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Clinical Studies

Who bleeds during elective anterior lumbar surgery?

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ABSTRACT

Background: Blood loss (BL) during elective anterior lumbar access for interbody fusion or disc replacement is a potentially major complication. This study sought to identify factors other than major vascular injury which contribute to BL and therefore this risk. Factors suggested to effect blood loss include age, increasing body mass index (BMI), sex, prothesis, intraoperative heparinization and continuation of low-dose aspirin (LD-ASA).

Methods: A Cell Saver was used in all cases with BL measured and recorded by an independent autotransfusionist. Heparin was administered intravenously when one or both of 2ndtoe saturation metre signal/s lost pulsatility indicating lower limb arterial flow was interrupted.

Results: The mean age of the 364 patients was 47 ± 13.2 yrs. [95% CI: 45 – 48]; and 191 (52%) were male. Age, BMI and heparinization showed a positive correlation with increased BL. There was no significant association with continuation of low-dose ASA with increased BL. Most patients underwent an ALIF - 265 (72%), 52 (14%) had a TDR, and 47 (13%) had a hybrid operation. There was a significant increase in mean BL between single- and two-level procedures in the non-heparinised group (48 vs 83 mls, $p = 0.003$). Intraoperative heparinization was administered in 102 patients (28%). The total mean BL for the heparin group (104 ml) which was significantly higher than for the non-heparin group (53 ml) ($p = 0.001$). Heparinisation did not significantly increase the mean BL in single or double level ALIF patients but did significantly increase the BL in single level TDR (57 vs 151 mls, $p = 0.039$).

Conclusions: Younger, leaner, non-heparinized, single level ALIF patients represented the lowest bleeding risk in anterior lumbar surgery. Conversely, older, increasing BMI, two operative levels, TDR prosthesis and heparinization represent the highest bleeding risk. Continuation of LD-ASA was not associated with an increase in BL.

Introduction

Over the last 2 decades, anterior access for lumbar interbody disc surgery is growing 24% annually [12]. However, blood loss (BL) during elective anterior lumbar access for interbody fusion [1,2] or disc replacement [3,4] is a potentially major complication. BL may be due to major vessel injury, or alternatively may be due to multiple small bleeding sources the cumulative effect of which can be substantial. Bleeding can be immediately life threatening, cause peri-operative complications (e.g. Acute cardiac events) or require blood transfusion which carries potentially serious complications (e.g. Infection, transfusion reaction and acute haemolytic reaction).

It is common practice even amongst experienced spine surgeons to operate in tandem with a vascular access surgeon to expertly manage the major vessels [13] due to the possibility of injury to the great vessels with resultant significant BL and increased morbidity [5]. Anatomical and surgery related factors influence the risk and location of major vascular injury. The approach to the L5/S1 disc is routinely between the iliac vessels and may require minimal disturbance of the iliac vessels. However, a low bifurcation level of the Aorta and/or IVC may require significantly more dissection and retraction and imperil the major vessels to a greater extent than a high bifurcation. The approach to the L4/5 or L3/4 disc is usually made from the left of the iliac arteries and veins, and the left common iliac artery and vein is retracted to the right.

FDA device/drug status: Not applicable.

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Abbreviations: ALIF, anterior lumbar interbody fusion; BMI, body mass index; BL, blood loss; CI, confidence interval; TDR, total disk replacement; LD-ASA, low-dose aspirin.

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More substantial retraction from their initial position is required when compared to the L5/S1 level which increases the risk of major vascular injury. It also increases the chance of avulsion of branches and tributaries. The type of prosthesis also can affect the blood loss – total disc replacement can require greater exposure of the disc annulus and has a more involved disc space preparation including a keel cut which can increase bleeding.

In addition to the level, prosthesis and number of target discs, factors suggested to effect blood loss include age [6], increasing body mass index (BMI) [7], intraoperative heparinization [8] and continuation of low-dose aspirin (LD-ASA) [9]. There is concern that elderly patients with an increased BMI have a higher propensity to bleed during anterior exposure.

Objective

The aim of this study was to examine which factors effect intraoperative blood loss (BL) during anterior lumbar surgery.

Methods

Study design

This was a prospective, multi-centre observational cohort study of consecutive patients undergoing anterior retroperitoneal exposure for anterior lumbar interbody fusion (ALIF), total disc replacement (TDR), or a combination of both procedures at levels L4/L5 and/or L5/S1. Patients were recruited from the investigators' private practice, from January 2009 to December 2021. All surgeries were performed in The Epworth hospital network in Victoria, Australia by a single vascular surgeon and 4 consultant neurosurgeons. These 4 neurosurgeons used the same disc space preparation with similar interbody and TDR prostheses impacted as per manufacturers' instructions. Patients underwent a single or double level anterior lumbar interbody fusion (ALIF), a single or double level total disc replacement (TDR), or a hybrid procedure with a TDR at L4/5 and an ALIF at L5/S1. Three patients were excluded due to excessive BL (>1000 mls) caused by intraoperative vascular injury (median sacral artery division, slipped tie from ascending lumbar vein and avulsed tributary from CIV). This excess blood loss represented >10 times the average procedural blood loss.

We examined the effects of patient age, BMI, sex, operative level, prosthesis, intraoperative heparinization and LD-ASA. Bilateral lower limb digital saturation probes were placed on the second toes. Heparin (heparin sodium, Baxter, IL) was administered (50–75 U/kg) intravenously when one or both saturation metre signal lost pulsatility indicating lower limb arterial flow was interrupted. Palpation of the iliac artery beyond the retractors confirmed the absence of a pulse. On return of the signals, the heparin was reversed using intravenous Protamine (protamine sulfate, Sigma-Aldrich, Inc.) as appropriate. haemostasis was secured with Surgicel Fibrillar (Ethicon, Inc.), and Floseal hemostatic Matrix (Baxter), if required.

Indications for surgery were degenerative disc disease (DDD, including disc prolapse, foraminal stenosis, discogenic pain confirmed on discography) or Grade 1–2 spondylolisthesis (degenerative or isthmic). Exclusion criteria were more than 2 level disc disease, Grade 3–4 spondylolisthesis, significant iliac artery pathology (heavy calcification, aneurysmal disease and severe stenosing atherosclerotic disease), morbid obesity (BMI > 40 kg/m^2) [10], previous complex/extensive retroperitoneal surgery, and abdominal/pelvic radiotherapy. All oral anticoagulants and antiplatelet agents were ceased preoperatively [11] except patients taking LD-ASA (100 mg) which was continued.

Patients underwent a preoperative abdominal duplex ultrasound scan of the abdominal and iliac major vessels to exclude vascular anomalies, severe atheromatous disease, and calcification. If the duplex scan had limited visibility or a possible abnormality was detected, a CT angiogram was performed. A right lower transverse muscle-sparing incision with a right-sided retroperitoneal approach was used to access the L5–S1 level. A midline lower abdominal incision with a left-sided retroperitoneal approach was used to access the L4–5 level or multiple levels.

A table-mounted abdominal retractor was used; this was combined with the use of vessel retraction pins driven into the vertebral bodies to restrain iliac vessels. For the L4–5 level, the left common iliac vein was mobilized, and the left ascending lumbar vein was usually prophylactically dissected out, ligated in continuity, and divided. This was done to prevent tears of the common iliac vein due to traction on the ascending lumbar vein, potentially causing significant BL.

The Cell Saver 5+ Autologous Blood Recovery System (Haemonetics Corp.) was used in all cases. The cell saver only was used, not in conjunction with standard intraoperative suction. An independent autotransfusionist measured and recorded the BL collected in the cell saver reservoir. All patients undergoing an ALIF received either an integrated cage-plate device or a separate cage and plate construct. For a TDR, patients received a keeled anterior arthroplasty device. A hybrid construct comprised a TDR at L4–5 and an ALIF at L5–S1.

Bias / sample size

To address design and patient selection bias, the appropriateness of the spinal procedure was determined by an experienced spine surgeon, while the suitability for the anterior exposure was determined by an experienced access surgeon.Analysis bias was addressed by performing statistical measures of significance (p=≤0.05) and a 95% confidence interval (CI=95%) to evaluate possible sources of confounding. The data was also jointly analysed by a blinded third-party, for statistical accuracy and significance. The study size of n = 384 patients was chosen, as this represented the entire summation of the patients treated by the investigators from January 2009 – December 2021.

Statistical analysis

Data is presented as mean ± SD, or as frequencies and percentages and compared with*t*-test or chi-squared test as appropriate. Binary logistic regression with BL (ml) as an outcome was performed at a univariable level, and further univariable regression analyses were performed on continuous variables, with univariate covariates of P< 0.20. R^2 and Adjusted R values were generated to assess for correlation coefficients. Estimates are reported as odds ratios (OR) with 95% confidence intervals. A two-sided$P$-value of < 0.05 was statistically significant. There were n = 102 patients that received intra-operative heparinization. This sub-group was analysed via the same methods as the non-heparinized group. This included range, mean, SD, p-value, univariate logical regression for continuous and binary variables. All patients included in the study presented complete data for variables analysed and were followed up via standard of care guidelines. All analysis was performed using Stata MP/14.0 (StataCorp, College Station, TX) and Excel (Microsoft, Seattle, WA).

Results

Participants

The cohort consisted of 364 patients who underwent anterior lumbar spine surgery. Mean age was 47 ± 13.2 years (95% CI = 45 – 48) (range 17–82) and 191 (52%) were male. Mean Body Mass was 27 ± 4 kg/m^2 (95% CI 26.6 to 27.4) range 18–39. (Table 1).

The 6 primary diagnoses were, degenerative disc disease (DDD) (295 patients, 81%), degenerative spondylolisthesis (DS) (24 patients, 6%), isthmic spondylolisthesis (IS) (31 patients, 9%), facet arthropathy (FA) (2 patients, 0.5%), pseudoarthrosis (PA) (8 patients, 2%) and adjacent segment disease (ASD) (4 patients, 1%).

Table 1
Patient demography.

Characteristic	(n)
Reviewed Patients	367
Excluded Patients	3
Eligible Patients	364
Sex	
Male	191 (52%)
Female	173 (48%)
Age	
Range	17–82 yrs.
Mean	47 ± 13 (95% CI 45.7 to 48.3)
Body Mass Index	
Range	18–39
Mean	27 ± 4 (95% CI 26.6 to 27.4)
Admission Diagnosis	
Degenerative Disc Disease (DDD)	295
Degenerative Spondylolisthesis (DS)	24
Isthmic Spondylolisthesis (IS)	31
Facet Arthropathy (FA)	2
Pseudoarthrosis (PA)	8
Adjacent Segment Disease (ASD)	4
Operative Levels	
Total Levels	482
Single Level	246
L4/5	52
L5/S1	194
Two level	118
L3/4 + L4/5	8
L4/5 + L5/S1	110
Procedure Type	
ALIF	265
TDR	52
HYDRID (ALIF + TDR)	47
Intra-Operative Heparin Administration	
Heparinized Patients	102
Non-Heparinized Patients	262
Low-Dose Aspirin Patients	21

Most patients underwent an ALIF 265 (72%), 52 (14%) had a TDR, and 47 (13%) had a hybrid operation. A total of 482 surgical levels were treated. Two hundred and forty-six (51%) were single level procedures with 194 at L5/S1 (78%) and 52 at L4/5 (22%). There were 118 double level procedures, with 110 (93%) at L4/5 + L5/S1 and 8 (7%) at L3/4 + L4/5.

Only autotransfused blood collected in the cell saver was returned to the patients. No patient needed a supplementary autologous or allogeneic blood transfusion. There were 102 (28%) patients who received intra-operative heparinization. The mean BL for heparinized patients was 104 ± 100 mls [95% CI 84.6 - 123] (range 10–500 ml). Mean BL for non-heparinized patients was 53 ± 76 mls (range 10 – 650) [95% CI 43.8 to 62.2]. ($p < 0.001$).

BMI, age and sex

Age, BMI and sex were assessed via univariate regression analysis for both non-heparinized and heparinized patients (Figs. 1, 2, 3).

In the non- heparin group, age yielded an R-square of 0.33 and a coefficient of 1.07 [95% CI: 0.89 – 1.25] $p = 0.006$. BMI yielded an R-square of 0.36 and a coefficient of 1.85 [95% CI: 1.56 – 2.15] $p = 0.015$. Sex was analysed via a binary logistical regression. This yielded an R-square of 0.73, and a coefficient of 0.03 [95% CI: 0.02 – 0.16], $p = 0.12$.

In the heparinized group, age yielded an R-Square of 0.45 and a coefficient of 2.10 [95% CI: 1.64 – 2.56] $p = 0.007$. BMI yielded an R-square of 0.50 and a coefficient of 3.73 [95% CI: 3.05 – 4.52] $p = 0.017$. Sex was analysed via a binary logistical regression. This yielded an R-square of 0.83, and a coefficient of 0.06 [95% CI: 0.02 – 0.20]. $p = 0.48$.

These results indicate that in both the heparinized and non-heparinized group, increasing age and BMI are accompanied by an incremental gain in BL. Sex demonstrated no significant relationship with BL.

Single *vs* multi-level surgery

There was a significant difference observed in BL when comparing single level non-heparinized patients ($n = 213$, 48 ± 75 mls - 95% CI: 37.9 to 58.1) versus multi-level non-heparinized patients ($n = 49$, 83 ± 78 mls) ($p = 0.003$). (Table 2)

When comparing BL for single level heparinized patients ($n = 49$, 115 ± 112 mls - 95% CI: 83.6 to 146) versus double level heparinized patients ($n = 69$, 99 ± 93 mls - 95% CI: 77.1 to 121) there was no significant difference observed in BL ($p = 0.44$).

ALIF procedures

In the non-heparinized group, 183 patients underwent single level ALIF surgery, and 32 patients underwent double level ALIF surgery. The mean BL was 48 ± 71 mls (95% CI:35 to 57) versus 89 ± 81 mls (95% CI: 60.9 to 117) and the difference was significant ($p = 0.003$).

In the heparinized group, 13 patients underwent single level ALIF surgery, and 37 patients underwent double level ALIF. The mean BL was 60 ± 66 mls (95% CI: 83.6 to 146) versus 100 ± 86 mls (95% CI: 69.4 to 139) and the difference was not significant ($p = 0.101$),

Comparing the mean BL for 183 single level non-heparinized vs 13 single level heparinized ALIF patients showed a mean BL was 48 ± 71 mls and 60 ± 66 mls which was not significant ($p = 0.47$).

Comparing 32 multiple level non-heparinized vs 37 multiple level heparinized ALIF patients showed a BL of 89 ± 81 mls vs 100 ± 86 mls. This difference was not significant ($p = 0.57$).

TDR only procedures

There was only 1 patient who underwent multiple level TDR in both the non-heparinized and heparinized groups – the difference between single and double level TDR was therefore not analysed.

In the non-heparinized group, there were 30 patients that underwent single level TDR surgery with a mean BL of 57 ml ± 60 (95% CI 35.5 to 78.5). In the heparinized group, there were 21 patients who underwent single level TDR surgery with a mean BL of 151 ± 116 (95% CI 101 to 201). This difference was significant ($p = 0.039$)

Hybrid procedures

There were 16 non-heparinized patients who underwent Hybrid surgery (ALIF + TDR) with a mean BL of 63 ± 72 mls (95% CI: 27.7 to 98.3). There were 31 heparinized patients who underwent Hybrid surgery with a mean BL of 95 ± 102 mls (95% CI: 59.1 to 131). This difference was significant ($p = 0.02$).

Difference in BL between procedure types (ALIF, TDR, Hybrid).

In the non-heparinized group, there was **no** significant difference in BL when comparing the different surgical procedures: ALIF vs TDR ($p = 0.79$), ALIF vs Hybrid ($p = 0.56$), TDR vs Hybrid ($p = 0.69$).

However, in the heparinized group, comparing the mean BL between single level ALIF (60 ± 66 mls) vs single level TDR (151 ± 116 mls) patients demonstrated a significant difference ($p = 0.02$). Likewise, comparing mean BL between double level ALIF (100 ± 86 mls) vs single TDR (151 ± 116 mls) patients demonstrated a significant difference ($p = 0.001$).

Aspirin

There were 21 patients that continued LD-ASA throughout their procedure. Mean blood loss was 49 ± 41(95% CI 31.5 to 66.5) for LD-ASA patients and 71 ± 91 (95% CI 61.1 to 80.8) for non LD-ASA patients, $P = 0.26$.

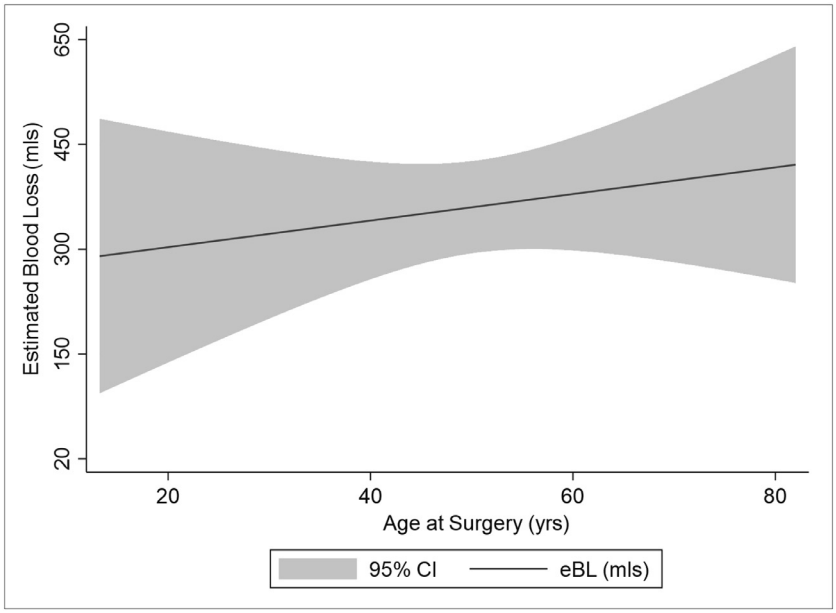

Fig. 1. Age regression analysis.

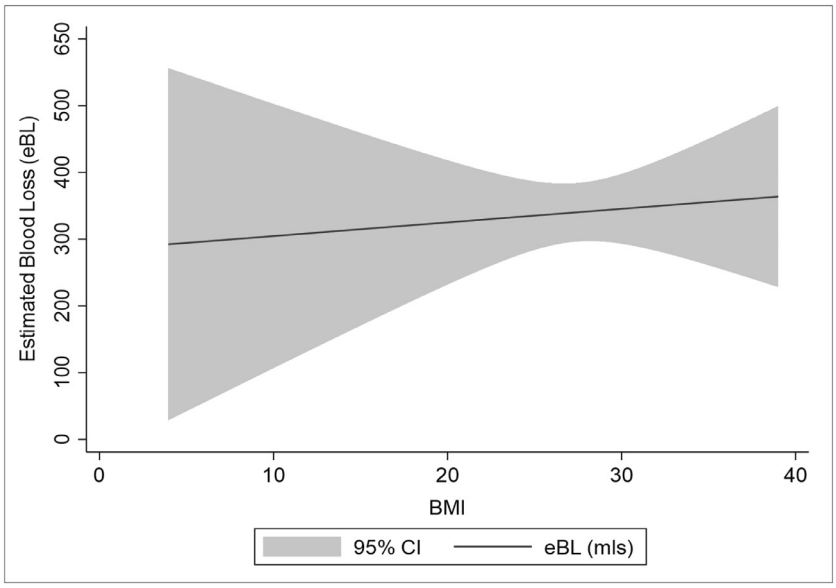

Fig. 2. BMI regression analysis.

LD-ASA was assessed via a binary logistic regression, at a univariate level to evaluate its effect on BL. This analysis produced a co-efficient of 0.05 ± 0.01 [95% CI: 0.02 −0.07], $p = 0.25$. This suggests that LD-ASA does not exert a significant effect on increasing BL during surgery.

Discussion

The risk of significant BL is a major concern even amongst experienced spine surgeons [13]. The investigators of this study sought to better understand the patient, medication, and prosthesis risk factors for increased BL.

There were 3 patients within our study who experienced a recognised technical event independent of patient anatomy, medications or prosthesis.They were excluded because their BL was 10 x greater than the mean hence erroneously skewed the results, and as such were appropriately excluded. These 3 patients were excluded to allow a more accurate statistical analysis of the effect of BMI, level, and prosthesis without being skewed by unrelated vascular injury.

Further potential barriers to utilizing an anterior approach are increased patient age and BMI. We examined the effect these factors had on the BL in our series. Older patients are more likely to have medical co-morbidities necessitating the use of LD-ASA. We have routinely continued LD-ASA to prevent peri-operative cardiovascular events. It was unknown whether this increased the risk of intra-operative bleeding in anterior lumbar surgery as research is limited [14].

We have opted to use intra-operative heparinization to prevent thrombo-embolic arterial complications when the iliac vessels were temporarily occluded by the necessary retraction. Preliminary findings regarding the use of intra-operative heparin suggested it had no significant effect, but rather the increase in the observed BL was due to the use of the TDR [8]. We wished to further investigate whether TDR was associated with higher BL compared with ALIF.

Age showed a strong positive correlation with elevated BL. Other studies have supported this [6, 15]. We postulate this is due to diminution of the supportive perivascular connective tissues which renders the small vessels more prone to disruption.

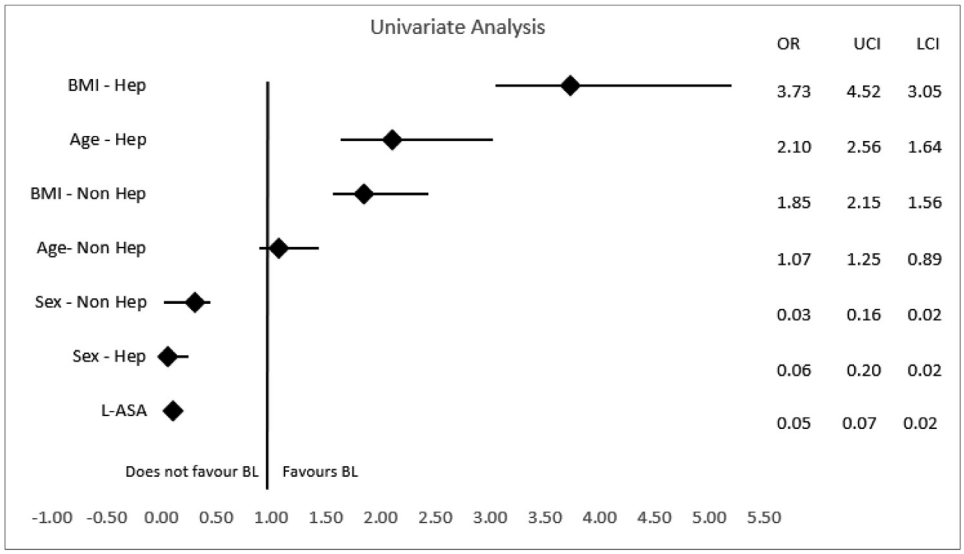

Fig. 3. Univariate analysis.

Table 2
Clinical outcomes: blood loss by procedure/level.

	N	Mean	Range	IQR	*P*=
All Patients	364	67 ± 87	10 - 650	(95% CI 58.1 to 75.9)	
Non-Heparinzed Patients	102	53 ± 76	10 - 650	[95% CI 43.8 to 62.2]	
					<0.001
Heparinized Patients	262	104 ± 100	10 - 500	[95% CI 84.6 to 123]	
One Level non-heparinized patients	213				
BL - ALIF (mls)	183	48 ± 71	10 - 650	(95% CI 35 to 57)	
					0.38
BL -TDR (mls)	30	57 ± 60	10 - 260	(95% CI 35.5 to 78.5)	
Double level non-heparinized patients	49				
BL - ALIF (mls)	32	89 ± 81	10 - 420	(95% CI 60.9 to 117)	
					0.83
BL - HYDRID (mls)	16	63 ± 72	10 - 280	(95% CI 27.7 to 98.3)	
BL - TDR	1	150	n/a	n/a	
One level heparinized patients	34				
BL - ALIF (mls)	13	60 ± 66	10 - 250	(95% CI 40.2 to 82.6)	
					0.02
BL -TDR (mls)	21	151 ± 116	10 - 450	(95% CI 101 to 201)	
Double level heparinized	68				
BL - ALIF (mls)	36	100 ± 86	10 - 400	(95% CI 69.4 to 139)	
					<0.001
BL - HYDRID (mls)	31	95 ± 102	15 - 500	(95% CI 59.1 to 131)	
BL - TDR (mls)	1	150	n/a	n/a	
Low Dose ASA (LD-ASA)					
Non LD-ASA patients	328	71 ± 91	10 - 650	(95% CI 61.1 to 80.8)	
					0.26
LD-ASA patients	21	49 ± 41	10 - 150	(95% CI 31.5 to 66.5)	

Our study found that as the BMI increased so did the BL in a co-linear fashion. There is conflicting evidence in the literature, with some studies supporting this [7], whilst other studies showed no correlation [16,17,18]. Surgery on overweight/obese patients is associated with higher necessary retractive forces, greater division of adipose tissue and more limited visualization of the surgical field. All these effects would intuitively be associated with greater bleeding from the divided adipose tissue and greater risk of vascular injury.

Independent of the intended prosthesis, the disc space preparation is identical. The use of the TDR requires keel cuts made in the sagittal plane which breach the cortex into the highly vascular cancellous bone. The patients that demonstrated the higher BL relative to prosthesis were TDR recipients, consistent with previous studies [8].

Heparinization did not increase in the BL for single level ALIF nor for double level ALIF procedures. In contrast, there was a significantly higher BL in patients receiving a single level TDR when heparin was administered. In addition, there was a significantly larger BL encountered in heparinized patients receiving a single level TDR compared to single level ALIF. Reinforcing this, heparinized patients receiving a *single* level TDR had a higher BL than heparinized patients receiving a *double* level ALIF. We postulate this is due to the keel cuts into the cancellous bone. It is difficult to control this bleeding except with the insertion of the device. Heparin potentiates this loss. This supports similar findings from earlier studies [8].

Double level ALIF has previously been correlated with higher BL [19]. We found a significant increase in BL between single and double level surgery in non-heparinized patients. There was no difference between single and double level surgery in heparinized patients. As the baseline BL is low, this is likely to be explained by the proportionally high increased volume lost from the keel cuts of TDR prostheses which occurred whether single or double level surgeries were performed.

Exposure of the L4/5 disc space more commonly resulted in temporary occlusion of the iliac artery when compared to L5/S1. The exposure for TDR at L4/5 requires wider exposure and more retraction of vessels

compared to L5/S1 again increasing the risk of vascular occlusion [20]. Hence heparin is more commonly needed at L4/5 with associated higher BL than ALIF [21]. Additionally, the most common prosthesis used at L4/5 was TDR for motion preservation.

This study found the occlusion of the iliac artery occurred almost exclusively with the retraction required to expose the L4/5 disc space. When used, the heparin was not administered prior to the exposure, rather only when the definitive vessel retraction was in place and found to be causing temporary occlusion of the artery. In double level procedures, the L4/5 procedure was performed first and when the compression of the iliac artery was relieved with release of the retraction, the heparin was reversed. The L5/S1 level procedure was then done without heparinization. As a result, the heparinization time was short.

The increased BL which occurred after administering heparin was not clinically important (approximately 50 ml). We previously reported that the TDR prosthesis was the biggest driver of BL in anterior exposure [8]. Heparin potentiates the increased bleeding from the keel cuts. This explains the significantly increased bleeding encountered after heparinizing single level TDR patients which was not observed after heparinizing single level or double level ALIF patients. It would also explain the difference noted in the BL between non-heparinized and heparinized patients receiving hybrid procedures.

The 'heparin toll' is paid at the disc space, not during the exposure. It is administered only when the operative field is dry, and usually reversed after a short period on restoration of the blood flow. The use of heparin does not magnify the blood loss, rather predominantly manifests as a predictable extra volume of BL particularly from the keel cuts during TDR when its effect is most noticeable. Utilizing heparin in this fashion is safe when combined with good surgical technique and helps prevent thromboembolic arterial complications. The effect of heparin is prosthesis related, not dependant on the number of operative levels.

The mean BL difference was statistically significant but minimally clinically significant and did not adversely impact on our patients LOS or post operative course. Our study did show that the BL was larger for the TDR cohort, particularly in the heparin group illustrating the effect of prosthesis rather than exposure. It also reinforced the safety of utilizing heparin to guard against thromboembolic complications.

Continuation of LD-ASA prior to anterior spine surgery is controversial. Multiple studies show increased perioperative risk of haemorrhage and wound drainage with LD-ASA continued or ceased only 3–7 days preoperatively [14]. Other studies advocate cessation of LD-ASA 10 days or longer before spine surgery without adverse effects [22] but the consequences of peri-operative cardiovascular complications such as myocardial infarction, stroke and coronary stent occlusion in patients are potentially catastrophic [23]. We did not find any increase in intraoperative BL with the continuation of LD-ASA consistent with systematic reviews and meta-analysis [24]. Meticulous surgical haemostasis accompanied with the use of modern haemostatic agents (e.g., Floseal, Surgicel) minimize BL. Therefore, our findings support not stopping protective LD-ASA preoperatively.

Strengths and limitations

This study reported BL from a single vascular surgeon and 4 consultant neurosurgeons at a single institution using the same techniques and prostheses. The use of the Cell Saver provided an accurate measurement of BL. We acknowledge limitations that our study was non-randomized and as an observational study, no conclusions regarding causality can be made. No inferences can be made of the effect on BL outside the reported ranges of age and BMI in this study cohort. While BMI was measured, there was no consideration made to body composition. Our study cohorts differ in size between the prostheses used and whether heparin was administered for a comparative study but these numbers reflect contemporary surgical usage. The patient cohort on LD-ASA was small, therefore to better answer whether LD-ASA should be stopped or continued before anterior surgery, larger randomized control trial studies are needed.

Conclusion

This study demonstrates that younger, leaner, non-heparinized, single level ALIF patients represented the lowest bleeding risk in anterior lumbar surgery. Conversely, older, increasing BMI, double operative levels, TDR prosthesis and heparinization represent the highest bleeding risk. There was no significant increase in BL with continuation of LD-ASA. This suggests it is safe to continue LD-ASA prior to surgery. The effect of heparin is prosthesis related, not dependant on the number of operative levels.

Funding

This study received no additional funding, as it was conducted within a standard or care setting that bore not funding requirement.

Short summary

This study investigated which factors are most likely to cause elevated blood loss during anterior lumbar surgery, and which patients represent the greatest risk.

Funding disclosure statement

This study received no financial support from internal or external sources.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.xnsj.2022.100180.

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