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Oral- is as Effective as Intravenous Tranexamic Acid at Reducing Blood Loss in Thoracolumbar Spinal Fusions: A Prospective Randomized Trial

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Mini Abstract

Tranexamic acid is widely utilized to decrease operative blood loss and blood transfusions. This prospective randomized trial compares perioperative blood loss in patients undergoing elective posterior thoracolumbar fusion treated with intravenous versus oral TXA. Not only is it cheaper, PO was equivalent to IV TXA in reducing blood loss.

Structured Abstract

Study Design: A prospective randomized trial at a university affiliated tertiary medical center between February 2017 and March 2020.

Objective: Compare perioperative blood loss in patients undergoing elective posterior thoracolumbar fusion who were treated with IV versus PO TXA.

Summary of Background Data: The use of antifibrinolytic agents such as tranexamic acid (TXA) to decrease operative blood loss and allogenic blood transfusions is well documented in the literature. While evidence supports the use of intravenous (IV) and topical formulations of TXA in spine surgery, the use of oral (PO) TXA has not been studied.

Methods: 261 patients undergoing thoracolumbar fusion were randomized to receive 1.95g of PO TXA 2 hours preoperatively or 2g IV TXA (1g before incision and 1g before wound closure) intraoperatively. The sample was further stratified into 3 categories based on number of levels fused (1-2 level fusions, 3-5, and >5). The primary outcome was the reduction of hemoglobin. Secondary outcomes included calculated blood loss, drain output, postoperative transfusion, complications, and length of hospital stay. Equivalence analysis was performed with a two one-sided test (TOST).

Results: 137 patients received IV and 124 received PO TXA. The average age was 62±13 years (Mean ± SD), including 141 females and 120 males. Revision cases comprised of 67% of the total sample. Patient demographic factors were similar between groups except for weight, BMI, and preoperative platelet count. The mean reduction of hemoglobin was similar between IV and PO groups (3.56 vs. 3.28 g/dL, respectively; P = 0.002, equivalence). IV TXA group had a higher transfusion rate compared to PO TXA group (22 patients [19%] vs. 12 patients [10%]; P = 0.03). In addition, IV group had longer length of stay (LOS) than PO group (4.4 vs. 3.7 days; P = 0.02).

Conclusion: Patients treated with IV and PO TXA experienced the same perioperative blood loss after small and large spinal fusions. In subgroup analysis, the intermediate (3-5 level) spinal fusions had less blood loss with PO TXA than IV TXA. Given its lower cost, PO TXA represents a superior alternative to IV TXA in patients undergoing elective posterior thoracolumbar fusion and may improve healthcare cost-efficiency in the studied population.

Keywords: tranexamic acid (TXA), spinal fusion, blood loss, allogeneic blood transfusion, healthcare cost efficiency

Level of Evidence: 1

Introduction

Intraoperative and postoperative blood loss with elective spinal fusion surgery adversely affects patient outcomes by increasing coagulopathy, hematoma formation, and anemia[1]. The ensuing need for allogenic blood transfusion gives rise to increased risk of infections, long-term mortality, and transfusion reactions, and economic burden[2-4]. Achieving optimal perioperative blood conservation, through prophylactic administration of antifibrinolytic agents, has been the focus in recent years. Specifically, a lysine analoge named tranexamic acid (TXA) reduces perioperative blood loss and need for blood transfusions in spine surgery by exerting its anti-fibrinolytic effect through the reversible blockade of lysine binding sites on plasminogen[5-7].

As the utilization of TXA becomes more ubiquitous in spine surgery, the search for the most efficacious route of TXA administration as well as dosing regimen becomes worthwhile. TXA can be given intravenously (IV), topically, and orally (PO). Much of the spine literature focuses on the IV or topical formation[8]. Potential advantages of the PO formulation include lower medication cost and ease of administration. There is recent evidence supporting the use of PO TXA in the adult reconstruction literature[9-10], which also showed that PO TXA is more cost effective than IV TXA. Similarly, our initial phase prospective randomized study showed equivalent blood loss with IV versus PO TXA[11]. However, the preliminary data had insufficient patient numbers to perform subgroup analysis.

Therefore, the objective of this final phase was to compare the efficacy of IV and PO routes of TXA on perioperative blood loss and allogeneic blood transfusion rate in adult patients undergoing posterior thoracolumbar instrumented fusion surgery that varied in fusion levels.

Materials and Methods

STUDY DESIGN AND PATIENTS

This study was a single-center, randomized, prospective trial designed to test equivalence between IV and oral TXA in the setting of elective thoracolumbar fusion between February 2017 and March 2020. Our institutional review board approved the present study, and it was registered with the public ClinicalTrials.gov registry (NCT03037515). After obtaining informed consent, adult patients (age>=18 years old) undergoing elective posterior thoracolumbar instrumented spinal fusions were enrolled in the study. Surgical indications included spinal stenosis, spondylolysis, spondylolisthesis, degenerative disc disease, adult spinal deformity, proximal junctional kyphosis, adjacent level disease, and pseudoarthrosis. Exclusion criteria included known allergy to TXA, history of renal failure or kidney transplant, history of arterial thromboembolic event (eg. myocardial infarction, stroke) within the past year, placement of an arterial stent within the past year, a history of thromboembolic event, coagulopathy, or refusal to receive blood products.

INTERVENTION

Enrolled patients were randomly assigned between the 2 treatment groups of IV and oral TXA using a computer-generated random number algorithm. Surgeons and data collectors were blinded to the patient allocation. Because the number of fusion levels can influence blood loss, the sample was sub-categorized before randomization by the number of vertebral levels arthrodesed (1-2 levels, 3-5 levels, >5 levels). Serum and pharmacokinetic studies have demonstrated that IV TXA reaches therapeutic concentration rapidly but falls below the threshold after 5 hours; PO TXA reaches therapeutic levels after 2 hours and maintains levels above the therapeutic threshold for 6 hours after administration[11]. Based on pharmacokinetic data, the oral TXA group received 1950 mg TXA (3 tablets of 650 mg) approximately 2 hours before incision. The IV TXA group received the standard dosing for our institution of 1 g TXA (diluted in 100 mL normal saline) given as an IV bolus immediately before incision and another 1 g TXA given before closure.

SURGICAL TECHNIQUE AND POSTOPERATIVE CARE

Posterior instrumented spinal fusions were performed prone on a Jackson table with the abdomen free. A forced-air warming device was used to maintain normothermia. A standard open midline approach was utilized, intertransverse fusion beds were prepared uniformly, and pedicle screws were inserted in the standard fashion. When indicated, transforaminal lumbar (TLIF) and direct lateral interbody (DLIF) fusions were also performed per surgeon preference. Before wound closure, hemostasis was achieved and drains were placed routinely. All cases were performed by surgeons with over 25 years experience in spine surgery.

BLOOD MANAGEMENT

An autologous blood recovery system (Cell Saver, Haemonetics, MA) was used when requested by the surgeon and salvaged red blood cells (RBCs) were returned to the patient. Suctioned blood from the surgical field was processed and given back to the patient if estimated blood loss (EBL) was greater than 500 mL or at the surgeon’s discretion. As a result, not every patient may have been given salvaged RBCs. Intraoperative blood transfusion was given if hemoglobin (Hgb) dropped below 7.0 g/dL or at the anesthesiologist’s discretion, such as if patient was unstable despite fluid resuscitation and salvaged RBC replacement. The postoperative transfusion protocol required transfusion for a Hgb level below 7.0 g/dL or if Hgb was between 7.0 and 8.0 g/dL and patients had symptomatic anemia including tachycardia, hypotension, or pallor.

DATA COLLECTION

Patient demographic and preoperative characteristics were documented for comparison between the treatment groups. All patients had postoperative labs including a complete blood count (CBC) nightly starting on Post-operative Day 0 (POD0) until drains were removed. Drain outputs were recorded three times a day (per 8 hour shift). Drains were discontinued if output was below 30 mL per shift or by the end of postoperative day 2. The recorded characteristics included the following: age, sex, American Society of Anesthesiologists'

physical status classification (ASA), weight, height, body mass index (BMI), and pertinent preoperative laboratory values (prothrombin time/international normalized ratio, creatinine, platelet count, hematocrit, and hemoglobin).

OUTCOME MEASURES

The primary outcome was reduction of Hgb, which was the difference between preoperative and the lowest postoperative Hgb values during the inpatient admission. Secondary outcomes included calculated blood loss, reduction of hematocrit, drain output, rate of postoperative transfusion, thromboembolic event, infections and length of hospital stay. In addition, intraoperative measures such as case length, calculated blood loss, intravenous fluid received and number receiving intraoperative cell saver and blood transfusion were investigated. Blood loss was calculated as a function of patient characteristics including sex, weight, and height as well as preoperative and postoperative hemoglobin balance[12-13].

SAMPLE SIZE AND STATISTICAL ANALYSIS

A pretest power analysis determined that 30 patients in each group were needed to show a 1.0 g/dL difference in hemoglobin drop, assuming an equivalence margin of ±1.0 g/dL, 5% alpha error, and 80% power. The primary outcome of Hgb drop and the secondary outcome of calculated blood loss were tested for equivalence using a two one-sided test (TOST). The remaining secondary outcomes and covariates were compared using traditional t-tests. Ordinal scale outcome variables were tested using nonparametric methods such as chi-square or Fisher exact test. A P-value of <0.05 suggests statistical significance. All data were analyzed by Microsoft Excel 2011 (Microsoft, Seattle, WA) and XLSTAT 2017: Data Analysis and Statistical Solution for Microsoft Excel (Addinsoft, Paris, France).

Results

During the period of study enrollment from February 2017 and March 2020, 300 patients were scheduled for elective thoracolumbar fusion surgery, which included spinal stenosis, spondylolysis, spondylolisthesis, degenerative disc disease, adult spinal deformity, proximal junctional kyphosis, adjacent level disease, and pseudoarthrosis. 39 patients were ineligible due to meeting exclusion criteria, refusal to participate or missing pertinent lab values (Figure 1). Among the 261 enrolled study participants who underwent randomization, 137 had IV TXA and 124 had PO TXA. No patient was lost or excluded during the follow-up period. Two orthopaedic spine surgeons performed the operations: GG performed majority of the surgeries (97% of total, 98% and 95% for IV and PO, respectively), and SB performed the rest. Standard posterior approach was utilized in all cases except for one DLIF that was performed in the PO group.

The average age of enrolled patients was 62±13 years (Mean ± SD). There were 141 females and 120 males. There were no statistical differences in the patient characteristics and preoperative measurements pertaining to age, sex, height, ASA, estimated blood volume,

preoperative anticoagulant use, and pertinent preoperative laboratory values including hemoglobin, hematocrit, INR, and creatinine (Table 1). Weight was higher in PO TXA group, so BMI was higher in the PO group (32.0±5.8 kg/m^2) than in the IV TXA group (29.5±5.9 kg/m^2) (P = 0.0006). Furthermore, preoperative platelet count was higher in PO group (246±70 x10^3/mm^3) than in IV group (224±77 x10^3/mm^3) (P = 0.02). Revision cases comprised of 67% of the total sample (66% and 67% for IV and PO, respectively). A single level pedicle subtraction osteotomy (PSO) was performed for 18 patients (12 and 6 for IV and PO, respectively) by GG. TLIF was performed for 22 patients (11 and 19 for IV and PO, respectively). Intraoperative measures between the treatment groups demonstrated no statistical difference in anesthesia time, surgery time, IVF, percentage of patients receiving cell saver, and percentage of patients receiving blood transfusion. Overall, the patients within the two treatment groups were considered similar in regard to the measured independent variables (Table 2).

PRIMARY OUTCOME MEASURE

The reduction in Hgb was statistically equivalent between IV and PO TXA (Table 3). The reduction in hemoglobin for the IV TXA group was 3.56±1.93 g/dL while the drop in Hgb for the PO TXA group was 3.28±1.60 g/dL (P = 0.002, equivalent).

SECONDARY OUTCOME MEASURES

The calculated blood loss between the IV and PO TXA groups was equivalent (Table 3). On average, the volume of blood loss for the IV and PO TXA groups was 1270±677 mL and 1219±610 mL (P = 0.001, equivalent), respectively. Hematocrit drop between IV and PO TXA groups was also equivalent (Table 3). The change in hematocrit for IV and PO groups was calculated to be 10.5±5.8% and 9.9±5.4% (P < 0.001, equivalent), respectively. Postoperative rate of transfusion, drain output, length of hospital stay, and complications demonstrated no statistical difference between IV and PO TXA groups (Table 3). Total drain output for IV and PO TXA groups was similar at 676±452 mL and 651±469 mL (P = 0.41), respectively. IV TXA group had a higher postoperative transfusion rate compared to PO TXA group (22 patients [19%] vs. 12 patients [10%]; P = 0.03). Three patients (2%) in each group experienced a DVT/PE (P = 0.90). Eight patients in IV TXA group (6%) and 5 patients in PO TXA group (4%) had surgical site infections (P = 0.50). Length of hospital stay was longer in IV group compared to PO group, 4.4±2.8 days and 3.7±2.4 days (P = 0.02), respectively.

SUBGROUP ANALYSIS

The total sample was sub-categorized by the number of vertebral levels arthrodesed (1-2 levels, 3-5 levels, >5 levels). The sample size was big enough in each subgroup to allow independent statistical analysis (Table 4a-c). The 1-2 level fusion group and the >5 level fusion group demonstrated that IV TXA was equivalent to PO TXA (Hgb drop: 2.34±1.35 vs. 2.73±1.32 g/dL [P < 0.01] and 4.97±1.65 vs. 4.79±1.65 g/dL [P = 0.03], respectively; equivalence). However, the 3-5 level fusion group showed that IV TXA had higher

hemoglobin drop compared to PO (4.22±1.54 vs. 3.04±1.22 g/dL; P < 0.001). The secondary outcomes of calculated blood loss and change in hematocrit showed similar trends (Table 4a-c). Additionally, body mass index, revision, interbody fusion, osteotomy, anticoagulant use, anesthesia and surgical time can all affect blood loss (Table 5a-c). In the 1-2 level fusion group and the >5 level fusion group, BMI was higher in PO than IV TXA (32.6±5.6 vs. 29.4±6.3 kg/m^2 [P < 0.005] and 32.1±6.9 vs. 28.2±5.2 kg/m^2 [P = 0.01], respectively). In the 3-5 level fusion group, number (%) of anticoagulant use was higher in IV vs. PO TXA (14% vs 0; P = 0.03) and anesthesia time was higher in IV vs. PO TXA (372±71 vs. 340±60 min; P = 0.04).

Discussion

Spinal fusion surgery has been associated with significant perioperative blood loss, which leads to elevated transfusion rates and serious complications[14-15]. Greater healthcare costs result from cost of blood products, increased hospital stay and complications[4]. Tranexamic acid has been studied and utilized as a hemostatic agent since the 1960s, and its use in spine surgery ranges from pediatric to adults, from routine degenerative cases to complex deformity cases. A plethora of studies has demonstrated TXA's effects in reducing blood loss and transfusion rates[5]. While most studies focused on the intravenous and topical forms of TXA[8,16], this is one of the first studies in the spine literature that compares IV versus PO formulations of TXA. We found no difference in the efficacy between the two routes of administration in both the primary outcome of hemoglobin drop and secondary outcomes. PO TXA appears to be as safe as IV TXA in regards to postoperative thromboembolic events and infections. Furthermore, PO TXA was associated with lower transfusion rate compared to IV group.

Compared to total joints literature, where all formulations of TXA have been shown to be effective[9,17-18], the spine literature has been limited to the IV route of administration. Spine surgeons preferred to use IV TXA, especially in larger cases due to larger exposures and more extensive dissection. In both the small (1-2 level) and large (>5 level) fusion subgroups, BMI was higher in the PO TXA treatment group. Previous studies indicated that higher BMI was associated with increased blood loss[19-20], but our sub-analysis showed that PO and IV TXA had similar blood loss for the small and large fusion subgroups, which provided further evidence that PO TXA is effective at reducing blood loss. On the other hand, PO TXA was more effective than IV TXA at reducing blood loss in 3-5 level fusions. In this subgroup, IV TXA group had more anticoagulant use compared to PO TXA group (14% vs. 0%, P = 0.03). Also, surgery was longer in IV group compared to PO group (372±71 vs. 340±60 min, P = 0.04). Similarly, Peters el al. showed that IV TXA became increasingly effective with higher fused levels and longer surgical time[21]. Although anticoagulants were stopped according to protocol in all of our patients, their systemic clearance cannot be accurately predicted in the patients.

Given the ever-changing landscape of medical reimbursement, cost effective health care practice is beneficial to patients, providers, the healthcare system and society at large. The

use of TXA in orthopaedic surgery has become a routine practice because it has been shown to be safe, clinically beneficial, and cost effective[22]. TXA offers not only direct savings from transfusion costs[23] but also inpatient hospital cost that is related to length of stay[24]. Given that PO TXA is cheaper and easier to administer than IV TXA, switching to PO can lead to greater cost savings. In our institution, the oral TXA dosage cost $14 compared with $53 for the generic IV formulation alone (not including the cost of pharmacy preparation). Reducing length of stay with PO TXA can generate even greater cost savings. As the American population continues to age, the number of spinal fusion surgeries performed in the United States will likely continue to increase from the current annual rate of about 500,000. Consequently, transitioning to PO TXA has potential to yield cost savings of at least 20 million dollars per year for the health care system.

Our study is not without potential limitations. First, the study population contains heterogeneity such as varying patient diagnosis and surgical technique/approach. However, heterogeneity was minimized through sub-stratification of the number of fusion levels into three categories. Posterior approach was mostly used (100% and 99% for IV and PO, respectively), and a single surgeon performed most of the cases (98% and 95% for IV and PO, respectively). Second, blood loss calculation was based on the lowest postoperative hemoglobin value, which may be inaccurate due to hemodilution if the patient was discharged before postoperative day five[18]. However, change in hematocrit was similar for IV and PO groups. Despite these limitations, the validity of our results should be maintained, as the same methodology was applied to both treatment arms.

The third potential limitation is that we did not include a placebo group and assumed that PO TXA was superior to placebo based on current literature. We believe that using the standard IV formulation as a control instead of a pure placebo was more clinically useful. Additionally, because perioperative bleeding during spine surgery is multifactorial and can be more significant than TKA or THA[25], we would put patients at increased risk for blood loss if we did not give TXA. Additionally, administration of TXA in spine surgery is already emerging as the standard of care, and this study is an attempt to optimize current standards. Lastly, the large percentage (67%) of revision cases in our cohort is a limitation as the results are not directly generalizable to primary cases. Strengths of this study include that it was completed at a single center and by a single surgeon predominantly.

Conclusion

In conclusion, in the setting of spine thoracolumbar fusions, oral tranexamic acid produced an equivalent reduction in hemoglobin and blood loss compared to its intravenous counterpart. Given the equivalent clinical outcomes, potential hospital cost savings, and the ease of drug administration, oral tranexamic acid is a superior alternative to intravenous tranexamic acid.

Key Points

- The mean reduction of hemoglobin and calculated blood loss were equivalent between IV and PO TXA groups.
- Postoperative complication rates were similar between the two groups, but transfusion rate was higher in IV TXA group. Length of stay was longer in IV TXA group.
- PO TXA is a superior alternative to IV TXA in patients undergoing elective posterior thoracolumbar fusion.

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Figure 1. CONSORT (Consolidated Standards of Reporting Trials) flow diagram of the study. TXA, tranexamic acid.

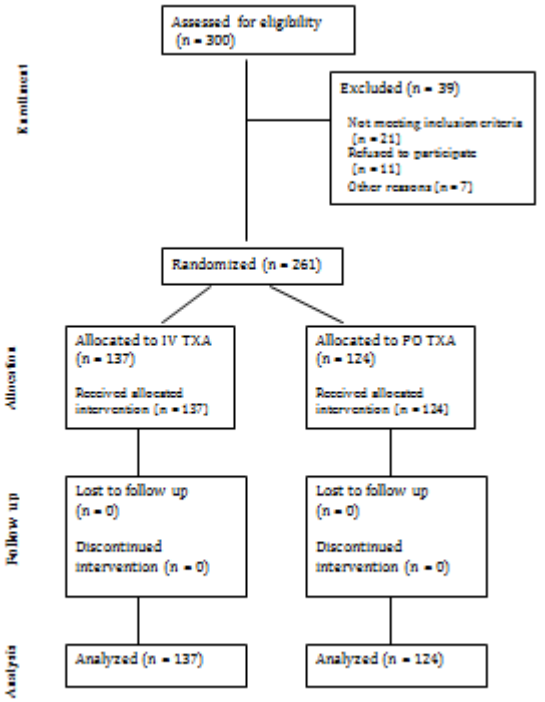

Table 1. Patient characteristics

	IV	PO	P*
Number of patients	137	124	
Mean age (yr)	64 (12)	61 (13)	0.07
Sex (M/F)	64/73	56/68	0.80[a]
Weight (kg)	85 (20)	92 (21)	0.005
Height (m)	1.69 (0.11)	1.69 (0.11)	0.9
Body mass index	29.5 (5.9)	32.0 (5.8)	0.0006
Estimated blood volume (mL)	4916 (972)	5144 (1050)	0.07
ASA	2.7 (0.5)	2.7 (0.5)	0.85
Class I (n)	0	2	
Class II (n)	40	31	
Class III (n)	93	90	
Class IV (n)	4	1	
Number of fused levels	4.0 (2.8)	3.7 (2.8)	0.38
1-2 levels	57	62	
3-5 levels	44	34	
>5 levels	36	28	
Number (%) of revisions	91 (66%)	83 (67%)	0.93[a]
Number (%) of interbody fusions	11 (8%)	19 (15%)	0.07[a]
Number (%) of osteotomies	19 (14%)	14 (11%)	0.53[a]
Number (%) of anticoagulant use	12 (9%)	6 (5%)	0.21[a]
Preoperative Hgb (g/dL)	13.4 (1.5)	13.6 (1.7)	0.34
Preoperative Hct (%)	40.0 (4.4)	40.5 (4.6)	0.34
Preoperative platelet count ($x10^3/mm^3$)	224 (77)	246 (70)	0.02
Preoperative INR	1.07 (0.12)	1.05 (0.16)	0.26
Preoperative creatinine (mg/dL)	0.97 (0.71)	0.92 (0.74)	0.6

Mean (SD)

*Statistical analysis for comparison between groups: $P < 0.05$, statistical significance.

[a]x^2 test or Fisher exact test.

Table 2. Intraoperative measures

	IV (N=137)	PO (N=124)	P*
Anesthesia time (min)	372 (104)	356 (98)	0.2
Surgical time (min)	275 (101)	266 (97)	0.45
Intravenous fluid (mL)	3402 (1759)	3365 (1449)	0.85
Number (%) receiving cell saver	54 (39%)	42 (34%)	0.35[a]
Number (%) receiving blood transfusion	9 (7%)	3 (2%)	0.11[a]

Mean (SD)

*Statistical analysis for comparison between groups: $P < 0.05$, statistical significance.

[a]x^2 test or Fisher exact test.

Table 3. Outcome measurements

	IV (N=137)	PO (N=124)	P*
Hgb drop (g/dL)	3.56 (1.93)	3.28 (1.60)	0.002[c]
Calculated blood loss (mL)	1270 (677)	1219 (610)	0.001[c]
Hct drop (%)	10.5 (5.8)	9.9 (5.4)	<0.0001[c]
Drain output (mL)	676 (452)	651 (469)	0.41
Number (%) postop transfusion	26 (19%)	12 (10%)	0.03[a]
Number (%) DVT/PE	3 (2%)	3 (2%)	0.90[a]
Number (%) infections	8 (6%)	5 (4%)	0.50[a]
Length of hospital stay (days)	4.4 (2.8)	3.7 (2.4)	0.02

Mean (SD)

*Statistical analysis for comparison between groups: $P < 0.05$, statistical significance.

[a]x^2 test or Fisher exact test.

[c] Welch two one-sided test: $P < 0.05$ demonstrates equivalence between treatments.

Table 4a. Outcome measurements for 1-2 fused levels

	IV (N=57)	PO (N=62)	P[c]
Hgb drop (g/dL)	2.34 (1.35)	2.73 (1.32)	<0.01
Calculated blood loss (mL)	850 (436)	1020 (514)	0.01
Hct drop (%)	6.6 (3.6)	8.1 (4.0)	0.02

Mean (SD)

[c] Welch two one-sided test: P < 0.05 demonstrates equivalence between treatments.

Table 4b. Outcome measurements for 3-5 fused levels

	IV (N=44)	PO (N=34)	P*
Hgb drop (g/dL)	4.22 (1.54)	3.04 (1.22)	<0.001
Calculated blood loss (mL)	1559 (582)	1115 (444)	<0.001
Hct drop (%)	12.7 (4.6)	9.2 (3.7)	<0.001

Mean (SD)

*Statistical analysis for comparison between groups: P < 0.05, statistical significance.

Table 4c. Outcome measurements for >5 fused levels

	IV (N=36)	PO (N=28)	P[c]
Hgb drop (g/dL)	4.97 (1.65)	4.79 (1.65)	0.03
Calculated blood loss (mL)	1706 (612)	1783 (651)	0.03
Hct drop (%)	14.7 (5.0)	14.7 (7.0)	0.04

Mean (SD)

[c] Welch two one-sided test: P < 0.05 demonstrates equivalence between treatments.

Table 5a. Baseline characteristics for 1-2 fused levels

	IV (N=57)	PO (N=62)	P*
BMI (kg/m^2)	29.4 (6.3)	32.6 (5.6)	<0.005
Number (%) of revisions	38 (67%)	36 (58%)	0.33[a]
Number (%) of interbody fusions	5 (9%)	11 (18%)	0.15[a]
Number (%) of osteotomies	0	0	N/A
Number (%) of anticoagulant use	4 (7%)	4 (6%)	0.9[a]
Anesthesia time (min)	302 (55)	303 (49)	0.97
Surgical time (min)	206 (50)	211 (47)	0.58

Mean (SD)

*Statistical analysis for comparison between groups: P < 0.05, statistical significance.

[a]x^2 test or Fisher exact test.

Table 5b. Baseline characteristics for 3-5 fused levels

	IV (N=44)	PO (N=34)	P*
BMI (kg/m^2)	30.6 (6.0)	30.9 (5.4)	0.84
Number (%) of revisions	27 (61%)	22 (65%)	0.76[a]
Number (%) of interbody fusions	3 (7%)	6 (18%)	0.14[a]
Number (%) of osteotomies	1 (2%)	2 (6%)	0.41[a]
Number (%) of anticoagulant use	6 (14%)	0	0.03[a]
Anesthesia time (min)	372 (71)	340 (60)	0.04
Surgical time (min)	272 (67)	253 (60)	0.18

Mean (SD)

*Statistical analysis for comparison between groups: P < 0.05, statistical significance.

[a]x^2 test or Fisher exact test.

Table 5c. Baseline characteristics for >5 fused levels

	IV (N=36)	PO (N=28)	P*
BMI (kg/m^2)	28.2 (5.2)	32.1 (6.9)	0.01
Number (%) of revisions	26 (72%)	25 (89%)	0.09[a]
Number (%) of interbody fusions	3 (8%)	2 (7%)	0.86[a]
Number (%) of osteotomies	18 (50%)	12 (43%)	0.57[a]
Number (%) of anticoagulant use	2 (6%)	2 (7%)	0.79[a]
Anesthesia time (min)	482 (102)	493 (88)	0.67
Surgical time (min)	387 (99)	402 (86)	0.52

Mean (SD)

*Statistical analysis for comparison between groups: P < 0.05, statistical significance.

[a]x^2 test or Fisher exact test.