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BRIEF REPORT

Mark W. J. Cutts
Antony N. Thomas
Roop Kishen

Transfusion requirements during continuous veno-venous haemofiltration: – the importance of filter life

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M. W. J. Cutts · A. N. Thomas (✉) · R. Kishen
Department of Intensive Care,
Salford Royal Hospitals NHS Trust,
Stott Lane, Salford M6 8HD, England
E-mail: tthomas@fs1.ho.man.ac.uk
Phone: +44-161-787 5106/7/8
Fax: +44-161-787 4677

Abstract *Objective*: To investigate the relationship between loss of haemofilter circuits due to blood clots and requirement for blood transfusion in intensive care patients.
Design: Retrospective case note review.
Setting: A British, nine-bed, tertiary, medical and surgical intensive care unit (ICU) serving a 950-bed university teaching hospital.
Patients: Thirty-three ICU patients requiring haemofiltration for more than 48 h. Thirty-three comparison patients requiring 7 or more days of intensive care, without haemofiltration.
Methods: ICU, haemofiltration and haematology records were examined retrospectively. Note was taken of demographic data, daily haemoglobin concentrations and the dates and numbers of blood transfusions and haemofilter clots.
Results: The study groups did not differ significantly in terms of age, sex and length of ICU stay. Haemofiltered patients had higher APACHE II scores (21 vs 15, $p = 0.006$), lower haemoglobin concentrations (102 vs 110 g/l, $p = 0.0001$) and higher blood transfusion rates (1.1 vs 0.3 units/day, $p < 0.0001$) when compared to the non-haemofiltered group. There was a positive correlation between haemofilter blood clot rate and blood transfusion rate ($r = 0.48$). More blood was transfused on days when haemofilter blood clots occurred than on days when no haemofilter clot occurred (1.0 vs 0.59 units, $p = 0.03$).
Conclusion: Haemofiltration is associated with an increased requirement for transfusion of blood. The temporal relationship between occurrence of haemofilter blood clots and transfusion of blood suggests that haemofilter lifespan may be an important determinant of this.

Key words Intensive care · Blood transfusion · Haemofiltration · Veno-venous haemofiltration

Introduction

Unnecessary blood transfusion is associated with many potential risks, including the transmission of infection and suppression of immunity [1]. Many intensivists use a transfusion threshold of 90–100 g/l [2]. However there is a significant individual and regional variation in the transfusion thresholds used [2]. The decision to transfuse is often multi-factorial, being influenced by age, illness severity, pre-morbid history, illness type and ongoing haemorrhage [2]. Anaemia is associated with a poor outcome in some groups of patients [3], however, in a recent randomised study, when managed with a liberal transfusion strategy, patients of less than 55 years old had a worse outcome than those in whom transfusion was restricted [4].

Conserving blood in critically ill patients has therefore been described as an imperative for critical care [5]. The main focus for this blood conservation has been reducing the volume of blood sampled for labora-

Table 1 Demographic data

	Haemofiltered patients	Comparison patients	*p* value
Number of patients	33	33	
Number of male patients (%)	18 (55)	21 (64)	0.273
Mean age, years (SD)	52 (17)	56 (16)	0.269
Mean APACHE II score (SD)	21 (9)	15 (6)	0.006
Mean length of ICU stay, days (SD)	19 (13)	16 (14)	0.59
Mean length of haemofiltration, days (SD)	12 (12)	–	
Mean life span of haemofilters, days (SD)	1.7 (0.8)	–	

tory investigations [6]. However, we have previously noted that continuous veno-venous haemofiltration is an important risk factor for blood transfusion [7]. The aim of this study has been to confirm this observation and to establish if a relationship exists between loss of haemofilter circuits due to blood clots and the requirement for blood transfusion.

Methods

We retrospectively reviewed the records of intensive care patients admitted to our nine-bed, general ICU. The unit admits approximately 350–400 patients each year, comprising mixed acute and elective surgery, trauma and medical emergencies. All the patients in 1997 who required continuous veno-venous haemofiltration for more than 48 h were selected as a consecutive cohort. A total of 51 patients underwent haemofiltration in that year. Of these, 39 had been subject to haemofiltration for more than 48 h. We were able to identify complete transfusion and intensive care records in 33 of these patients. These 33 made up the study group. Using our computerised record system, we also selected a comparison group of patients, admitted to the same ICU in the same year, but not managed with haemofiltration. In an effort to match them more evenly to the haemofiltration group, we excluded those patients who had required less than 7 days in the ICU. By doing this we aimed to exclude those patients passing through the ICU for uncomplicated post-operative care. We also excluded those patients for whom we were unable to identify complete transfusion and intensive care records. Eighty-seven patients fulfilled these criteria. Using random number tables, we selected 33 of these patients to form the comparison group. No further matching of cases to controls was used.

Haemofiltration was initiated either for the treatment of acute renal failure, for control of fluid balance, for the management of severe sepsis or for a combination of these indications. Vascular access was obtained using a double lumen catheter ('Dualyse-cath', Vygon, Ecouen, France) placed in a central vein. Filtration was established using a Hospal BSM 22 haemofilter pump and a 1.2 m^2 polyacrylonitrate 'Filtral 12' AN69 hollow-fibre filter (Hospal, Basle, Switzerland). The volume of the filter and extracorporeal circuit comprised approximately 0.3 l. The pump speed was set to produce flows of about 100 ml/min of blood through the filter. The circuit was adjusted to produce fluid exchange rates of between 1.5 and 2.0 l/h. Anticoagulation was provided with either heparin via the haemofilter, to maintain an activated clotting time of 180–220 s (16 patients) or with prostacycline (1 patient) or a combination of the two agents (16 patients). Patients received appropriate nutrition, with regular folate supplementation [8]. Blood was generally transfused using a threshold of 90–100 g/l. There was no conscious difference in the management of haemofiltered and non-haemofiltered patients in this respect. Transfusions were initiated in response to haemoglobin concentration measurements obtained from regular arterial blood sampling.

For patients undergoing haemofiltration, we studied the period during which they received haemofiltration. For the comparison group we studied the whole period of their intensive care stay. For all patients ICU and haematology records were examined to identify demographic data, daily haemoglobin concentrations and transfusion requirements. In addition to this we examined the detailed haemofiltration records of the study patients. These records defined each interruption to haemofiltration and its cause. Times of filter losses due to clots within the circuit were identified and matched to the days on which blood was transfused. Patients on our ICU are subject to haemoglobin estimation several times each day, often incidentally at the time of arterial blood gas analysis. We therefore postulated that if filters lost due to blood clots increased transfusion requirements, then it would be most likely that these transfusions would be given on the same day that the filter clotted. If filter loss increased blood transfusion, therefore, we would expect more blood to have been used on these days than on days when no filter clot had occurred. We also established the relationship between the number of filters lost due to blood clot and the transfusion requirements for individual patients.

Data was compared using Mann-Whitney, Wilcoxon and Student's *t*-tests as appropriate. The relationship between the rate of haemofilter circuit clotting and rate of blood transfusion was examined using regression analysis. Significance was set at the 5% level.

Results

Of 33 haemofiltered patients, 29 began haemofiltration within 48 h of admission to the ICU. Demographic data for both groups are summarised in Table 1. There were no significant differences between the two groups in terms of age, sex and length of ICU stay. Apache II score was significantly higher in the haemofiltered patients. Case mix was comparable between the two groups (Table 2).

Haematology data for the two groups are summarised in Table 3. The mean haemoglobin concentration was significantly lower in haemofiltered patients, who also had a transfusion requirement more than twice that of the comparison group both in terms of the total number of units of blood transfused and the number of days on which these transfusions took place. The mean

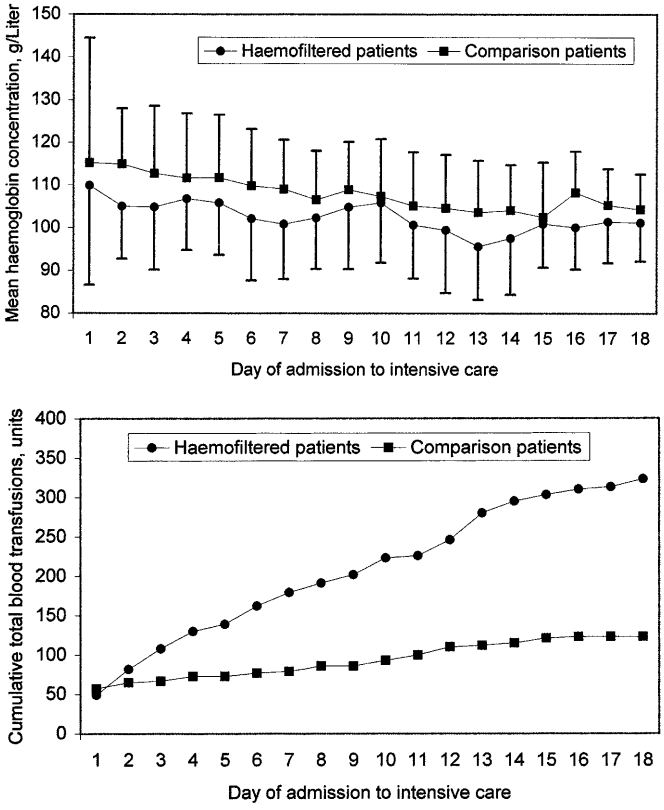

Fig. 1 Mean haemoglobin concentrations with standard deviations *(upper plot)* and cumulative total blood transfusions *(lower plot)* for the study and comparison groups

Table 2 Admission diagnosis

Admission diagnosis	Haemofiltered patients	Comparison patients
Pneumonia& respiratory failure	8	9
Head injury& neurosurgical	2	2
Gastrointestinal haemorrhage	2	2
Pancreatitis	1	1
Multiple trauma	2	3
Sepsis	10	8
Perforated viscous	3	7
Other	5	1

daily haemoglobin concentrations and cumulative total blood transfusions are shown in Fig. 1.

For the haemofiltered patients, the relationship between the units of blood transfused and the number of filters lost due to blood clots is shown in Fig. 2. There was a significant, but weak, relationship between these variables; the more filters lost, the higher was the transfusion requirement (correlation coefficient 0.49, $p = 0.004$). The temporal relationships between blood transfusion and filters lost due to blood clots are summarised in Table 4. Significantly more blood was transfused on the day of filter clots than on days when there had been no filter loss.

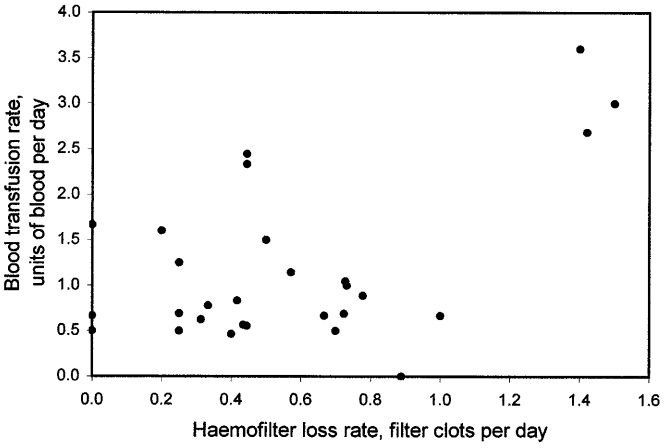

Fig. 2 Relationship between haemofilter circuit loss rate and blood transfusion rate for each patient in the haemofiltered group

Discussion

The blood transfusion rate in our non-haemofiltered patients (2.1 units/week) compares to a rate of 2–3 units/week found by other workers [9]. In our study haemofiltered patients had a higher transfusion rate (7.7 units/week) than the comparison patients, which concurs with our previous observation that haemofiltration is associated with increased transfusion of blood [7]. Mean haemoglobin concentrations were also significantly lower in the haemofiltered patients. The haemofilter pump and hollow-fibre filter used on our ICU has a prime volume of approximately 0.3 l. Clotting of the haemofilter circuit could, therefore, result in significant loss of blood. If a filter clot were to result in the loss of this volume of blood then an average filter lifespan of 1.8 days might lead to the loss of more than 1 l/week and transfusion of additional units of blood. This could partly account for the higher blood transfusion rate and lower haemoglobin concentrations seen in the haemofiltered patients. The correlation between blood transfusion rate and filter clot rate (Fig. 2) suggests that this may be the case. However, the fact that this relationship was not strong suggests that other factors are important. These are likely to be multi-factorial and may include erythropoietin deficiency [10, 11], bone marrow suppression, haemorrhage from other sites and greater illness severity. Haemofiltration is likely to be a marker for disease severity and the haemofiltered patients in our study had significantly higher APACHE II scores than the comparison patients. This may partly be due to the use of markers of renal failure in the calculation of APACHE scores [12].

Table 3 Haematology data

	Haemofiltered patients	Comparison patients	*p* value
Average haemoglobin, g/l (SD)	102 (7)	110 (7)	0.0001
Average number of units of blood transfused (SD)	11.5 (12.2)	4 (3.8)	0.002
Average number of units of blood transfused per day (SD)	1.1 (0.8)	0.3 (0.3)	< 0.0001

Table 4 The temporal relationship between occurrence of haemofilter clots and blood transfusion

	Mean units of blood transfused per patient	*p* value
On days when haemofilters clotted (SD)	1.0 (1.0)	–
On 1st day after haemofilters clotted (SD)	0.67 (0.77)	0.21
On 2nd day after haemofilters clotted (SD)	0.59 (0.69)	0.03

To further investigate the possibility that haemofilter blood loss might result in increased blood transfusion, we examined the temporal relationship between the occurrence of haemofilter clots and transfusion of blood. The finding of a significantly higher transfusion rate on the days of haemofilter clots supports the theory that haemofilter loss, and therefore haemofilter lifespan, is an important determinant of blood transfusion in this group. It is also possible, however, that a second variable could result in both coagulation of the filter circuits and independent transfusion of blood. Blood transfusion itself could also precipitate clotting of the haemofilter. The relationship must therefore be regarded as association at this stage. We are unable to determine if maintaining haemofiltered patients at a lower haemoglobin concentration would have affected their transfusion requirements.

There is an emerging view that blood transfusion may significantly worsen outcome in intensive care [3]. The association suggested here between blood transfusion and haemofilter life is therefore important as manoeuvres to prolong filter life could reduce transfusion requirements. Alternatives to transfusion such as recombinant human erythropoetin should also be considered [13]. Further studies should aim to define more clearly other factors, such as level of anticoagulation and platelet counts, that might affect transfusion requirements in patients subject to haemofiltration.

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