Cohort Study

Study to estimate the average blood loss in different orthopedic procedures: A retrospective review

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A B S T R A C T

Background: In orthopedic surgery, bleeding is an inevitable side effect. The study's aim was to provide estimated blood loss values in various orthopedic procedures and take a step towards developing statistically reliable formulae. This can provide blood loss values in orthopedic surgery, which will be a very good tool for operative planning.
Materials and methods: We reviewed case notes of 282 patients in a UK based trauma center from December 2020 to March 2021,who had undergone a various orthopedic procedures. The results were analyzed using SPSS version 25.
Results: Most common fracture was neck of femur (37.5%)followed by intertrochanteric fractures(27.6%). Paired t-test was used, and there is good evidence (t281 = 14.957, p = 0.000) that intraoperative transfusions increased HB levels in patients (t281 = 14.957, p = 0.000) by an average of 1.331 points, with a 95% confidence interval of 1.156–1.506. As a result, the variation between the Pre-op and Post-op HB levels is statistically important but minimal. We can see that the mean blood loss is statistically different in different age groups (0.03) of patients and by the existence of co-morbids using analysis of variance (0.04). The average number of days spent in the hospital varies by surgical type (0.01) performed on patients.
Conclusion: Orthopedic surgery can be associated with high levels of blood loss. There is a significant relation between fracture form and age groups, change of wound dressing (COD), use of a tourniquet, and drain insertion, no connection was noted between gender and fracture types.

1. Introduction

Clinicians face a regular challenge in estimating intraoperative blood loss as no method or approach currently exists or has been used regularly. Despite the fact that visual assessment is inaccurate, intraoperative blood loss is still reported visually [1,2]. Excessive bleeding and a high demand for blood transfusions are common complications of orthopedic surgery, especially arthroplasty surgery [3,4]. There is currently no practical and precise procedure for measuring intraoperative blood loss. The eyeball process, in which an estimation of blood loss is calculated

through visual inspection of surgical sponges, suction canisters, and the operating room setting, is the most common method used by surgeons and anesthesiologists. Many authors have argued that this approach is ineffective [5,6]. In the pre-operative phase blood loss can be measured using the observed decrease in hemoglobin and hematocrit levels, as well as the amount of blood transfused or expected to transfuse. (see Tables 1–4)

The approaches mentioned above, however, lack a realistic and reliable intraoperative estimated blood loss(EBL)evaluation in real time. For minor procedures where no significant blood loss is required,

accurate measurement is not a problem. However for procedures in which major blood loss is expected, such as during hip arthroplasties and open reduction and internal fixations of tibia, allogeneic blood transfusion is often the mainstay for intraoperative and postoperative hemodynamic management. A higher probability of blood product replacement is associated with inaccuracy in EBL evaluation, which is also based on patient weight. Finding an effective real-time blood loss measurement tool is therefore critical to providing the best intraoperative and postoperative treatment possible.

In different surgical settings, patient-related and surgery-related factors such as gender, preoperative hemoglobin levels, and operative technique are also predictive of transfusion requirement [7,8]. The main aim of our study is to use the evidence of the variables and put forward estimated average values of blood loss in different surgeries and to shed light on which form of operation causes more hemoglobin drop, which limb is more vulnerable to hb loss, the impact of morbidities, the impact of drain insertion, and the impact of a tourniquet. Continued research and data collection will help in developing a statistically relevant formula.

2. Materials and methods

A retrospective cohort study was conducted in a level 1 trauma center in the United Kingdom from December 2020 to March 2021 looking at case notes and operative details of all orthopedic patients who had surgery during this time. The work has been reported in line with the STROCSS criteria [13] and registered under UIN 7258. Our hospital serves as a level 1 trauma center in the country and covers a range of acute and elective orthopedic specialties. We registered our study with the clinical governance department of the hospital before collecting data. We looked through patient records and gathered information on demographics, type of injury, pre-morbidity and previous medical history, current drugs, type of operation, drain insertion and production, pre-operative hemoglobin, post-operative hemoglobin, transfusions given pre, intra, and post-operatively, and dressing changes. Exclusion Criteria for the study were all spinal procedures, all re-look or re-operated procedures and all open procedures. Inclusion criteria were all upper and lower limb fracture surgery that happened during the 4 month period.

We analyzed the data using SPSS version 25. The Chi-Square Test was used to evaluate all categorical variables. Paired *t*-test was used to examine the difference in mean of Pre-OP HB and Post-OP HB levels. Levene's test is was used to calculate significance in Blood loss when drain inserted compared to the drain not being inserted.

3. Results

We studied case notes of a total of 282 patients. Our study consisted of males(43%) and females(57%) divided by age anywhere from<20 to >81. Our results showed that the most common fracture was intracapsular neck of femur followed by intertrochanteric and bimalleolar fractures. In our study all categorical variables are analyzed using the Chi-Square Test and there is significant association between Fracture type with Age groups, Change of Wound Dressing (COD), Tourniquet Used and Drain Inserted. Gender exhibits no association with Fracture Types.

To analyze the whether there is difference in mean of Pre-OP HB and Post-OP HB levels, Paired *t*-test is used and there is a strong evidence ($t_{281} = 14.957$, p = 0.000) that the Intraoperative transfusions during surgery performed improves HB level in patients. In this study, it increased HB level, on average, by approximately 1.331 points and 95% CI is from 1.156 to 1.506. So, the difference in Pre-OP HB and Post-OP HB level is statistically significant but relatively small.

For comparison of drains and tourniquet used the Levene's test is used and its p-value shows that variance in Blood loss when drain inserted is significantly different than that of drain not inserted and p-value not statistically significant for blood loss when tourniquet used.

By Analysis of variance we can see that mean of blood loss is statistically different in different Age Groups (0.03) of patients and by presence of Comorbids (0.04). Mean of days of stay at hospital is statistically different in surgery types (0.01) done on patients.

For different types of surgeries done on patients a Paired *t*-test was applied and p value < 0.05 was considered statistically significant. We compared the pre and post Hb numbers for different upper and lower limb operations and calculated the mean and standard deviation for each cohort of operation. We found that for femur open reduction and internal fixation(ORIF) blood loss was significant(P = 0.00). All upper limb ORIFs included in our review followed suit(P = 0.00) and so did tibial nailing(P = 0.00). In our review we included 130 NOF fractures that were treated with dynamic hip and screws(DHS) femoral nails and hip hemi arthroplasties and replacement. The mean pre-op HB was 116 $\pm$ 17.37 and post op HB was 103.48 + 17.16.

4. Discussion

The main findings of our study were as follows: (1) Fracture type and age groups have a close relationship. i.e. 54.5% of patients with femur neck fractures were over the age of 81, and 40% of patients with intertrochanteric fractures were in the same age group as well as other variables showing a significant P value such as Change of Wound

Table 1
Variables used in study analyzed via chi-squared test.

Variables		Fracture Type					P-value
		Fracture of Femur	Fracture of Tibia and Fibula	Bimalleolar fracture	Intertrochanteric fracture	Other Type of Fractures	
	Categories \ *N*	**106**	**23**	**44**	**78**	**31**	–
Gender, n(%)	Male	50 (40.7%)	8 (6.5%)	21 (17.1%)	31 (25.2%)	13 (10.6%)	p = 0.720
	Female	56 (35.2%)	15 (9.4%)	23 (14.5%)	47 (29.6%)	18 (11.3%)	
Age Groups, n(%)	≤20	6 (42.9%)	1(7.1%)	4 (28.6%)	3 (21.4%)	0 (0.0%)	p = 0.000
	21 to 40	8 (21.1%)	10 (26.3%)	10 (26.3%)	4 (10.5%)	6 (15.8%)	
	41 to 60	15 (27.3%)	9 (16.4%)	11 (20.0%)	8 (14.5%)	12 (21.8%)	
	61 to 80	41 (37.6%)	3 (2.8%)	18 (16.5%)	36 (33.0%)	11 (10.1%)	
	≥81	36 (54.5%)	0 (0.0%)	1 (1.5%)	27 (40.9%)	2 (3.0%)	
COD, n(%)	<2	60 (31.3%)	16 (8.3%)	35 (18.2%)	52 (27.1%)	29 (15.1%)	*p = 0.011*
	2 to 4	44 (51.2%)	7 (8.1%)	9 (10.5%)	24 (27.9%)	2 (2.3%)	
	>4	2 (50.0%)	0 (0.0%)	0 (0.0%)	2 (50.0%)	0 (0.0%)	
Tourniquet Used, n (%)	No	104 (43.5%)	22 (9.2%)	12 (5.0%)	78 (32.6%)	23 (9.6%)	*P = 0.000*
	Yes	2 (4.7%)	1 (2.3%)	32 (74.4%)	0 (0.0%)	8 (18.6%)	
Drain Inserted, n(%)	No	79 (35.0%)	19 (8.4%)	42 (18.6%)	56 (24.8%)	30 (13.3%)	*P = 0.002*
	Yes	27 (48.2%)	4 (7.1%)	2 (3.6%)	22 (39.3%)	1 (1.8%)	

Dressing(p = 0.011), Tourniquet Used(p = 0.00) and Drain Inserted(p = 0.002).(2)Strong evidence (t_{281} = 14.957, p = 0.000) to prove that the Intraoperative transfusions during surgery performed improves HB level in patients(3). When a drain is inserted, blood loss is significantly different than when it is not used, and the significance value(0.055)for blood loss when a tourniquet is used is not statistically relevant.

It's crucial not only to be able to measure the patient's blood losses, but also to be able to rectify them with the right tools. A variety of materials are now available to help limit blood loss due to direct thrombosis, thanks to the progress of thrombogenic drugs. Direct thrombogenesis is possible with surgical hemostats, internal tissue sealants, and adhesion barriers. Electro-cautery and harmonic scalpels, for example, have been demonstrated to considerably minimize surgical wound bleeding [9].

Unnecessary trauma and injury to the microvasculature can be avoided with basic surgical technique and soft tissue care. Simple factors like operative time management and operative technique play a role, as it is well known that the length of time a surgical wound is open is strongly connected to the demand for blood transfusions [10]. Furthermore, in the face of chronic hemodilution, allogeneic blood products such as fresh frozen plasma and platelets boost the patient's coagulation potential. Using all of these instruments, in addition to accurate blood loss assessment, will allow the surgeon to stay ahead of the game.

Preoperative hemoglobin and hematocrit measurements will serve as a baseline for tracking intraoperative trends. The hematocrit of blood lost intraoperatively should be equivalent to that of pre-operative blood. However, keep in mind that when the patient receives substantial amounts of intravenous fluids to maintain normovolemia, this value may fall. As a result, many authors advocate using the patient's mean post-operative hematocrit [11]. The mean difference between preoperative and postoperative hemoglobin was 3.3 g/dL according to Howe and colleagues [12]. Clinical assessment of blood loss using a multiple linear regression model was closely linked with actual decrease in perioperative hemoglobin in their retrospective investigation. While this provides some insight into the changes in hemoglobin as a result of surgery, it leaves open the question of how to accurately estimate blood loss. This study, on the other hand, confirms the validity of EBL and its importance as a direct predictor of hemoglobin alteration.

5. Limitations

The small number of patients included in this study was a drawback, as it prevented further subgroup research. The findings may have been affected by the lack of a specific transfusion procedure or transfusion causes, as well as the presence of a large number of physicians involved in the treatment of these patients. However, one of the study's strengths is that it was conducted on a large number of patients in a real-world clinical environment with no selection bias.

6. Conclusion

Orthopedic surgery has been linked to a large amount of blood loss. Our study has shown that there is a significant relationship between fracture type and age groups, change of wound dressing (COD), use of a tourniquet, and drain insertion in our research, but no relationship was found between gender and fracture types. Acute orthopedic procedures that we have highlighted on are associated with significant Hb drop and there is a need for more studies, research for estimating blood loss in different acute every day trauma procedures and development of statistically relevant formulae that can be used to calculate accurate Hb drops provided variables such as current Hb, estimated operative time and type of fracture are available.

Table 3

Levenes test to show significance of tourniquet and drain used on blood loss.

Target Variable	Independent Variables	P = value	Test
Blood Loss	Drain Inserted	**0.000***	Independent *t*-test
Blood Loss	Tourniquet Used	0.055	
Blood Loss	Age Groups	**0.039***	ANOVA
Blood Loss	Comorbids Cat	**0.048***	
Blood Loss	Surgery Type	0.297	
Drain Output	Surgery Type	0.220	
Days of Stay at Hospital	Surgery Type	**0.014***	

Table 4

Paired *t*-test to compare blood loss in different surgeries.

Surgery type	N(%)	Pre hb (Mean ± SD)	Std. Error Mean (SEM)	Post hb (Mean ± SD)	Std. Error Mean (SEM)	P value
Femur (ORIF)	33 (11.3)	120.33 ± 20.39	3.55	100.48 ± 16.87	2.93	0.000
Upper limb (ORIF)	34 (11.6)	123.08 ± 20.87	3.58	108.97 ± 18.62	3.19	0.000
Tibial nail	66 (22.6)	128.60 ± 19.68	2.42	116.43 ± 18.36	2.26	0.001
NOF	130 (44)	116.00 ± 17.37	1.52	103.48 ± 17.16	1.50	0.000
spine	29 (10)	129.93 ± 17.027	3.16	121.75 ± 15.91	2.95	0.000

Table 2

Comparison of pre vs post HB using paired T-test.

Paired Samples Statistics		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-OP Hb(g/dl)	12.02	282	1.915	.114
	Post-OP Hb (g/dl)	10.69	282	1.801	.107

Paired Samples Correlations		N	Correlation	Sig.
Pair 1	Pre-OP Hb(g/dl) & Post-OP Hb (g/dl)	282	.678	.000

Paired Samples Test

		Paired Differences						T	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
					Lower	Upper				
Pair 1	Pre-OP Hb(g/dl) - Post-OP Hb (g/dl)	1.331	1.495	.089	1.156	1.506		14.957	281	.000

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Ethical approval

Retrospective study looking at patient notes so no ethical approval needed.

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Author contribution

Mr Mohammad Noah H Khan: lead author idea and write up.
Dr K.Yasser Jamal: data collection.
Mr Hassan Shafiq: proof reading and corrections of statistics.
Miss Ammal Imran Qureshi: proof read and correction.
Dr Basharat Khan: data collection and analysis.
Miss Sadia Farrukh: data analysis.

Consent

All data anonymised.

Registration of research studies

Name of the registry.
Unique Identifying number or registration ID:
Hyperlink to your specific registration (must be publicly accessible and will be checked):

Guarantor

Mohammad Noah H Khan corresponding author.

Declaration of competing interest

Nil.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2021.102965.

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