SNI
SURGICAL NEUROLOGY INTERNATIONAL
SNI: Spine
OPEN ACCESS
For entire Editorial Board visit : http://www.surgicalneurologyint.com
Editor: Nancy E. Epstein, MD Winthrop Hospital, Mineola, NY, USA

Original Article

Tisseel's impact on hemostasis for 2–3 and 4–6-level lumbar laminectomies

Nancy E. Epstein

Professor of Clinical Neurosurgery, Schoold of Medicine, State University of New York at Stony Brook and Chief of Neurosurgical Spine and Education, NYU Winthrop Hospital, NYU Winthrop NeuroScience, NY, USA

E-mail: *Nancy E. Epstein - nancy.epsteinmd@gmail.com
*Corresponding author

Received: 12 August 17 Accepted: 14 August 17 Published: 11 December 17

Abstract

Background: Tisseel (Baxter International Inc., Westlake Village, CA, USA), a fibrin sealant, was originally devised to strengthen repairs of spinal cerebrospinal fluid (CSF) fistulas. Here, we evaluated how Tisseel correlated with hemostasis (e.g., defined as reduced postoperative drainage, time to drain removal, length of stay (LOS), and postoperative transfusion requirements) in 58 patients undergoing 2–3 vs. 79 patients having 4–6 level lumbar laminectomies.

Methods: We assessed how Tisseel correlated with hemostasis in 58 patients undergoing 2–3 level laminectomies/stenosis (with 48 herniated discs and 20 synovial cysts, 1 degenerative spondylolisthesis) vs. 79 having 4–6 level laminectomies/stenosis (with 39 lumbar discs, 45 synovial cysts, and 26 degenerative spondylolisthesis).

Results: Following 2–3 level laminectomies, the average drainage on postoperative day 1 was 87.26 cc, and on day 2 was 59.62 cc; most drains were removed and the majority of patients were discharged on postoperative day 2, requiring no transfusions. After 4–6 level decompressions, greater postoperative drainage was observed on postoperative days 1 (e.g., 156.63 cc), and 2 (115.8 cc), and many were continued for 3 (85.7 cc; 44 patients), and 4 postoperative days (93.6: 6 patients) respectively. Drains were typically removed and patients were discharged on postoperative days 3 and 4, with just 6 requiring transfusions. Notably, there were four CSF fistulas for patients undergoing 4–6 level laminectomies; one had a large disc hernation in conjunction with postoperative scare, while three had massive calcified synovial cysts extending to/through the dura.

Conclusions: Utilizing Tisseel as a hemostatic allowed us to quantitate hemostasis (the average postoperative drainage, time to drain removal, LOS, and postoperative transfusion requirements) for those undergoing 2–3 level laminectomies vs. 4–6 level procedures with large subsets also exhibiting herniated discs, synovial cysts, and degenerative spondylolisthesis.

Access this article online
Website: www.surgicalneurologyint.com
DOI: 10.4103/sni.sni_302_17
Quick Response Code:

How to cite this article: Epstein NE. Tisseel's impact on hemostasis for 2–3 and 4–6-level lumbar laminectomies. Surg Neurol Int 2017;8:299.
http://surgicalneurologyint.com/Tisseel's-impact-on-hemostasis-for-2–3-and-4–6-level-lumbar-laminectomies/

Key Words: Discs, hemostatic agent, lumbar spine surgery, no CSF fistulas, no fusions length of stay, stenosis, timing drain removal, Tisseel, transfusion requirements

INTRODUCTION

Tisseel (Baxter International Inc., Westlake Village, CA, USA), a fibrin sealant, was originally introduced to strengthen repairs of cerebrospinal fluid (CSF) fistulas (traumatic and deliberate) resulting from lumbar spinal surgery. However, Tisseel is increasingly being utilized in the absence of CSF fistulas as a hemostatic agent for lumbar surgery, with hemostasis variably defined by the amount of postoperative drainage, time to drain removal, length of stay (LOS), and postoperative transfusion requirements. Here we quantitated the comparative impact of Tisseel on hemostasis for patients undergoing 2–3 vs. 4–6 level laminectomies for stenosis with varying frequencies (e.g. with/without) of disc herniations, synovial cysts, and degenerative spondylolisthesis (DS).

MATERIALS AND METHODS

We prospectively followed 58 patients undergoing 2–3 level laminectomies/stenosis and 79 patients undergoing 3–6 level laminectomies/stenosis [Table 1]. The 2–3 level procedures addressed more herniated discs (48 patients), fewer synovial cysts (20 patients), and only rarely degenerative spondylolisthesis (1 patient). Alternatively, the 4-6 level laminectomies/stenosis included more patients with degenerative spondylolisthesis (26 patients), fewer disc herniations (39 patients), but many more synovial cysts (45 patients: often multilevel and/or multifocal). All laminectomies were performed utilizing somatosensory evoked potential (SEP) and electromyographic monitoring. They were performed by the same surgeon, utilizing the operating microscope, and undercutting the lateral gutters to preserve facet joints, thus avoiding the need for fusions.

RESULTS

Postoperative drainage/other variables

Data for 2–3-level laminectomies

The average operative times for 58 patients undergoing 2–3 level laminectomies was 3.3 h (STDEV 0.7 h) [Table 2]. For 2–3 level decompressions, the average postoperative drainage on days 1–4 was 97.26 cc (day 1:58 patients), 59.62 cc (day 2:58 patients), 73.3 (day) 3:12 patients), and 65 cc (day 4; 2 patients) respectively. Drains were removed and patients were largely discharged on postoperative days 2 (39 patient), 3 (16 patients), and 4 (2 patients). Only one patient, whose drain was removed on postoperative day 2 was discharged on postoperative day 7 due to persistent hypotension associated with benign prostatic hypertrophy medications.

Data for 4–6-level laminectomies

For the 79 patients undergoing 4–6 level laminectomies, the average operative time was 4.0 h (STDEV 0.9) [Table 2]. The mean postoperative drainage on postoperative days 1–4 averaged: 156.63 cc (day 1: 79 patients), 115.8 cc (day 2: 79 patients), 85.7 cc (day 3: 44 patients), and 93.6 cc (day 4: 6 patients) [Table 2]. Note, for those undergoing 4–6 level laminectomies, discharges were performed on postoperative days 2–5; day 2 (16 patients), day 3 (35 patients), day 4 (19 patients), and day 5 (18 patients). Only one patient who developed a postoperative sterile seroma with persistent drainage, required secondary surgery on postoperative day 7 (still in the hospital); he was discharged home on postoperative day 10.

Postoperative cerebrospinal fluid fistulas

Correlation of intraoperative cerebrospinal fluid fistulas with massive calcified synovial cysts extending to/through the dura

Intraoperative traumatic CSF fistulas were only observed in four patients undergoing the more extensive 4–6 level laminectomies/stenosis. This correlated with a higher incidence (45 cases) of one to four level synovial cysts observed amongst these 79 patients. One patient developed a CSF fistula following an L1-S1 laminectomy for stenosis and excision of a massive disc herniation; this patient had prior surgery, and the fistula was largely attributed to postoperative scar. The other three CSF fistulas occurred during decompressions/removals of massive calcified synovial cysts extending to/through the dura resected during L1-S1, L2-S1, and L3-S1 laminectomies. Notably, although 20 of 58 patients undergoing 2-3 level laminectomies had single/multiple synovial cysts, none developed intraoperative CSF fistulas [Tabel 1].

Lack of correlation of cerebrospinal fluid fistulas with postoperative scar

Prior surgery did not appear to uniquely contribute to CSF fistulas during secondary or tertiary surgery for patients undergoing 2–3 or 4–6 level laminectomies/stenosis [Table 1]. In fact, although seven of 58 patients undergoing 2–3 level laminectomies had prior surgery (e.g., 1 with one prior, 6 with two prior operation), none developed new intraoperative fistulas. For 5 of 79 patients undergoing 4-6 level laminectomies (1 with one prior, and 4 with two prior operations), only one of the four with a single prior operation developed a CSF fistula.

Transfusion requirements: 6 (7.6%) of 79 patients undergoing4-6-level laminectomies

Utilizing Tisseel to facilitate hemostasis, no transfusions were required for the 58 patients undergoing 2–3 level laminectomies, while 6 (7.6%) of the 79 undergoing 4–6 level laminectomies required transfusions [Tables 2 and 3]. Notably, these 6 patients underwent more extensive procedures that incurred increased postoperative drainage, time to drain removal, and therefore, greater blood loss thus requiring postoperative transfusions [Tables 2 and 3]. Four of the six

Table 1: Tisseel used for hemostasis in patients undergoing 2-3 (58 patients) vs. 4–6-level (79 patients) lumbar laminectomies

Data	58 Patients 2-3-level laminectomies	Patients 79 4-6-level laminectomies
Average Age	50.34	57.31
STDEV age	13.14	10.0
Males	29	43
Females	30	35
Levels of surgery	Average 2.8 levels	Average 5.0 levels
2 levels	12	0
3 levels	46	0
4 levels	0	27
5 levels	0	28
6 levels	0	24
Disc herniations	52 discs/48 patients	45 discs/39 patients
L23	2	4
L34	3	8
L45	22	23
L5S1	25	10
Synovial cysts	20 patients	45 patients
1 Levels	14	15
2 Levels	6	22
3 Levels	0	6
4 Levels	0	2
L23	1	0
L23/L34	2	2
L34	2	5
L34/L45	2	14
L45	5	8
L45/L5S1	2	2
L5S1	6	2
L23/L45	0	3
L23/l34/L45	0	5
L12/23/34/45	0	2
L34/45/5S1	0	1
Degenerative spondylolisthesis	1 DS	26 DS
Prior surgery	7 patients	5 patients
1 prior operation	1	1
2 prior operations	6	4
CSF fistulas	0	4
L1-S1 stenosis/disc	0	1
L1-S1St/Syn cyst^ ^	0	1
L3-S1 St/Syn cyst^ ^	0	1
L2-S1St/Syn cyst^ ^** (2nd Surgery)	0	1**

*Delay to day 7; BPH/Urinary Retention/Hypotension, **Postoperative Seroma requiring secondary surgery, Syn Cyst=^^Massive Synovial Cysts, DS=Degenerative Spondylolisthesis

Table 2: Tisseel's impact as a hemostatic on postoperative drainage and length of stay

Data	58 Patients 2-3-level laminectomies	Patients 79 4-6-level laminectomies
Drainage Postop Day 1	58 Patients	79 Patients
Average	97.26 cc	156.63 cc
STDEV	131.09 cc	82.49 cc
Median	75 cc	140 cc
Mode	30 cc	150 cc
Range	0-318 cc	15-500cc
Drainage Postop Day 2	58 patients	79 patients
Average	59.62	115.8
STDEV	41.88	68.83
Median	57.50	110
Mode	50	80
Range	0-425	5-25 ccs
Drainage PostopDay 3	12 patients	44 patients
Average	73.3	85.70
STDEV	27.1	62.9
Median	67.5	70
Mode	70	60
Range	45-150	9-390
Drainage postop Day 4	2 patients	6 patients
Average	65 cc	93.6
STDEV		44.7
Discharged home	Average 2.4 days	Average 3.3 days
Day 2	39	16
Day 3	16	35
Day 4	2	19
Day 5	0	8
Day 6	0	0
Day 7	1*Drain out day 2	0
Day 10	0	1**Drain Out day 6; Reoperation Day 7; Home Day 10
Transfusions	0 patients	6 patients
None	58 Patients	73 patients
1 U RBC		2 (2 patients)
2 U RPC		4 (4 patients)
Platelets		2 units (1 patient)
Surgical yime	Average 3.3 hours	Average 4.01 hours
STDEV	0.7 Hours	0.9 hours
Median	3.0 Hours	4.0 hours
Mode	3.0 Hours	4.0 hours
Range	2.5 Hours Range	2.5-6.5 hours range

* Patient with Benign Prostatic Hypertrophy Hypotension with BPH Medications; **Postoperative Seroma (Sterile) Removed Postoperative Day 7

has preoperative anemia (HCT with hydration preoperatively 32). The estimated blood loss (EBL) during surgery ranged from 50 cc to 450 cc, and the volume of postoperative drainage varied. The average postoperative drainage on day 1 (70–150), day 2 (20–200), day 3 (30–390), and day 4 (30-300) were skewed by the patient with a postoperative seroma (drained until day 6, reoperation day 7, and discharged home day 10).

DISCUSSION

Fibrocaps (dry powder fibrin sealant) contributes to spinal hemostasis

Two studies in 2015 utilized Fibrocaps for epidural spinal hemostasis and other surgical procedures [Table 4].[1,11] Verhoef *et al.* (2015) employed Fibrocaps, "ready-to-use, dry-powder fibrin sealant containing human plasma-derived thrombin and fibrinogen" in 126 adults undergoing hepatic (*N* = 58), spinal (*N* = 37), peripheral vascular (*N* = 30), and soft tissue procedures (*N* = 1).[11] Patients were randomized to Fibrocaps: N = 47 vs. sponge alone *N* = 23, secondary Fibrocaps *N* = 39, and gelatin sponge vs. sponge alone *N* = 17. The time to hemostasis was shorter utilizing Fibrocaps. Bochicchio *et al.* (2015), using Fibrocaps in 480 patients vs. a gelatin sponge alone (239 patients) for patients randomized to multiple surgical procedures [spinal (*N* = 183), vascular (*N* = 175), hepatic (*N* = 180), or soft-tissue (*N* = 181)].[1] They also found Fibrocaps significantly reduced the time to hemostasis.

Role of fibrin sealants/fibrin glues in spinal and orthopedic surgery

Multiple studies have documented the efficacy of fibrin sealant/fibrin glue (FS/FG) in promoting postoperative spinal hemostasis [Table 4].[9,12] In 2008, Yeom *et al.*, performed a retrospective analysis of 30 matched-pairs of patients undergoing >or = 3 level anterior cervical fusions; they documented FS contributed to hemostasis using 2.0 mL of fibrin sealant (e.g., fine aerosolized spray) vs. control group (no FS).[12] They found FS reduced total drainage (averaged 47 mL vs. 98 mL), time until drain removal (< or = 20 mL/shift (average 17 h vs. 24 h)), and decreased LOS (average 1.2 days vs. 2.1 days). Complication rates for both groups were comparable: two readmissions from each group within 4 postoperative days for dysphagia, dyspnea, and pneumonia. In 2009, Thoms and Marwin documented the beneficial role of fibrin sealants in limiting the time to hemostasis and perioperative bleeding for knee and hip arthroplasty.[9]

Tranexamic acid (fibrin Sealant) reduces blood loss in spine surgery

Several studies demonstrated how preoperative intravenous administration of tranexamic acid (TXA) (FS)

Table 3: Transfusion requirements in six patients undergoing 4-6-level laminectomies/stenosis

Patient	Preoperative Anemia Surgical Levels#	EBL In Surgery HCT in OR	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Transfusion	#Day Drain Out #Day Home
1	No 6 Levels	300	200	135	80	30			2 UPC 2 U Plts Von Willbrand Disease	Drain Out Day 4 Home Day 4
2	Yes Preop HCT <32 6 Levels	450	150	80	30				1 UPC	Drain Out Day 3 Home Day 3
3	Yes Preop HCT <32 6 Levels	150	150	40					2 UPC	Drain out Day 2 Home Day 2
4	Yes Preop HCT <32 4 Levels	100	145	125	175	30			2 UPC	Drain out Day 4 Home day 4
5	Yes Preop HCT >32 6 Levels	50	70	20					2 UPC	Drain Out Day 3 Home day 4
6	No 5 Levels Second Surgery	150 Second Surgery: 20 cc	120 2nd: 60 cc	200 2nd: < 30 cc	390	300	260	120	1 UPC Reop Day 7	Drain Out Day 6 Reop Day 7 Home Day 10
Total	1-4 Levels 1-5 Levels 4-6 Levels 4 Preop Anemia HCT <32	Avg EBL 200 cc	Avg 139.1 cc	Avg 100	Avg 196.3	Avg110			10 U PC 2 U Platelets	Home 1-Day 2 1-Day 3 3-Day 4 1-Day 10

Preop: Preoperative: Reop: Reoperation, HCT: Hematocrit, UPC: Units Packed Cells, Plt: Platelets, EBL: Estimated Blood Loss, Avg.: Average, OR: Operating Room, U: Units

Table 4: Comparison of fibrin sealants, fibrin glues, fibrocaps, transexamic acid, and Tisseel for hemostasis in spine and other surgery

Author year	Product number patients	Surgery data	Surgery data	Conclusions
Verhoef[11] 2015	Fibrocaps 126 Patients	58 Hepatic 37 Spinal	30 Vascular 1 Soft Tissue	Fibrocaps Shorter time to hemostasis
Bochicchio[1] 2015	Fibrocaps 480 Patients 2239 Gelatin Sponge	183 Spinal 175 Vascular	180 Hepatic 181 Soft tissue	Fibrocaps reduced time to hemostasis
Yeom[12] 2008	Fibrin Sealant (FS) 30 Study 30 Controls	3 or >level Anterior Cervical fusions 2.0 mL FS Aerosolized spray	FS reduced drainages; 47 mL (FS) vs. 98 mL (Controls)	Time to drainage FS: 17 h vs Controls 24 hLOS FS 1.2 days controls 2.1 days
Dunn[3] 1999	TXA (FS) 10 mg/kg IV 1 H preop/1 mg/kg/hour	Cardiac surgery	Reduced EBL 29% Transfusion reduced 54%	Effective hemostatic (also liver and pancreas
Tsutsumimoto[10] 2011	TXA: French Door Laminoplasty C3-C6	20 TXA preop at 15 mg/kg) vs. 20 Controls	37% Reduced Blood Loss TXA in first 16 hours	40 h Blood Loss TXA 264 mL vs. 353 mL
Huang[7] 2014	Meta-analysis46 RCT TXA 2925 patients	Major orthopedic procedures	TXA reduced blood loss by 214.58 mL	Transfusions Reduced by 0.78 U/patient TXA
Cheriyan[2] 2015	11 RCT 644 patients TXA	TXA prior to spinal surgery	TXA reduced EBL mean 219 cc	< Transfusions No complications
Yu[13] 2017	73 Study TXA 46 Controls Cervical Lam/Fusions	TXA intraopEBL 179.66 vs. 269.13 mL	Postop EBL 108.08 and 132.83 ML	< EBL TXA 287.74 vs. 401.96 ML Controls No complications
Sekhar[8] 2007	Tisseel Applied	200 spinal epidural use	20 Vertebral Venous Plexus	No complications
Epstein[5] 2014	Tisseel 22 Intraop (excess bleeding) vs. 17 Controls	39 Lam/F for Stenosis DS	= Time drain removal Tisseel 3.41 vs. Control 3.38 days	LOS Tisseel 5.86 days vs. Controls 5.82 None
Epstein[6] 2015	Tisseel 39 LamF 48 Lam	OR Times 4.1 h Tisseel LamF 3.0 h Tisseel Lam EBL Tisseel LamF 192.3 cc Tisseel 147.9 Lam	Postop drainage Day 1 199.6 LamF 167.4 Lam Day 2 172.9 LamF 63.9 Lam	> Transfusions Lam F 11 patients/18 UPC vs. Transfusions 2 LAM patients 3 UPC

EBL: Estimated blood loss, Preop: Preoperative, Intraop: Intraoperative, Postop: Postoperative, Lam: Laminectomy, FS: Fibrin Sealant, TXA: Tranexamic acid, DS: Degenerative Spondylolisthesis, LOS: Length of stay, LamF: Laminectomy/Non-instrumented fusions, UPC: Units packed cells, RCT: Randomized controlled trials

contributed to hemostasis and reduced postoperative blood loss following spinal surgery [Table 4].[2,7,10,13,14]

Tranexamic acid reduces blood loss in cardiac and orthopedic surgery

In 1999, Dunn and Goa defined TXA as a "synthetic derivative of the amino acid lysine that exerts its antifibrinolytic effect through the reversible blockade of lysine binding sites on plasminogen molecules [Table 4]."[3] When TXA was administered intravenously (TXA 10 mg/kg initial dose and subsequent infusion of 1 mg/kg/h) prior to cardiac surgery, it reduced blood loss by 29%, and the transfusion requirement by 54%. It was also effective for other operations (e.g., liver and pancreas). Huang *et al.* (2014) in their meta-analysis of 46 randomized controlled trials (RCTs) identified 2,925 patients undergoing major orthopedic procedures.[7] On average, TXA reduced total blood loss by 408.33 mL, intraoperative blood loss by 125.65 mL, postoperative blood loss by 214.58 mL, and blood transfusions per patient by 0.78 U without an increase in thrombotic risks.[7]

Tranexamic acid reduces blood loss in cervical spine surgery

In 2011, Tsutsumimoto *et al.* performed 40 consecutive French door cervical laminoplasties (C3-C6); 20 patients received intravenous TXA prior to the incision (15 mg/kg body weight) vs. 20 receiving placebo [Table 4].[10] Despite nearly comparable intraoperative blood loss in both groups, within the first 16 postoperative hours, TXA patients demonstrated a 37% decrease in postoperative blood loss vs. controls (132.0 ± 45.3 vs. 211.0 ± 41.5 mL); at 40 postoperative hours the difference was TXA (264.1 ± 75.1 mL) vs. controls (353.9 ± 60.8 mL). In 2017, Yu *et al.* (2017) documented TXA effectively promoted hemostasis for 73 patients undergoing cervical laminectomy/lateral mass screw fusion vs. 46 controls; TXA contributed to decreased intraoperative blood loss (179.66 vs. 269.13), postoperative blood loss (108.08 and 132.83), total blood loss (287.74 vs. 401.96), without any major thromboembolic/other complications.[13]

Tranexamic acid reduces blood loss in spinal surgery overall

In 2014, when Zhang *et al.* performed a meta-analysis of six RCTs (randomized controlled trials) involving spinal surgery (RCTs; 411 patients), TXA-treated patients exhibited significantly reduced blood loss and transfusion requirements vs. placebo patients, without increasing thromboembolic complications [Table 4].[14] Cheriyan *et al.* (2015) analyzed 11 RCTs in which 644 patients received TXA prior to spinal surgery; TXA reduced "intraoperative, postoperative, and total blood loss by an average of 219 mL" and reduced transfusion rates without thrombotic complications.[2]

Tisseel's (fibrin sealant) role in spinal hemostasis

Several studies have unsuccessfully utilized Tisseel FS/FG to promote epidural spinal hemostasis [Table 4].[4-6,8] Sekhar *et al.* (2007) successfully utilized Tisseel to facilitate hemostasis in the epidural space (N = 200 patients) and vertebral venous plexus (N = 20 patients) without complications.[8] When Epstein (2014) reviewed the literature regarding the utility of Tisseel and other FS/FG not only to treat CSF fistulas, but also to promote hemostasis in spine surgery; it reduced perioperative bleeding, transfusion requirements, LOS, postoperative scar/radiculitis, and infection (e.g., if impregnated with antibiotics).[4] In 2014, for 39 patients undergoing multilevel laminectomies/1–2 level non-instrumented fusions (LamF) for stenosis/degenerative spondylolisthesis (DS), Epstein also utilized Tisseel in 22 patients demonstrating increased intraoperative bleeding vs. 17 showing no increased intraoperative bleeding (the latter not requiring Tisseel).[5] Here, the addition of tisseel both equalized the time to drain removal (3.41 days vs. 3.38 days), and LOS (5.86 vs. 5.82).[5] Epstein in 2015 then compared two different series of patients receiving Tisseel; 39 underwent average 4.4 level laminectomies/1.3 level non-instrumented fusions (LamF) vs. 48 having average 4.0 level laminectomies (LAM) alone.[6] The LamF patients had (as anticipated) longer average surgical times (4.1 h LamF vs. 3.0 h Lam), greater EBL (192.3 vs. 147.9 cc), more postoperative drainage (day 1; 199.6 vs. 167.4 cc; day 2; 172.9 vs. 63.9 cc), longer LOS (4.6 vs. 2.5 days), and greater transfusion requirements (11 LamF patients; 18 UPC (units of packed cells) vs. 2 Lam patients; 3 UPC). Additionally, here data for the previous 48 patients undergoing average 4.0 level LAM (without non instrumented fusions) were compared with those from this series of 79 patients having 4–6 level LAM (also without non instrumented fusions) (averaging 5.0 level procedures). Although drainage on postoperative day 1 was nearly comparable for both groups, as anticipated, those undergoing 4 vs. 5 level laminectomies had less blood loss on postoperative day 2 (63.9 cc vs. 115.8 cc), shorter LOS (2.5 days vs. 3.3 days), and lower transfusion greater transfusion requirements [2 patients; 4.0 level laminectomies (3 UPC) vs. six patients undergoing 5.0 level laminecotmies (10 UPC; 2 U platelets)]. Of interest, the present series of 58 patients having less extensive 2–3 level laminectomies (average 2.8 levels), exhibited less EBL on postoperative days 1 and 2 (97.6 cc and 59.62 cc), nearly equal LOS (2.4 days), but required no transfusions.

CONCLUSIONS

One may utilize the data presented in this study to advise patients undergoing 2-3 and 4-6 level laminectomies regarding their anticipated time to drain removal, LOS, risk of a CSF fistula, and potential requirement for a transfusion. Here, the addition of Tisseel to facilitate hemostasis for 79 patients undergoing the more extensive 4-6 level laminectomies (without non instrumented fusions), correlated with greater postoperative drainage, time to drain removal, LOS, and postoperative transfusion requirements. Alternatively, for those undergoing more restricted 2-3 level laminectomies (without non instrumented fusions), all parameters were appropriately/respetively decreased. Notably, utilizing Tisseel, there were no neurological complications, no infections, and no readmissions for patients in either operative group.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Bochicchio GV, Gupta N, Porte RJ, Renkens KL, Pattyn P, Topal B, *et al.* The FINISH-3 trial: A phase 3, international, randomized, single-blind, controlled trial of topical fibrocaps in intraoperative surgical hemostasis. J Am Coll Surg 2015;220:70-81.
2. Cheriyan T, Maier SP 2nd, Bianco K, Slobodyanyuk K, Rattenni RN, Lafage V, *et al.* Efficacy of tranexamic acid on surgical bleeding in spine surgery: A meta-analysis. Spine J 2015;15:752-61.
3. Dunn CJ, Goa KL. Tranexamic acid: A review of its use in surgery and other indications. Drugs 1999;57:1005-32.
4. Epstein NE. Hemostasis and other benefits of fibrin sealants/glues in spine surgery beyond cerebrospinal fluid leak repairs. Surg Neurol Int 2014;5(Suppl 7):S304-14.
5. Epstein NE. Tisseel utilized as hemostatic in spine surgery impacts time to drain removal and length of stay. Surg Neurol Int 2014;5(Suppl 7):S354-61.
6. Epstein NE. Tisseel does not reduce postoperative drainage, length of stay, and transfusion requirements for lumbar laminectomy with noninstrumented fusion versus laminectomy alone. Surg Neurol Int 2015;6(Suppl 4):S172-6.
7. Huang F, Wu D, Ma G, Yin Z, Wang Q. The use of tranexamic acid to reduce blood loss and transfusion in major orthopedic surgery: A meta-analysis. J Surg Res 2014;186:318-27.

8. Sekhar LN, Natarajan SK, Manning T, Bhagawati D. The use of fibrin glue to stop venous bleeding in the epidural space, vertebral venous plexus, and anterior cavernous sinus: Technical note. Neurosurgery 2007;61(3 Suppl):E51; discussion E51.
9. Thoms RJ, Marwin SE. The role of fibrin sealants in orthopaedic surgery. J Am Acad Orthop Surg 2009;17:727-36.
10. Tsutsumimoto T, Shimogata M, Ohta H, Yui M, Yoda I, Misawa H. Tranexamic acid reduces perioperative blood loss in cervical laminoplasty: A prospective randomized study. Spine (Phila Pa 1976) 2011;36:1913-8.
11. Verhoef C, Singla N, Moneta G, Muir W, Rijken A, Lockstadt H, *et al*. Fibrocaps for surgical hemostasis: Two randomized, controlled phase II trials. J Surg Res 2015;194:679-87.
12. Yeom JS, Buchowski JM, Shen HX, Liu G, Bunmaprasert T, Riew KD. Effect of fibrin sealant on drain output and duration of hospitalization after multilevel anterior cervical fusion: A retrospective matched pair analysis. Spine (Phila Pa 1976) 2008;33:E543-7.
13. Yu CC, Gao WJ, Yang JS, Gu H, Md MZ, Sun K, Hao DJ. Can tranexamic acid reduce blood loss in cervical laminectomy with lateral mass screw fixation and bone grafting: A retrospective observational study. Medicine (Baltimore) 2017;96:e6043.
14. Zhang F, Wang K, Li FN, Huang X, Li Q, Chen Z, *et al*. Effectiveness of tranexamic acid in reducing blood loss in spinal surgery: A meta-analysis. BMC Musculoskelet Disord 2014;15:448.