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Title: DESIGN OF A FAST BLOOD TRANSFUSION SET

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Introduction. Occurrences of rapid intraoperative hemorrhage during which transfusion rates through 2 or 3 large bore intravenous cannulae were inadequate motivated us to evaluate and improve the design of intravenous administration sets. Using correlates described by Poiseuille, relating the laminar flows of fluids through tubes to the radius and length of the tube and the viscosity of the fluid (Figure 1), we created and evaluated a new transfusion set designed specifically for the rapid transfusion of blood, with or without the benefits of warming and filtration, in comparison with existing equipment.

$$\dot{V} = \frac{P\pi a^4}{8nl}$$

Figure 1

Formula relating laminar flow rate $\dot{V}$ of a fluid of viscosity n through a tube of radius a and length l. (Poiseuille 1843)

Method. The design of existing equipment in comparison with the new is illustrated in Figure 2. Briefly stated, the tubing radius is increased to 0.48 cm. Secondly, connections for a warmer are placed high in the IV set allowing warmed and therefore less viscous blood to flow through the remainder of the set. Furthermore, this configuration greatly reduces the total length of the set. A comparison in vitro of the flow rates of 100 cc aliquots of whole expired blood at pressure heads of 36" of blood, 150 torr and 300 torr was performed between existing equip-ment and prototypes of the new set [Baxter Travenol]. The sets were equipped with a blood warmer [Hamilton Industries and Gormann Rupp] with a 14 gauge intravascular cannula [Deseret Angiocath], were used in this comparison. (Figure 2) A blood filter was not used. The mean and SD of 5 measurements of projected time for the transfusion of 500 ccs [one unit whole blood] was graphed against pressure head for the 2 systems (Figure 3). Flows in the new set using a 14 gauge cannula were then compared with those when an 8 gauge cannula was substituted.

Results. The new set was faster than the old by a factor of 2-3 depending on the pressure head. (Figure 3) rates for the new set varied between 1.4 minutes at 300 torr to 7 minutes at 36 inches blood per unit of whole blood. Substituting the 8 guage intravascular cannula only increased the flow rate by 3% at 300 torr in the new set.

Discussion. Advantages of a faster blood transfusion set include safety, ease and convenience in the management of severe hemorrhage. Disadvantages include a potential danger in that practitioners used to having to work hard to transfuse rapidly may be lulled into an easy and fulminant over transfusion. The internal diameter of injection sites and connections in these prototype sets was narrow. Turbulence generated in these may account for the lesser apparant improvement of the new set over the old at higher flow rates. Evaluation of the effects of these restrictions may dictate a redesigning of the injection sites and connections in order to reduce turbulence and further improve overall flow rates. Further design refinements promise to improve flow rates even further.

Reference.

1. Poiseuille J.J.: Ann. de Chim. et de Physiol. 7:1843

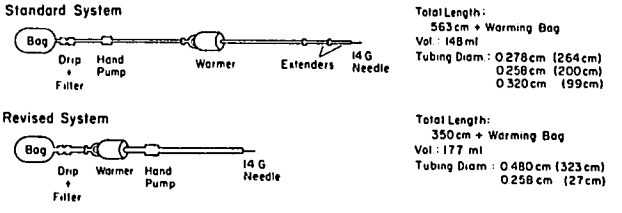

Figure 2

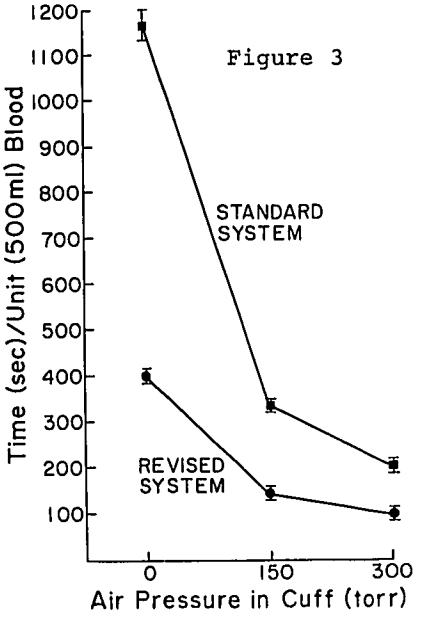

Figure 3