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Title : A COMPUTER NOMOGRAM FOR BLOOD LOSS REPLACEMENT

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Introduction. In 1975, Furman et al[1] published a method of red blood cell replacement in children, which was based on a difference between the initial hematocrit (Hct) and a minimum Hct=30%, and which assumed that blood loss and volume replacement were step functions. The method is most reliable in children when the initial Hct is close to 30%, but becomes less accurate when (a) the initial Hct is much larger than 30%, (b) the blood loss is a smooth continuous function and (c) continuous matched volume replacement with crystalloid and colloid fluids causes hemodilution. Accordingly, we have derived an equation to represent the clinical situation of slow blood loss and volume replacement for patient weight of 1-100 kg with initial Hcts of 31-50%. The equation calculates the amount of blood loss necessary to produce a Hct=30% when the rate of volume replacement with crystalloid/colloid maintains intravascular volume near normal. The validity of the system was then tested in a dog model and in several patients.

Methods. The equation was evolved as follows: $Hct_i = RBCV_i/EBV$ $\Delta V = EBL$

$Hct_F = RBCV_F/EBV$ $RBCV_F = RBCV_i(EBV - \Delta V/EBV)$

$Hct_F = Hct_i(I - \Delta V/EBV)$ $dV = EBV/Hct\ dHct$

$$\int dV = EBV \int_{Hct_i}^{Hct_F} \frac{1}{Hct}\, dHct$$

$$V_L = EBV \ln \frac{Hct_F}{Hct_i}$$

Hct_i=initial Hct_F=final
EBV=estimated blood volume
V_L=allowable blood loss

WT in Kg	ml/kg
1—4.9	90
5—9.9	85
10—49.9	80
50—100	

Using this expression, values for ΔV were obtained using the values indicated at the left for EBV:

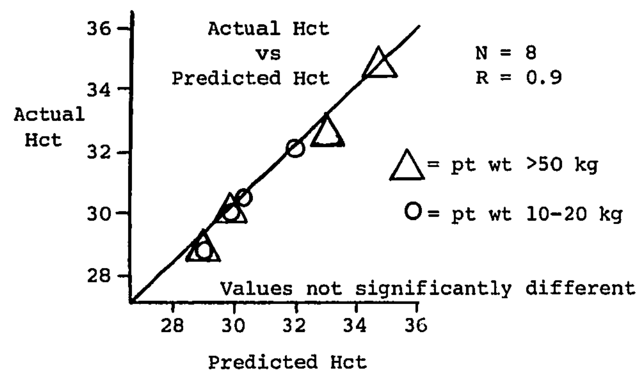
Results. 5 mongrel dogs were anesthetized with iv pentobarbital 25 mg/kg, intubated and ventilated with 100% O_2. The right external jugular vein, left femoral vein and artery and left atrium were cannulated for fluid administration, blood removal and measurement of mean arterial pressure (MAP) and left atrial pressure (P_{la}). Blood was withdrawn from the femoral artery line via a pump at a rate equal to 1% of the estimated blood volume per minute until the amount withdrawn equaled the calculated blood loss predicted to result in Hct=30. Lactated Ringer's solution was infused into the venous circulation at a rate sufficient to keep P_{la} and MAP constant. This data is presented in Table 1. The final mean Hct obtained for all dogs was 30.2±1.6 (±SE) and did not significantly vary from the calculated endpoint of 30%.

Table 1:

Kg	EBV	Withdrawal Rate	Hct Initial	Hct Final	Error
18.4	1572	15.7 ml/min	42	30	0
15.3	1300	13	35	33	+3
18	1530	15.3	47	29	-1
21	1785	17.9	34	30	0
23	1955	19.6	49	29	-1

Eight patients have been studied. The initial Hct was that obtained preoperatively, either the night prior or the day of surgery as clinically indicated. A final Hct was drawn just prior to the beginning of transfusion, or at the termination of the procedure if transfusion was uncalled for. A comparison of expected Hct (from equation) vs actual Hct is seen in Fig. 1. Similar to the dog data, the agreement between the expected vs actual Hct was excellent.

Figure 1:



Discussion. We find the above preliminary data encouraging with regard to the accuracy of our derived equation. Since the equation utilizes four different values for EBV (ml/kg), large numbers of patients will be required to validate the entire table. The validation of the equation (and resultant table of blood loss guidelines) is useful because it emphasizes the difference between RBC mass and blood volume, and should decrease blood transfusion therapy based on the stubborn concept of the number of "units" lost instead of patient requirements. Further patient studies are under way to validate the table, with an eventual goal of routine use as an aid in making the decision to transfuse red cells.

Reference

1. Furman EB et al: Anesthesiology 42: 187-193, 1975.