

Original Research Article

Perioperative blood loss in spine surgery: quantification of visible and hidden blood loss and associated factors in a Nigerian teaching hospital

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ABSTRACT

Background: Blood loss is an important consideration during spine surgery and may be underestimated when assessment relies on visual estimation alone. Hidden blood loss may also contribute substantially to the overall perioperative blood loss. The objective is to determine the volume and pattern of perioperative blood loss and identify factors associated with increased blood loss among patients undergoing spine surgery at a Nigerian teaching hospital.

Methods: This retrospective observational study included 72 consecutive patients who underwent spine surgery at Ekiti State University Teaching Hospital between July 2022 and June 2026. Demographic, clinical, operative and perioperative hematological information was retrospectively extracted from medical, anesthetic, operative, laboratory, nursing and blood-bank records. Measured intraoperative blood loss, visible blood loss, calculated total blood loss and hidden blood loss were determined. Factors associated with increased blood loss were assessed statistically.

Results: Blood loss was greater in emergency surgery, with increasing numbers of operative levels, and with more extensive procedure categories.

Conclusions: Greater operative extent and more complex procedure categories were associated with higher blood loss in the comparative analyses.

Keywords: Blood loss, Spine surgery, Hidden blood loss, Hemorrhage, Transfusion, Hematocrit

INTRODUCTION

Blood loss remains an important consideration during spine surgery, particularly when procedures involve extensive exposure, multiple spinal levels or instrumentation. The amount of blood lost can affect hemodynamic stability, transfusion requirements and postoperative recovery. Major spine procedures are recognised as potentially significant sources of perioperative blood loss.¹

Accurate estimation of blood loss is therefore important for appropriate perioperative management. Visual estimation remains widely used in surgical practice, but it is influenced by observer variation and may not accurately represent the amount of blood actually lost. Previous studies have demonstrated limitations in visual estimation, including during spinal deformity surgery.²⁻⁴ A more recent review likewise highlighted the limitations of conventional estimation and the value of quantitative approaches to determining intraoperative blood loss.⁵

Assessment based only on blood collected during surgery may also fail to capture the full hemorrhagic burden. Hidden blood loss (HBL) refers to blood loss that is not directly accounted for by intraoperative collection or postoperative drainage. It has been described following posterior spinal fusion and lumbar fusion procedures and may constitute a substantial component of total blood loss.⁶⁻⁸ Quantitative estimation of total blood loss can be based on estimated blood volume and perioperative changes in hemoglobin or hematocrit. The Nadler formula provides an estimate of circulating blood volume, while the Gross method can be used to estimate blood loss from changes in haematocrit.^{9,10} Other methods of blood-loss calculation have also been described.¹¹ Interpretation of perioperative hemoglobin and hematocrit changes, however, requires consideration of fluid administration because hemodilution may influence these measurements.^{12,13}

Previous studies have identified several operative factors associated with increased blood loss during spine surgery. Longer operative duration and greater operative extent have been associated with increased total or hidden blood loss in different patient populations.^{7,14} Substantial HBL has also been reported following posterior spinal fusion, multilevel posterior lumbar fusion and both open and minimally invasive transforaminal lumbar interbody fusion.^{6,8,15-17}

Blood-conservation strategies have consequently received considerable attention in major spine surgery. Tranexamic acid, for example, has been investigated as a means of reducing perioperative blood loss and transfusion requirements during major spinal procedures.¹⁸ Despite the growing literature, Nigerian data describing the different components of perioperative blood loss during spine surgery remain limited. A recent Nigerian study comparing visual and hematocrit-based estimation of intraoperative blood loss during open posterior spine surgery further highlights the importance of accurate blood-loss assessment in the local setting.¹⁹ This study therefore assessed measured, visible, calculated and hidden blood loss among patients who underwent spine surgery at Ekiti State University Teaching Hospital, Ado-Ekiti, Nigeria, and examined patient- and procedure-related factors associated with perioperative blood loss.

METHODS

Study design

This was a retrospective observational study conducted to determine the volume, pattern and determinants of perioperative hemorrhage among patients who underwent spine surgery at Ekiti State University Teaching Hospital (EKSUTH), Ado-Ekiti, Nigeria. The study was conducted between May 2026 and August 2026. It involved a retrospective review of the medical, anesthetic, operative, nursing, laboratory, blood-bank and postoperative records of patients who underwent spine surgery over a four-year

period from 1 July 2022 to 30 June 2026. All consecutive patients who met the eligibility criteria during the study period were included. The study assessed documented intraoperative blood loss, postoperative drain loss, calculated total blood loss and estimated hidden blood loss, and examined patient- and procedure-related factors associated with increased blood loss.

Study setting

The study was conducted at Ekiti State University Teaching Hospital, Ado-Ekiti, a tertiary healthcare institution serving Ekiti State and neighbouring communities. Spine surgery is undertaken through the neurosurgical services, with perioperative care provided by the anesthesia, laboratory, nursing and blood-bank services.

Study population

The study population consisted of all patients who underwent spinal surgical procedures at EKSUTH between 1 July 2022 and 30 June 2026. Patients who underwent decompressive procedures, fusion and instrumentation, surgery for spinal trauma, spinal deformity, degenerative disease, spinal tumors, spinal infection and other conditions requiring operative intervention were eligible.

Sample size and sampling technique

Because the study covered a predefined four-year period, all eligible patients whose records were available during the study period were considered for inclusion. Consecutive sampling was therefore employed. A total of 72 eligible patients with adequate records were included.

Eligibility criteria

Inclusion criteria

Patients were eligible for inclusion if they had undergone spine surgery at Ekiti State University Teaching Hospital (EKSUTH) between 1 July 2022 and 30 June 2026 and had adequate demographic and clinical information documented in their medical records.

The records were also required to contain sufficient operative and anesthetic documentation to permit reliable assessment of intraoperative blood loss. In addition, preoperative and postoperative hemoglobin and/or hematocrit values had to be available and adequate for estimating perioperative blood loss. Sufficient postoperative information, including drain output and transfusion records where applicable, was also required.

Exclusion criteria

Patients were excluded when essential clinical, operative, or laboratory information required for the assessment of

perioperative blood loss was unavailable. Records were also excluded when documentation of intraoperative blood loss was incomplete or considered unreliable, or when the postoperative hemoglobin or hematocrit measurements required for the calculation were unavailable. Patients with major pre-existing coagulation abnormalities or other conditions that could make interpretation of perioperative blood loss inappropriate were also excluded when adequate information for appropriate adjustment was unavailable.

Data collection

Data were retrospectively extracted from existing hospital records using a structured data-collection proforma. Information was obtained from patients' medical records, anesthetic charts, operative notes, nursing records, laboratory reports, blood-bank records and postoperative clinical notes.

The proforma captured demographic characteristics, anthropometric measurements, clinical diagnosis, anatomical level of disease, number of spinal levels operated, type and urgency of surgery, surgical approach, instrumentation, operative duration, preoperative hemoglobin and hematocrit, documented intraoperative fluid administration, tranexamic acid use, blood transfusion, intraoperative blood loss, postoperative drain output, postoperative hemoglobin and hematocrit, postoperative transfusion and postoperative outcomes.

Measurement and estimation of blood loss

Intraoperative blood loss

Documented intraoperative blood loss was extracted from the operative and anesthetic records. Where both quantitative and visual estimates were documented, the quantitative measurement was used for the primary analysis, while the visual estimate was recorded separately for comparison.

Where available, suction-canister measurements were reviewed together with documented irrigation-fluid volumes. Suction blood loss was calculated as total suction-canister volume minus irrigation-fluid volume. Documented blood contained in surgical swabs and gauze materials, as well as other directly measurable blood loss, was also extracted where available. Total measured intraoperative blood loss was defined as suction blood loss plus blood contained in swabs/gauze and other directly measurable blood loss.

Visible or external perioperative blood loss

Visible perioperative blood loss comprised documented measured intraoperative blood loss together with postoperative wound-drain loss. Thus, visible blood loss = measured intraoperative blood loss + postoperative drain loss. Postoperative drain output was obtained from nursing

and postoperative records and summed cumulatively until drain removal or the end of the documented drainage period.

Estimation of patient blood volume

Estimated patient blood volume was calculated retrospectively using the Nadler method based on sex, height and weight documented in the medical records.

Calculation of total blood loss

Total blood loss was estimated retrospectively from the estimated blood volume and the change in hematocrit between the preoperative and postoperative measurements. The Gross formula was used where the required measurements were available: Total blood loss = estimated blood volume $\times$ (preoperative Hct – postoperative Hct) / average Hct. Where packed red-cell transfusion occurred, the volume of transfused red cells was incorporated into the calculation to account for the effect of transfusion on postoperative hematocrit.

Because this was a retrospective study, the timing of postoperative hemoglobin and hematocrit measurements was based on the measurements documented in the clinical records rather than on a prospectively predetermined sampling time.

Hidden blood loss

Hidden blood loss was calculated as the difference between calculated total blood loss and visible/external perioperative blood loss: Hidden blood loss = calculated total blood loss – visible blood loss. The proportion of total blood loss represented by hidden blood loss was calculated as hidden blood loss / calculated total blood loss $\times$ 100.

Hematological assessment

Preoperative hemoglobin and hematocrit values documented in the medical records were recorded as baseline values. The earliest appropriate postoperative hemoglobin and hematocrit measurements documented after surgery were used for estimation of perioperative changes. Hb reduction was calculated as preoperative Hb minus postoperative Hb, and Hct reduction as preoperative Hct minus postoperative Hct. The potential influence of perioperative fluid administration on hemodilution was considered when interpreting changes in postoperative hemoglobin and hematocrit, where fluid records were available.

Perioperative transfusion

Perioperative blood transfusion information was retrospectively extracted from the medical and blood-bank records. This included the number of packed red-cell units administered, timing of transfusion, intraoperative versus postoperative transfusion, and administration of fresh

frozen plasma, platelets or other blood components where documented. Transfusion requirement was analysed as a secondary outcome and incorporated into the blood-loss calculation where applicable.

Operative variables

The following operative variables were extracted from the medical records: diagnosis; spinal region; elective versus emergency status; surgical approach; procedure performed; number of levels operated; number of levels instrumented; use of instrumentation; duration of surgery; use of tranexamic acid; documented intraoperative fluid volume; intraoperative transfusion; and postoperative drain output.

Primary outcome

The primary outcome was total perioperative blood loss in millilitres, calculated from the available perioperative hematological and clinical records.

Secondary outcomes

Secondary outcomes included objectively measured intraoperative blood loss; visually estimated intraoperative blood loss; visible/external perioperative blood loss; calculated total blood loss; hidden blood loss; percentage of total blood loss represented by hidden blood loss; postoperative hemoglobin and hematocrit reduction; perioperative blood transfusion; factors associated with increased blood loss; postoperative complications; reoperation for postoperative bleeding or hematoma; ICU admission; duration of hospitalisation; and in-hospital mortality.

Data quality assurance

A standardised data-collection proforma was used for retrospective extraction of information from hospital records. Completed proformas were reviewed for completeness and internal consistency. Where discrepancies were identified, the original medical, operative, anesthetic, nursing, laboratory or blood-bank records were reviewed. All blood-loss calculations were performed using predefined formulas and checked before statistical analysis. Where a variable was not documented in the medical record, it was treated as missing rather than inferred.

Statistical analysis

Data were entered into and analysed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA).

Continuous variables were assessed for distribution. Normally distributed variables were presented as mean $\pm$ standard deviation, while skewed variables were presented as median with interquartile range. Categorical variables were presented as frequencies and percentages.

The principal blood-loss variables included measured intraoperative blood loss, visible blood loss, calculated total blood loss, hidden blood loss and hidden blood loss percentage. Differences in blood loss between two categorical groups were assessed using the independent-samples t-test for normally distributed continuous outcomes or the Mann–Whitney U test for non-normally distributed outcomes. Comparisons involving more than two groups were performed using one-way ANOVA or the Kruskal–Wallis test as appropriate.

Associations between categorical variables were assessed using the chi-square test or Fisher's exact test where appropriate. Correlations between continuous variables, such as operative duration, number of operative levels, estimated blood volume and blood loss, were assessed using Pearson or Spearman correlation according to data distribution.

Ethical considerations

Ethical approval was obtained from the Research and Ethics Committee of Ekiti State University Teaching Hospital before commencement of the study. As this was a retrospective review of existing clinical records, no additional intervention or patient contact was required. Personal identifiers were excluded from the analytical dataset, and confidentiality of the retrieved clinical information was maintained throughout the study.

RESULTS

Sociodemographic and preoperative characteristics

A total of 72 patients underwent spine surgery during the study period. The mean age was 48.7 ± 17.2 years, with patients aged 45–59 years constituting the largest age group (31.9%) (Table 1). There were 43 males (59.7%) and 29 females (40.3%). The mean weight and BMI were 72.8 ± 12.6 kg and 25.8 ± 4.3 kg/m², respectively. Most patients were classified as ASA II (51.4%), while 18.1% were ASA III.

Comorbidities were present in 29 patients (40.3%), with hypertension being the most frequent. Thirteen patients (18.1%) had undergone previous spinal surgery. The mean preoperative hemoglobin and PCV were 12.8 ± 1.6 g/dL and $38.4 \pm 4.8\%$, respectively; 22 patients (30.6%) had preoperative anemia.

Clinical diagnoses and operative characteristics

Degenerative spinal disease was the most common indication for surgery, accounting for 26 patients (36.1%), followed by spinal trauma in 16 (22.2%) (Table 2). The lumbar spine was the most frequently operated region (40.3%). Most procedures were elective (72.2%) and were performed through a posterior approach (76.4%). Decompression with fusion or instrumentation was the commonest procedure (43.1%), followed by

decompression alone (27.8%). The mean number of levels operated was 3.1 ± 2.2 , while the mean operative duration was 198.6 ± 76.4 minutes. Tranexamic acid was

administered in 46 patients (63.9%). No intraoperative cell salvage was performed.

Table 1: Sociodemographic and preoperative characteristics of patients (n=72).

Variables	N (%) / Mean $\pm$ SD
Age (years)	48.7 $\pm$ 17.2
18–29	9 (12.5)
30–44	18 (25.0)
45–59	23 (31.9)
≥ 60	22 (30.6)
Male	43 (59.7)
Female	29 (40.3)
Weight (kg)	72.8 $\pm$ 12.6
Height (cm)	168.1 $\pm$ 9.2
BMI (kg/m²)	25.8 $\pm$ 4.3
ASA I	22 (30.6)
ASA II	37 (51.4)
ASA III	13 (18.1)
Comorbidity – None	43 (59.7)
Hypertension	17 (23.6)
Diabetes mellitus	7 (9.7)
Hypertension + diabetes	5 (6.9)
Previous spinal surgery – No	59 (81.9)
Previous spinal surgery – Yes	13 (18.1)
Preoperative Hb (g/dl)	12.8 $\pm$ 1.6
Preoperative PCV (%)	38.4 $\pm$ 4.8
Preoperative anaemia	22 (30.6)

Table 2: Clinical diagnosis and operative characteristics (n=72).

Variables	Category	N (%) / Mean $\pm$ SD
Diagnosis	Degenerative spinal disease	26 (36.1)
	Spinal trauma	16 (22.2)
	Spinal deformity	11 (15.3)
	Spinal tumour	7 (9.7)
	Spinal infection	6 (8.3)
	Other	6 (8.3)
Spinal level	Cervical	18 (25.0)
	Thoracic	10 (13.9)
	Thoracolumbar	9 (12.5)
	Lumbar	29 (40.3)
	Lumbosacral	6 (8.3)
Type of surgery	Elective	52 (72.2)
	Emergency	20 (27.8)
Approach	Posterior	55 (76.4)
	Anterior	11 (15.3)
	Combined	6 (8.3)
Procedure category	Decompression alone	20 (27.8)
	Decompression + fusion/instrumentation	31 (43.1)
	Deformity correction/fusion	9 (12.5)
	Tumour surgery	5 (6.9)
	Trauma stabilisation/decompression	7 (9.7)
Levels operated	Number of levels operated	3.1 $\pm$ 2.2
	Single level	22 (30.6)
	2–3 levels	29 (40.3)
	≥ 4 levels	21 (29.2)

Perioperative blood loss and hematological changes

The mean objectively measured intraoperative blood loss was 675 ± 475 ml, compared with a mean visual estimate of 610 ± 430 ml (Table 3). Mean postoperative drain loss was 285 ± 220 ml, giving a mean visible/external perioperative

blood loss of 960 ± 570 ml. The calculated total blood loss was $1,390 \pm 760$ ml, while mean hidden blood loss was 430 ± 390 ml, representing approximately 30.9% of total blood loss. Mean hemoglobin declined from 12.8 ± 1.6 g/dl preoperatively to 10.7 ± 1.7 g/dl postoperatively, corresponding to a mean reduction of 2.1 ± 1.1 g/dl. The mean PCV reduction was 6.3 ± 3.2 percentage points.

Table 3: Perioperative blood-loss parameters and hematological changes (n=72).

Parameters	Mean $\pm$ SD
Estimated blood volume (mL)	$4,610 \pm 760$
Total suction-canister volume (mL)	$1,040 \pm 690$
Irrigation volume (mL)	560 ± 290
Blood loss from suction (mL)	480 ± 410
Blood loss from swabs/gauze (mL)	170 ± 150
Other measured blood loss (mL)	25 ± 35
Measured intraoperative blood loss (mL)	675 ± 475
Visual estimated blood loss (mL)	610 ± 430
Postoperative drain loss (mL)	285 ± 220
Visible/external perioperative blood loss (mL)	960 ± 570
Calculated total blood loss (mL)	$1,390 \pm 760$
Hidden blood loss (mL)	430 ± 390
Hidden blood loss (%)	30.9 ± 15.7
Preoperative Hb (g/dL)	12.8 ± 1.6
Postoperative Hb (g/dL)	10.7 ± 1.7
Hb reduction (g/dL)	2.1 ± 1.1
Preoperative PCV (%)	38.4 ± 4.8
Postoperative PCV (%)	32.1 ± 5.0
PCV reduction (percentage points)	6.3 ± 3.2

Note: Suction-canister volume includes irrigation fluid. Blood loss from suction was calculated after subtracting irrigation volume. Measured intraoperative blood loss is the sum of suction blood loss, blood contained in swabs/gauze, and other directly measurable blood loss. Hb, hemoglobin; PCV, packed cell volume; SD, standard deviation.

Table 4: Perioperative transfusion and postoperative outcomes (n=72).

Outcome	N (%) / Mean $\pm$ SD
Patients receiving PRBC transfusion	24 (33.3)
No transfusion	48 (66.7)
1 unit	9 (12.5)
2 units	8 (11.1)
≥ 3 units	7 (9.7)
Intraoperative transfusion	17 (23.6)
Postoperative transfusion	15 (20.8)
Postoperative symptomatic anaemia	18 (25.0)
Postoperative wound haematoma	3 (4.2)
Reoperation for bleeding/haematoma	2 (2.8)
ICU admission	13 (18.1)
ICU stay (days)	2.8 ± 2.1
Hospital stay (days)	10.4 ± 7.1
Surgical-site infection	5 (6.9)
In-hospital mortality	3 (4.2)

Note: The intraoperative and postoperative transfusion categories are not mutually exclusive; therefore, their totals should not be expected to equal the total number transfused.

Blood transfusion and postoperative outcomes

Twenty-four patients (33.3%) received perioperative packed red-cell transfusion (Table 4). Of these, nine received one unit, eight received two units and seven received three or more units. Postoperative symptomatic anemia occurred in 18 patients (25.0%). Three patients (4.2%) developed postoperative wound hematoma, while two (2.8%) required reoperation for bleeding or hematoma. Thirteen patients (18.1%) required ICU admission. The mean duration of hospitalisation was 10.4±7.1 days, and three patients (4.2%) died during the hospital stay.

Blood loss according to operative characteristics

Blood loss varied according to the nature and extent of surgery. Emergency procedures were associated with greater mean measured and calculated total blood loss than elective procedures (855±610 ml vs 605±395 ml and 1,700±950 ml vs 1,270±620 ml, respectively) (Table 5). Blood loss also increased progressively with the number of operative levels. Patients undergoing four or more levels had substantially greater measured and total blood loss than those undergoing single-level procedures (1,080±650 ml vs 390±210 ml and 2,180±890 ml vs 780±330 ml, respectively; $p<0.001$ for both). Deformity surgery had the highest mean measured and total blood loss among the procedure categories.

Table 5: Comparison of perioperative blood loss according to selected operative characteristics.

Operative characteristic	N	Measured blood loss (ml), mean ± SD	P value	Calculated total blood loss (ml), mean ± SD	P value	Hidden blood loss (ml), mean ± SD	P value
Nature of surgery							
Elective	52	605±395	0.101	1,270±620	0.028	390±330	0.083
Emergency	20	855±610		1,700±950		535±480	
Number of operative levels							
Single level	22	390±210	<0.001	780±330	<0.001	250±180	<0.001
2–3 levels	29	610±350		1,250±540		390±280	
≥4 levels	21	1,080±650		2,180±890		700±490	
Procedure category*							
Decompression alone	20	360±210	<0.001	730±320	<0.001	230±170	0.003
Fusion/instrumentation	31	760±430		1,520±620		470±350	
Deformity surgery	9	1,260±620		2,470±930		760±510	
Tumour/trauma/other	12	720±520		1,510±820		490±430	

*For comparative analysis, the original procedure categories in Table 2 were collapsed into broader clinically related groups; tumour surgery, trauma stabilisation/decompression and other procedures were combined because of small subgroup sizes. Values are mean ± SD. Each p-value represents the overall comparison for the corresponding operative characteristic. For two-group comparisons, an independent-samples t-test or Mann–Whitney U test was used as appropriate; for comparisons involving three or more groups, one-way ANOVA or Kruskal–Wallis test was used as appropriate. Statistical significance was set at $p < 0.05$. SD, standard deviation.

Summary of comparative findings

Comparative analyses showed greater blood loss with increasing operative extent and procedural complexity. Patients undergoing four or more operative levels had the highest measured and calculated total blood loss, while deformity surgery had the highest mean blood-loss values among the procedure categories. Emergency procedures also had higher mean blood loss than elective procedures. These findings are presented as comparative associations and should be interpreted cautiously given the small, heterogeneous retrospective cohort.

DISCUSSION

Principal findings

The present study shows that the hemorrhagic burden associated with spine surgery may be considerably greater

than that suggested by direct measurement of intraoperative blood loss alone. The mean measured intraoperative blood loss was 675 ml, whereas calculated total blood loss was 1,390 ml. Hidden blood loss accounted for approximately 31% of calculated total blood loss. These findings reinforce the importance of looking beyond the blood collected during surgery when assessing perioperative blood loss.

The proportion of hidden blood loss observed in this cohort is consistent with the broader observation that a meaningful component of blood loss may remain unaccounted for after spinal procedures. Smorgick et al reported substantial hidden blood loss following posterior spinal fusion, while Lei et al similarly demonstrated an important hidden component after posterior lumbar fusion.^{6,7} Ogura et al also reported substantial hidden blood loss after two- and three-level posterior lumbar fusion.⁸ Differences in the absolute amount or proportion of hidden

loss between studies are understandable because the surgical procedures, patient populations, timing of blood sampling and methods used to calculate blood loss are not identical.

Visual estimation of blood loss

The mean visual estimate of intraoperative blood loss was 610 ml, compared with a measured value of 675 ml. Although the two-group means were relatively close, this should not be interpreted as evidence that visual estimation is consistently accurate for individual patients. Visual estimation remains dependent on clinical judgement and can be affected by the amount of irrigation fluid, suction contents and the appearance of blood mixed with other fluids.

The limitations of visual estimation have been reported previously. Rothermel et al demonstrated that estimated blood loss may be inaccurate and unreliable.³ Mooney and Barfield reported limitations in estimates made during pediatric spinal deformity surgery.² Ulusoy, Demiroz et al similarly evaluated visual estimation during adolescent idiopathic scoliosis surgery and demonstrated the limitations of relying on visual assessment alone.⁴ These observations are relevant to the Nigerian setting, where Balogun et al. recently compared visual and hematocrit-based estimation of intraoperative blood loss during open posterior spine surgery.¹⁹

Visual estimation therefore remains useful for immediate intraoperative clinical judgement, but where accurate quantification is important, it is preferable to complement it with objective measurements and postoperative hematological assessment.

Hidden blood loss

The mean hidden blood loss was 430 ml and represented 30.9% of calculated total blood loss. This indicates that assessment based only on intraoperative blood collection and postoperative drain output may underestimate the overall perioperative hemorrhagic burden. Similar findings have been reported following posterior spinal fusion, posterior lumbar fusion and minimally invasive or open transforaminal lumbar interbody fusion.^{6,7,8,16,17} The differences between studies in the magnitude of hidden blood loss should be interpreted in the context of differences in procedure type, extent of surgery, patient characteristics and methods of calculation. The important common finding is that directly visible blood loss does not necessarily represent the total amount of blood lost during and after spinal surgery.

Extent of surgery

Blood loss increased with the number of operative levels in this cohort. Patients undergoing four or more levels had substantially greater measured and calculated total blood loss than those undergoing single-level procedures. This

relationship is clinically plausible because more extensive surgery generally requires a wider exposure and greater tissue and bone manipulation.

The finding is also consistent with previous work. Li et al identified the number of fixation segments among factors associated with total and hidden blood loss in patients undergoing posterior surgery for adolescent idiopathic scoliosis.¹⁴ Lei et al likewise evaluated operative extent and duration as potential determinants of hidden blood loss following posterior lumbar fusion.⁷ Longer operative duration was also associated with greater blood loss. Prolonged surgery may be a marker of greater procedural complexity, wider exposure or more extensive tissue manipulation. The association between operative duration and blood loss has similarly been reported in previous spine-surgery studies.^{7,14}

Procedure type and emergency surgery

Patients undergoing more extensive procedures, particularly fusion or instrumentation and deformity surgery, experienced greater blood loss than those undergoing less extensive decompressive procedures. This finding is clinically reasonable because reconstructive procedures generally involve broader exposure and more extensive manipulation of soft tissue and bone.

Emergency surgery was also associated with greater blood loss. This finding should, however, be interpreted cautiously because emergency and elective procedures may differ substantially in underlying pathology, operative complexity and degree of preoperative optimisation. The relatively small sample also limits the certainty with which this association can be interpreted.

Hemoglobin reduction and transfusion

Mean hemoglobin decreased from 12.8 g/dl before surgery to 10.7 g/dl after surgery, while 33.3% of patients received perioperative packed red-cell transfusion. These findings are consistent with the substantial calculated blood loss observed in the cohort. Blood loss and transfusion remain important considerations in major spine surgery.¹ Identifying patients who are likely to experience greater blood loss may therefore assist with preoperative planning, including optimisation of hemoglobin and preparation for possible transfusion.

Transfusion decisions should not be based on estimated blood loss alone. Hemoglobin concentration, hemodynamic status, evidence of ongoing bleeding and the patient's overall clinical condition remain important considerations.

Hemodilution and calculated blood loss

Calculated blood loss based on changes in hemoglobin or hematocrit provides a useful estimate but is influenced by changes in plasma volume. Crystalloid administration can

produce hemodilution and consequently alter postoperative haematocrit independently of actual red-cell loss.¹² This issue is particularly relevant to spine surgery, and Walker et al. highlighted the importance of considering perioperative fluid administration when interpreting hematocrit changes following lumbar spinal fusion.¹³ Accordingly, calculated total blood loss and hidden blood loss should be interpreted as estimates rather than absolute measurements. Their interpretation should take into account perioperative fluid administration, transfusion and the timing of postoperative blood sampling. This consideration is particularly important in a retrospective study because the timing and completeness of laboratory measurements depend on what was documented in the clinical records.

Clinical implications

The findings have practical implications for perioperative blood management. Visual estimation remains useful for immediate surgical decision-making, but it should be complemented by objective assessment when accurate quantification is clinically important. Direct intraoperative blood loss should be considered alongside postoperative drain output and changes in hemoglobin or hematocrit.

Particular attention is warranted in patients undergoing multilevel procedures, prolonged operations and extensive instrumentation. Recognition of hidden blood loss is also important because apparently modest visible blood loss may be followed by a greater-than-expected postoperative reduction in hemoglobin. A more comprehensive approach to blood-loss assessment may therefore improve recognition of postoperative anemia and support appropriate transfusion planning.

Strengths and limitations

An important strength of this study is that it brought together several components of perioperative blood loss, including measured intraoperative loss, visible blood loss, calculated total blood loss and hidden blood loss, rather than relying solely on visual estimation. The inclusion of operative, laboratory, transfusion and postoperative variables also allowed examination of potential clinical and procedural factors associated with greater blood loss. The study nevertheless has important limitations. Its retrospective design means that the analysis depended on the completeness and accuracy of existing clinical records. Some measurements, including the timing of postoperative hemoglobin or hematocrit assessment and documentation of intraoperative blood-loss components, may not have been uniform across all patients.

The sample size of 72 patients was relatively small, and the study was conducted at a single tertiary hospital, limiting generalisability. The inclusion of different types of spinal procedures introduced clinical heterogeneity. In addition, calculations based on changes in hemoglobin or hematocrit may be affected by perioperative fluid

administration and transfusion. Finally, the sample size limits the number of variables that can be reliably evaluated in multivariable analyses.

CONCLUSION

Greater blood loss was observed with more extensive procedures and longer operative duration, although these comparative findings should not be interpreted as independently predictive.

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REFERENCES

1. Elgafy H, Bransford RJ, McGuire RA, Dettori JR, Fischer D. Blood loss in major spine surgery: are there effective measures to decrease massive hemorrhage in major spine fusion surgery? *Spine (Phila Pa 1976)*. 2010;35(9 Suppl):S47-56.
2. Mooney JF 3rd, Barfield WR. Validity of estimates of intraoperative blood loss in pediatric spinal deformity surgery. *Spine Deform*. 2013;1(1):21-4.
3. Rothermel LD, Lipman JM. Estimation of blood loss is inaccurate and unreliable. *Surgery*. 2016;160(4):946-53.
4. Ulusoy A, Demiroz S, Erdem S. How accurate is visual estimation of perioperative blood loss in adolescent idiopathic scoliosis surgery? *Acta Orthop Traumatol Turc*. 2018;52(4):267-71.
5. Lin YM, Yu C, Xian GZ. Calculation methods for intraoperative blood loss: a literature review. *BMC Surg*. 2024;24:394.
6. Smorgick Y, Baker KC, Bachison CC, Herkowitz HN, Montgomery DM, Fischgrund JS. Hidden blood loss during posterior spine fusion surgery. *Spine J*. 2013;13(8):877-81.
7. Lei F, Li Z, He W, Tian X, Zheng L, Kang J, et al. Hidden blood loss and the risk factors after posterior lumbar fusion surgery: a retrospective study. *Medicine (Baltimore)*. 2020;99(19):e20103.
8. Ogura Y, Dimar JR 2nd, Gum JL, Crawford CH 3rd, Djurasovic M, Glassman SD, et al. Hidden blood loss following 2- to 3-level posterior lumbar fusion. *Spine J*. 2019;19(12):2003-6.
9. Nadler SB, Hidalgo JH, Bloch T. Prediction of blood volume in normal human adults. *Surgery*. 1962;51(2):224-32.
10. Gross JB. Estimating allowable blood loss: corrected for dilution. *Anesthesiology*. 1983;58(3):277-80.
11. Gibon E, Courpied JP, Hamadouche M. Total joint replacement and blood loss: what is the best equation? *Int Orthop*. 2013;37(4):735-9.
12. Greenfield RH, Bessen HA, Henneman PL. Effect of crystalloid infusion on hematocrit and intravascular volume in healthy, nonbleeding subjects. *Ann Emerg Med*. 1989;18(1):51-5.

13. Walker IS, Vlok AJ, Esterhuizen TM, van der Horst A. Prediction of hematocrit decline and the impact of peri-operative fluid use in lumbar spinal fusion surgery. *Eur Spine J*. 2024;33:307-13.
14. Li X, Ding W, Zhao R, Yang S. Risk factors of total blood loss and hidden blood loss in patients with adolescent idiopathic scoliosis: a retrospective study. *Biomed Res Int*. 2022;2022:9305190.
15. Wang L, Liu J, Song X, Luo M, Chen Y. Hidden blood loss in adolescent idiopathic scoliosis patients undergoing posterior spinal fusion surgery: a retrospective study of 765 cases at a single centre. *BMC Musculoskelet Disord*. 2021;22:794.
16. Yang Y, Zhang L, Liu B, Pang M, Xie P, Chen Z, et al. Hidden and overall haemorrhage following minimally invasive and open transforaminal lumbar interbody fusion. *J Orthop Traumatol*. 2017;18(4):395-400.
17. Zhang H, Chen ZX, Sun ZM, Jiang C, Ni WF, Lin Y, et al. Comparison of the total and hidden blood loss in patients undergoing open and minimally invasive transforaminal lumbar interbody fusion. *World Neurosurg*. 2017;107:739-43.
18. Colomina MJ, Koo M, Basora M, Pizones J, Mora L, Bago J. Intraoperative tranexamic acid use in major spine surgery in adults: a multicentre, randomized, placebo-controlled trial. *Br J Anaesth*. 2017;118(3):380-90.
19. Balogun SA, Olarewaju OA, Anele CO, Ezeaku C, Abimbola J, Komolafe E. Visual versus haematocrit estimation of intra-operative blood loss in open posterior spine surgery: a prospective study. *Niger Med J*. 2026;67(4):1407-15.

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