

Surgeon Estimated Blood Loss is Discordant with Calculated Blood Loss in Acetabular and Pelvic Fracture Surgery

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INTRODUCTION: The orthopaedic trauma surgeon plays a key role in management of the critically ill trauma patient. Accurate quantification of both traumatic and intraoperative blood loss is crucial for decision making in the perioperative period and for performing quality research. Surgeon estimated blood loss (EBL) is unreliable, subjective and biased; several formulas have been proposed to objectify blood loss measurements. To date: there is no gold standard method for estimation. The Gross formula (and Mercuriali derivative) and the hemoglobin balance (HB) equation were recently identified as the most commonly used methods. The purpose of this study was to compare blood loss as estimated by surgeon EBL, the Gross formula, and the HB equation in open pelvic and acetabular surgery.

METHODS:

All open acetabular and pelvic surgeries performed at a Level 1 academic center (2008-18; age 18-89) were analyzed via retrospective chart review. Demographics, laboratory data, surgery details, and surgeon EBL were collected. Baseline circulating blood volume is a necessary equation input and was estimated using both the Moore and Nadler formulas. Blood loss was calculated using the Gross formula, a Gross formula derivative, and the HB equation with both Moore and Nadler blood volume estimations. Correlations were calculated and data were analyzed using Wilcoxon sign-rank tests.

RESULTS:

710 patients who underwent index open surgery for management of pelvic (n=344) or acetabular (n=366) fractures met inclusion criteria for this study. 192 patients (27%) received intraoperative blood transfusions. Average surgeon EBL was 550±665 [0, 6000] (**Table 1**). In an analysis of the entire cohort, surgeon EBL significantly differed from all formulas except the Gross/ Nadler and the modified Gross/ Nadler calculations. In subgroup analyses of both patients who received transfusions and those who did not, the results of the Gross and HB calculation methods yielded significantly different results. (**Figure 1**)

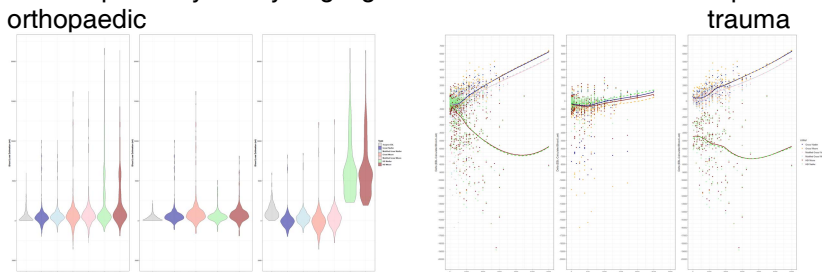
A delta was calculated between surgeon EBL and calculations to determine concordance between predictions and calculations. A delta of zero indicated that surgeon EBL matched calculated values. At low levels of surgeon EBL, delta for all four formulas tended to be near zero. However, as surgeon EBL increased, the magnitude of delta values for all four formulas also increased, indicating greater discordance between EBL and calculations (Gross/ Nadler: rho=0.50; p<0.0001; modified Gross/ Nadler: rho=0.49; p<0.0001; Gross/ Moore: rho=0.38; p<0.0001; modified Gross/ Moore: rho=0.35; p<0.0001. Corrective factors for the Gross equations mildly improved concordance. When transfused patients were removed from the cohort, there was improved concordance between surgeon EBL and calculated values, even at high EBL. (**Figure 2**)

DISCUSSION AND CONCLUSION:

Our study retrospectively reviewed blood loss in 710 patients who underwent index open surgery for management of pelvic or acetabular fractures at our institution between 2008 and 2018. We found significant differences between EBL and blood loss estimations calculated by the formulas. To our knowledge, this is the first study in the orthopaedic trauma literature to directly compare blood loss formulae.

As there is no gold standard, our study does not postulate that any one method of determining blood loss is correct. Instead, we compare the results of the blood loss estimation methods to assess for similarities and correlations. Our results demonstrate discordance between formula predictions and surgeon estimated blood loss. At higher levels of blood loss, this discrepancy worsens. Furthermore, use of different blood loss estimation formulas can yield significantly different results. This is important to consider clinically and when evaluating the orthopaedic literature.

This exploratory study highlights the need for the development of improved methods of quantifying blood loss in orthopaedic trauma surgery.



	Predicted and Calculated Blood Loss					
	Overall (n=710)		Without Transfusion (n=517)		With Transfusion (n=192)	
	Mean (SD)	Median (Min, Max)	Mean (SD)	Median (Min, Max)	Mean (SD)	Median (Min, Max)
Surgeon EBL	550 (665)	300 [0, 6000]	332 (374)	250 [0, 3500]	1140 (887)	887 [0, 6000]
Gross/ Moore	819 (2080)	543 [1360, 16200]	1138 (16200)	711 [1410, 16200]	924 (1730)	1350 [1360, 12300]
Modified Gross/ Moore	936 (2040)	617 [280, 16000]	752 (1410)	486 [116, 10100]	399 (1680)	270 [280, 12300]
Gross/ Nadler	547 (1380)	363 [0, 10100]	752 (1410)	486 [116, 10100]	-16.1 (1120)	-105 [0, 8270]
Modified Gross/ Nadler	663 (1340)	449 [1530, 10100]			415 (1070)	316 [1530, 840]
HB/ Moore	2390 (3210)	1040 [1930, 3214000]	884 (1180)	668 [1930, 8120]	6380 (3460)	5630 [1910, 21400]
HB/ Nadler	2160 (3270)	690 [1390, 21600]	562 (779)	434 [1390, 5060]	6460 (3560)	5730 [1390, 21600]