corrective surgery. Importantly, since February 2012, no patient has required an intraoperative or postoperative blood product transfusion, which highlights the effectiveness of this change in patient management. Indeed, since July 2013, it is no longer standard practice for patients to be routinely cross-matched prior to surgery.

Table 1 Mean demographic data comparing the two patient groups

	No tranexamic acid ($n = 25$)	Received tranexamic acid ($n = 31$)	p value
Age (years)	16.4	15.3	0.15
Sex (m/f)	10/15	9/22	0.38
BMI	21.2	20.3	0.26
ASA physical status (I/II)	22/3	28/3	0.81
Pre-donated autologous blood (%)	24 ($n = 6$)	6 ($n = 2$)	0.54
Pre-op Cobb angle (°)	60.8	58.81	0.33
Post-op Cobb angle (°)	24.0	22.6	0.44
Magnitude of correction (°)	35.2	36.1	0.49
Number of levels fused	12.7	12.7	0.43
Pedicle screw density (%)	76.0	75.8	0.49
Pre-op Hb (g/dL)	13.2	13.5	0.12
Pre-op Hct (%)	40.4	39.6	0.09

Table 2 Measured outcomes for the two patient groups

	No tranexamic acid ($n = 25$)	Received tranexamic acid ($n = 31$)	p value
Required perioperative transfusion (number)	18	4	0.01
Estimated intraoperative blood loss (mL)	1414	781	<0.001
Hb drop from pre- to postoperative (g/dL)	5.0	4.0	0.01
Operative time (min)	223	188	0.03
Length of post-op stay (days)	6.63	5.86	0.08

The use of tranexamic acid has also led to a statistically significant reduction in operation time (188 vs 223 min, $p = 0.03$). This is an important change as prolonged operative time is associated with increased blood loss, therefore increasing the likelihood of transfusion [22]. The decrease in the haemoglobin level between preoperative and postoperative measurements associated with this extensive and prolonged procedure has also been decreased by the introduction of tranexamic acid (4.0 vs 5.0 g/dL, $p = 0.01$). Similarly, there has been a significant reduction in the estimated intraoperative blood loss between the groups, with the tranexamic acid group nearly 50 % less. Combined reduction in operative time, intraoperative blood loss and improvement in postoperative haemoglobin levels have contributed to the decreased requirement for transfusions in this study population.

Postoperative length of stay was also decreased in the group who received tranexamic acid, but this was not found to be a statistically significant change in this study (6.63 vs 5.86, $p = 0.08$). However, a recent retrospective study of 36,901 patients undergoing elective spinal surgery found that those who received transfusions, even a single unit, had increased length of stay and postoperative morbidity [23]. Therefore, it is likely that the reduction in transfusion rates at our institution will lead to reduced patient lenght of stay and reduced morbidities with associated improvements in patient outcomes and reduced costs.

The limitations of this study are typical of those associated with retrospective analysis. It was not possible to implement a standardised protocol for tranexamic acid dosing for the group under review. The anaesthetic team administered tranexamic acid at varying doses, depending on their preference. Likewise, there was no set criterion for giving blood transfusions, either intraoperative or postoperative course. However, the best practice was followed, as described previously.

This study has demonstrated the effectiveness of perioperative tranexamic acid at reducing the requirement for transfusion in patients undergoing corrective surgery for adolescent idiopathic scoliosis. Together with a reduced operating time, this has led to improvements in patient outcomes and reduced costs associated with this procedure. It has been suggested that with the use of tranexamic acid now playing a major role in blood conservation strategies, routine preoperative group and save or cross-match testing may no longer be essential in hip and knee arthroplasty surgery [24, 25] and in surgery for adolescent idiopathic scoliosis [26]. On the basis of findings reported here, since July 2013, it is no longer standard practice at our centre for patients undergoing spinal surgery for adolescent idiopathic scoliosis to be routinely cross-matched prior to surgery.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standard All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of retrospective study, formal consent is not required. This article does not contain any studies with animals performed by any of the authors.

References

1. Kane WJ (1977) Scoliosis prevalence: a call for a statement of terms. Clin Orthop 126:43–46
2. Asher MA, Burton DC (2006) Adolescent idiopathic scoliosis: natural history and long-term treatment effects. Scoliosis 1:2
3. Barois A (1999) Respiratory problems in severe scoliosis. Bull Acad Natl Med 183(4):721–730
4. Horne JP, Flannery R, Usman S (2014) Adolescent idiopathic scoliosis: diagnosis and management. Am Fam Phys 89(3):193–198
5. Weinstein SL, Zavala DC, Ponseti IV (1981) Idiopathic scoliosis. Long term follow up and prognosis in untreated patients. J Bone Joint Surg Am 63:702–712
6. Potter BK, Kuklo TR, Lenke LG (2005) Radiographic outcomes of anterior spinal fusion versus posterior spinal fusion with thoracic pedicle screws for treatment of Lenke type I adolescent idiopathic scoliosis curves. Spine 30:1859–1866
7. Florentino-Pineda I, Thompson GH, Poe-Kochert C et al (2004) The effect of amicar on perioperative blood loss in idiopathic scoliosis: the results of a prospective, randomized double-blind study. Spine 29(3):233–238
8. Neilipovitz DT, Murto K, Hall L et al (2001) A randomized trial of tranexamic acid to reduce blood transfusion for scoliosis surgery. Anesth Analg 93(1):82–87
9. Murray DJ, Forbes RB, Titone MB et al (1997) Transfusion management in pediatric and adolescent scoliosis surgery. Efficacy of autologous blood. Spine 22(23):2735–2740

10. Madjdpour C, Spahn DR (2005) Allogenic red blood cell transfusions: efficacy, risks, alternatives and indication. Br J Anaesth 95(1):33–42
11. Chiavetta JA, Escobar M, Newman A et al (2003) Incidence and estimated rates of residual risk for HIV, hepatitis C, hepatitis B and human T-cell lymphotropic viruses in blood donors in Canada, 1990–2000. CMAJ 169(8):767–773
12. Robillard P, Nawej KI, Jochem K (2004) The Quebec hemovigilance system: description and results from the first two years. Transfus Apher Sci 31(2):111–122
13. Hardy JF, De Moerloose P, Samama M (2004) Massive transfusion and coagulopathy: pathophysiology and implications for clinical management. Can J Anaesth 51(4):293–310
14. Shafi S, Kauder DR (2004) Fluid resuscitation and blood replacement in patients with polytrauma. Clin Orthop Relat Res 422:37–42
15. Dunn CJ, Goa KL (1999) Tranexamic acid: a review of its use in surgery and other indications. Drugs 57(6):1005–1032
16. Ker K, Edwards P, Perel P, Shakur H, Roberts I (2012) Effect of tranexamic acid on surgical bleeding: systematic review and cumulative meta-analysis. BMJ 17(344):e3054
17. Wu Q, Zhang HA, Liu SL, Meng T, Zhou X, Wang P (2015) Is tranexamic acid clinically effective and safe to prevent blood loss in total knee arthroplasty? A meta-analysis of 34 randomized controlled trials. Eur J Orthop Surg Traumatol 25(3):525–541
18. Li ZJ, Fu X, Xing D, Zhang HF, Zang JC, Ma XL (2013) Is tranexamic acid effective and safe in spinal surgery? A meta-analysis of randomized controlled trials. Eur Spine J 22(9):1950–1957
19. Tzortzopoulou A, Cepeda MS, Schumann R, Carr DB (2008) Antifibrinolytic agents for reducing blood loss in scoliosis surgery in children. Cochrane Database Syst Rev 16(3):CD006883
20. Yagi M, Hasegawa J, Nagoshi N, Iizuka S, Kaneko S, Fukuda K, Takemitsu M, Shioda M, Machida M (2012) Does the intraoperative tranexamic acid decrease operative blood loss during posterior spinal fusion for treatment of adolescent idiopathic scoliosis? Spine (Phila Pa 1976) 37(21):E1336–E1342
21. Spahn DR, Goodnought LT (2013) Alternatives to blood transfusion. Lancet 381(9880):1855–1865
22. Ialenti MN, Lonner BS, Verma K, Dena L, Valdevit A, Errico T (2013) Predicting blood loss during spinal fusion for adolescent idiopathic scoliosis. J Pediatr Orthop 33(4):372–376
23. Seicean A, Alan N, Seicean S, Neuhauser D, Weil RJ (2014) The effect of blood transfusion on short-term, perioperative outcomes in elective spine surgery. J Clin Neurosci 21(9):1579–1585
24. Marson BA, Shah J, Deglurkar M (2015) Blood transfusion in hip and knee arthroplasties: the end of the pre-operative group and save? Eur J Orthop Surg Traumatol. doi:10.1007/s00590-015-1597-2
25. Alshryda S, Sarda P, Sukeik M, Nargol A, Blenkinsopp J, Mason JM (2011) Tranexamic acid in total knee replacement: a systematic review and meta-analysis. J Bone Joint Surg Br 93(12):1577–1585
26. Verma RR, Williamson JB, Dashti H, Patel D, Oxborrow NJ (2006) Homologous blood transfusion is not required in surgery for adolescent idiopathic scoliosis. J Bone Joint Surg Br 88(9):1187–1191