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A novel algorithm to calculate target preoperative hemoglobin for patients declining allogeneic transfusion

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To the Editor:

Patients declining transfusion require optimal treatment of preoperative anemia to minimize risks, costs, and surgical delays. Here we describe a novel algorithm to calculate the ideal target preoperative hemoglobin required to avoid allogeneic transfusion. This algorithm is derived from the classic allowable blood loss formula, which considers body mass and expected surgical blood loss to determine the ideal target preoperative hemoglobin concentration. We examined a small retrospective cohort of patients who declined transfusion to determine if severe anemia would be avoided using this novel algorithm.

The formula for calculating the ideal preoperative target Hb (formula B) is a modification of the allowable blood loss equation (formula A) [1], and was obtained by solving this equation for the preoperative Hb (Hb_{preop}).

Classic allowable blood loss formula (formula A)

$$ABL = EBV\left[\frac{Hb_{preop} - Hb_{postop}}{\left(Hb_{preop} + Hb_{postop}\right)/2}\right]$$

Novel Preoperative Ideal Hb target formula (formula B)

$$Hb_{preop} = Hb_{postop}\left[\frac{\frac{ABL}{2EBV} + 1}{1 - \frac{ABL}{2EBV}}\right]$$

ABL = allowable blood loss, Hb_{preop}= the target preoperative Hb concentration required to avoid transfusion, Hb_{postop} = the lowest postoperative Hb concentration the patient would tolerate, EBV = estimated blood volume. EBV is calculated as 70 mL/kg for males and 65 mL/kg for females [2].

A nomogram derived from formula B depicts the calculated target preoperative Hb concentration for various degrees of expected blood loss according to the patient's body mass in kg (Fig. 1). For this nomogram, 70 mL/kg was used to derive estimated blood volume (EBV), 8 g/dL was used as the Hb_{postop}, and estimated blood loss (EBL) substituted for allowable blood loss (ABL) was plotted for four different amounts (500, 1000, 1500, and 2000 mL). The Hb_{postop} of 8 g/dL was chosen as a cautious acceptable level according to evidenced-based red cell transfusion guidelines recommending 7–8 g/dL for most patients [3], which adds some allowance for postoperative bleeding.

To test this algorithm, after IRB approval with waived informed consent, we retrospectively identified 25 adult patients who declined blood transfusions for religious or personal reasons and underwent spine surgery at Johns Hopkins Hospital between 2017 and 2021. We chose spine surgery to ensure a homogeneous group by surgical procedure, but with a wide variation in blood loss allowing us to test our algorithm. For these patients not accepting transfusion, the expected blood loss for the planned surgical procedure was estimated (based on the posted procedure), then the patient's body mass and most recent Hb concentration were obtained, following which our consultant hematologist (L.M.S.R.) ordered additional testing to diagnose the cause of anemia, and identify specific treatments required to achieve a reasonable preoperative Hb concentration as we have previously described [4,5]. Preoperatively, seven patients (28.0%) required oral iron therapy, 10 (40.0%) required intravenous iron, and only 3 (12.0%) required an erythropoietic stimulating agent (ESA). Using the algorithm for these 25 patients, the calculated ideal target preoperative Hb values ranged from 8.2 to 11.9 g/dL, and the mean was 9.7 ± 0.9 g/dL. The mean actual achieved preoperative Hb exceeded the calculated ideal Hb in the majority (23 of 25; 92.0%) of patients (Supplemental Fig. 1).

In addition to preoperative anemia diagnosis and treatment, patients received intraoperative tranexamic acid, cell salvage, normothermia, and controlled hypotension when indicated, and phlebotomy blood loss was minimized using smaller tubes and less frequent laboratory testing [6]. The mean estimated intraoperative blood loss was (346 ± 280 mL), and the range was large, up to a maximum of 1000 mL. Cell salvage was used for most cases, however only 3 patients (12.0%) had sufficient salvaged blood to allow processing and reinfusion. Tranexamic acid was used for the larger cases (e.g. multilevel spinal fusion cases) – in 15 patients.

The mean, median, minimum and maximum Hb concentrations over

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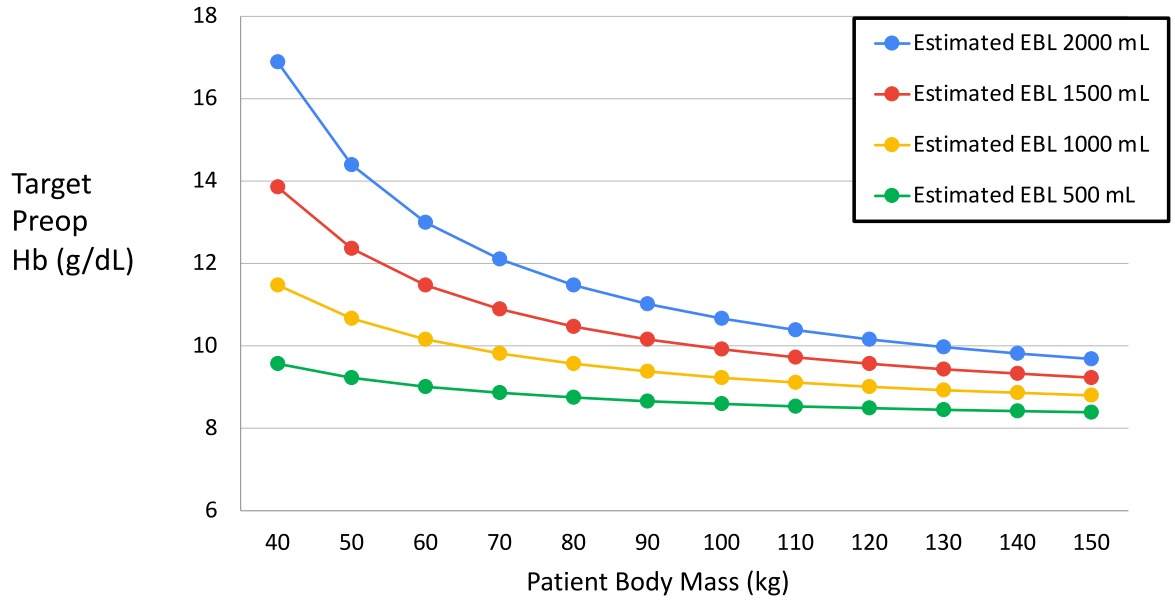

Fig. 1. Nomogram demonstrating the ideal target preoperative hemoglobin (Hb) based on varying EBL and patient body mass, with a postoperative allowable Hb of 8 g/dL. This figure was created using the preoperative Hb target formula (Formula B).
Hb – hemoglobin, EBL – expected blood loss.

the perioperative course are shown in Table 1. The mean first measured Hb (prior to preoperative anemia treatment) indicated mild anemia (11.2 ± 3.0 g/dL), with a wide variation (range 5.7 to 14.6 g/dL). The lowest postoperative Hb was 6.6 g/dL and the lowest Hb upon discharge was 6.7 g/dL indicating that severe anemia was avoided in these cases. No patients required intravenous iron or ESAs in the postoperative period. There were no in-hospital mortalities.

In conclusion, our novel algorithm used to calculate the target ideal preoperative Hb concentration required to avoid transfusion would have been effective in this small retrospective cohort. As a practical example using the nomogram in Fig. 1, for a 1500 mL blood loss surgery, a 100 kg patient requires a Hb_{preop} of 10 g/dL, while a 50 kg patient requires a Hb_{preop} slightly above 12 g/dL. While prospective studies will be needed to confirm the utility of this algorithm, calculation of the ideal preoperative Hb may be useful to guide preoperative anemia treatment regimens. In addition, the algorithm may reduce unnecessary and expensive preoperative anemia treatments (e.g. intravenous iron or ESAs), for those who only require oral iron or no therapy to avoid transfusion [7,8]. Using this algorithm to guide preoperative anemia therapy could be relevant for all patients, including those who accept transfusion, in order to avoid allogeneic blood along with its associated risks and costs.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclinane.2023.111070.

Table 1
Perioperative hemoglobin (Hb) concentrations for 25 spine surgery patients.

	Pre-Anemia Treatment Hb	Post-Anemia Treatment Hb	Post-Op Hb	Discharge Hb
Mean	11.2 ± 3.0	12.7 ± 2.3	11.0 ± 2.5	11.1 ± 2.5
Median	12.6	13.1	10.25	11.0
Min	5.7	6.3	6.6	6.7
Max	14.6	15.8	15.9	15.9

Hb concentrations are reported before and after preoperative anemia treatment, immediately after surgery (Post-op), and upon discharge.

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Author contributions

N.C., N.R.G., J.A., J.H., A.J.T., and B.D.L. helped collect and interpret the data and critically revise the manuscript.

S.C. and L.M.S.R. helped conceive and design the study, analyze and interpret the data, and write the manuscript.

S.M.F. helped conceive and design the study, collect, analyze, and interpret the data, and write and revised the manuscript.

Declaration of Competing Interest

Steven M. Frank has served on scientific advisory board for Haemonetics. All other authors declare no conflicts of interest.

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