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Allogeneic Versus Autologous Blood During Abdominal Aortic Aneurysm Surgery

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Objectives: *To determine if cell-salvaged autologous blood can serve as an alternative to homologous blood, and to examine the incidence of infected complications and length of postoperative stay.*
Design: *A prospective randomised study comprising autologous and homologous blood transfusions in patients undergoing elective infrarenal abdominal aortic surgery.*
Methods: *Fifty patients undergoing AAA surgery were prospectively randomised to homologous blood (n=27), or autologous blood transfusion (n=23), using a cell salvage autotransfusion device.*
Results: *The haemoglobin at the time of hospital discharge was similar for both groups (11.0 vs. 10.8 g/dl) with no difference in perioperative mortality. The length of stay was reduced in those patients who received autologous blood (9 days vs. 12 days, p<0.05 Mann–Whitney U test). There were four infected cases in the autologous group and 12 in the homologous group (p=n.s., Fisher's exact probability test). However, patients who received 3–4 units of homologous blood had an increased risk of infection compared to those who received a similar amount of autologous blood (50% vs. 0%).*
Conclusions: *Cell salvage autologous blood can safely replace, or at least decrease, exposure to homologous blood transfusion, with a reduction in the mean hospital stay.*

Key Words: Autologous blood; Aortic aneurysm; SIRS; Sepsis.

Introduction

Blood transfusion has assumed a major role in the development of modern medical and surgical practice. However, it involves side effects and risks that have been well documented over the years. These risks have been dramatically reduced by accurate donor screening, safer blood processing and more reliable pretransfusion testing. Nevertheless, today 1 in 5 transfused units of blood still cause some adverse effect that can be serious enough to compromise the outcome of highly complex surgical procedures.[1,2]

It has been proposed that patients receiving homologous blood transfusions have an increased risk of postoperative bacterial infections.[3–5] Increasing numbers of homologous transfusions are also a major independent predictor of septic complications after trauma.[6] Other proposed consequences of homologous transfusions include improved success rates for renal allografts,[7] increased rates of solid tumour recurrence,[8–11] and a decreased rate of recurrence of Crohn's disease.[12] The proposed mechanism for such effects centre on impaired immunological function in the transfused patient. Despite many studies on these clinically important questions, the answers remain unclear. Most studies in human beings have been retrospective or hampered by the lack of adequate controls, and the results have been even more confusing.[13–15]

Intraoperative autotransfusion (IAT) has been shown to be a safe and effective method of salvaging autologous blood lost during operation, and there is no indication that autologous blood transfusion leads to any significant immunosuppression.[16–19] We therefore used IAT as a control for the hypothetical effect of homologous blood. The aims of our study were to perform a pilot study to determine if it was possible to perform elective infrarenal abdominal aortic aneurysm repair using IAT alone, and to determine the incidence of postoperative infection and hospital stay in a single University teaching hospital, in patients receiving homologous blood (HBT) or IAT.

Patients

The protocol used in this study was approved by the local ethics committee. The study group consisted of

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Table 1. Characteristics of study patients.

	Autologous blood ($n=23$)	Homologous blood ($n=27$)
M/F	19/4	20/7
Age (Median & IQRs)	71 (54–78)	68 (54–82)
Smoking	17	23
Diabetes	5	4
Ischaemic heart disease	14	17
Haemoglobin (g/dl) (median & IQRs)		
Admission	13.5 (12.7–14.5)	12.8 (10.5–15.2)
Discharge	11.0 (10.3–12.0)	10.8 (10.0–12.9)
Aortic cross clamp time (mins) (median & IQRs)	40 (35–60)	43 (27–55)
Anaesthetic time (mins) (median & IQRs)	150 (120–240)	144 (135–225)
Blood loss (ml) (median & IQRs)	1800 (500–2800)	1500 (500–3045)

50 patients, 39 men and 11 women with a median age of 70 (range 54–82), who underwent elective infrarenal abdominal aortic aneurysm repair (Table 1).

The patients were prospectively randomised using sealed envelopes to receive either homologous blood ($n=27$) or autologous blood ($n=23$) via IAT. They were transfused with homologous blood if the haematocrit fell below 25%, as surgical patients tolerate limited dilutional anaemia providing the blood volume is maintained and adequate arterial oxygen saturation is provided.[20]

Methods

The COBE Baylor rapid autologous transfusion system (COBE laboratories Inc. Lakewood, Colorado, U.S.A.) was employed in all cases as the intraoperative cell-saver. The cell-saver apparatus was monitored and operated by a trained operating department assistant.

In brief, blood is retrieved from the operative site by suctioning into a double lumen catheter at a vacuum pressure <150 mmHg, to minimise haemolysis. The blood is anticoagulated immediately with heparin (30 000 U heparin/1000 ml of 0.9% saline). The salvaged blood is then collected in a reservoir where a macrofilter of 150 microns removes larger particles of debris. When 500 ml of blood has been collected, it is pumped to a spinning centrifuge bowl. The red cells are packed against the outer wall of the centrifuge bowl, washed with 0.9% saline, and concentrated to a haematocrit above 50%. The effluent containing plasma fractions, platelets, leukocytes, free haemoglobin, anticoagulant and saline is discarded. The washed red cells, suspended in saline, are pumped from the centrifuge to a reinfusion bag and can be returned to the patient through a microfilter of either 20 or 40 microns. Anticoagulation is monitored during the operation by measurement of the activated clotting time, since heparin is removed in the washing process.

Data collection

The following parameters were collected on all patients; preoperative haemoglobin, estimated blood lost (suction and swab weight), intraoperative and postoperative homologous blood transfused, amount of autologous blood given, and postoperative haemoglobin values on postoperative day 1 and day of discharge. The development of sepsis, and systemic inflammatory response syndrome (SIRS), as proposed by the American College of Chest Physicians-Society of Critical Care Medicine (ACCP/SCCM) (Table 1).[21] In addition, the length of postoperative stay was also noted.

Statistical analysis

The results are expressed as medians and interquartile ranges, and the Mann–Whitney U test was used as the test of significance. The groups were compared by Chi-squared tests with Yate's correction or Fisher's exact test when appropriate. Patients were analysed on an intention-to-treat basis.

Results

There were no deaths in this study.

Pre- and postoperative haemoglobin values

There was no significant difference between the median admission haemoglobin concentration (autologous group Hb 13.5 g/dl [range 12.7–14.5] vs.

Table 2. ACCP/SCCM definition of SIRS and sepsis.

SIRS	Signs of a systemic response (two of the following): Fever or hypothermia (core or rectal temperature >38.4 °C or <35.6 °C). Tachycardia (Heart rate >90 beats/min). Tachypnoea (respiration >20 breaths/min [if patient is mechanically ventilated, >10 l/min]) or White blood cell count $>12 \times 10^9$/l or $<4 \times 10^9$/l or the presence of more than 0.1% immature neutrophils.
Sepsis	The presence of SIRS associated with a confirmed infectious process.

homologous group Hb 12.8 g/dl [10.5–15.2]). Interestingly, there was no difference between the median haemoglobin concentration at the time of hospital discharge (autologous group Hb 11.0 g/dl [10.3–12.0] vs homologous group Hb 10.8 g/dl [10.0–112.9]) (Table 2).

Blood loss

There was no significant difference in blood loss between the HBT group, median 1500 ml vs. 1800 ml for the IAT group.

Blood transfusion requirements

In this study 96% of patients in the HBT group and 100% of the IAT group required a blood transfusion in the perioperative period. In the IAT group three (13%) patients received homologous blood during their AAA repair: two because of an error in the autologous blood collection during the early part of the study, and one returned to theatre because of a proximal anastomotic leak. The proportions who required 2 units or more of blood did not differ significantly between the groups (Table 3). The median blood requirements for the HBT group was 2.96 units per case, and 3.29 units per case for the IAT group.

Postoperative infections

The study groups were similar in terms of distribution of risk factors for infectious complications.

Systemic inflammatory response syndrome

Three patients in the IAT group and nine patients in the HBT group developed a systemic inflammatory response ($p = 0.088$, Table 4).

Sepsis

There were no cases of sepsis in the IAT group and three cases in the HBT group, all due to pneumonia. Although the analysis of infectious complications showed a tendency to more events in the HBT group (4/23 [17.3%] vs. 12/27 [44%]), the difference was not statistically significant ($p = 0.07$, Fisher's exact test).

Multiple blood transfusions

The infection rate increased with the number of transfused blood units (Table 5) and was higher in the HBT group than the IAT group for all categories, except patients who received >4 units of blood. The severity of infection in those patients requiring more than 4 units of blood was less in the IAT group compared to the HBT group (Table 4). Of the four patients in the HBT group who received >4 units of blood, three developed sepsis and one developed signs of SIRS, while the patients in the IAT group showed signs of SIRS only. Twelve patients received 3–4 units of homologous blood, with six developing SIRS compared to none of the 13 patients who received autologous blood ($p = 0.025$, Fisher's exact probability test).

Table 3. Details of transfusion requirements.

	Autologous blood $n=23$	Homologous blood $n=27$
Total number of units transferred	75	80
No. (%) patients receiving:		
No units	0 (0)	1 (4%)
1–2 units	7 (30%)	10 (37%)
>2 units	16 (70%)	16 (59%)
Homologous units transfused	11	68
No. (%) patients transfused with homologous blood	3 (13%)	26 (96%)

Table 4. Incidence of postoperative infections.

	Autologous blood ($n=23$)	Homologous blood ($n=27$)	p
No. of cases of SIRS	3	9	n.s.
No. of cases of sepsis	0	3	n.s.
Days of antibiotics	4 (1–6)	7 (1–14)	<0.01
Days of fever	2 (1–5)	3 (1–7)	n.s.
Length of postoperative stay	9 (7–13)	12 (7–19)	<0.05

Results are expressed as medians and interquartile ranges and analysed with a Mann–Whitney U test.

Table 5. Increase in infection rate with number of blood transfusions.

Unit of blood transfused	Autologous blood		Homologous blood		p
	n	No. with infection	n	No. with infection	
0	0	0	1	0	n.s.
1–2	7	0	10	2	n.s.
3–4	13	0	12	6	0.025
>4	3	3	4	4	n.s.

Length of stay

The duration of hospital stay was significantly reduced in those receiving autologous blood, with a median stay of 9 days (range 7–13) vs. a median stay of 12 days (range 7–19) in the homologous blood group ($p<0.05$, Mann–Whitney U test).

Discussion

The hazards of homologous transfusion have been reduced, but not eliminated, by modern blood banking methods. The small risk associated with a single transfusion is compounded for the patient who requires multiple units of blood. Vascular surgeons now see patients who have had multiple homologous blood transfusions during both coronary artery and peripheral vascular surgery. Such patients present significant problems in cross-matching because of alloimmunisation, the formation of antibodies to human leukocyte antigens. Also, there are practical considerations regarding the availability and cost of large quantities of homologous blood. There is also a group of patients who, for religious reasons, refuse to accept homologous blood and whose surgery must be performed without blood. The present study aims to minimise homologous bleed requirements in patients undergoing elective abdominal aortic aneurysm repair using IAT, and to determine if this affected the incidence of SIRS/sepsis and the duration of postoperative hospital stay.

The median blood requirements for the homologous group were 2.96 units/case and 3.26 units/case for the autologous group, similar to previous reports.[22–23] Eighty-six percent of patients in the autologous group avoided homologous transfusions, and 3.8% of patients in the homologous group did not require a transfusion. Therefore, IAT saved a median of 2.6 units of homologous blood/case, which is an improvement on previous published reports.[22–24] This may represent improved haemoconcentration during the wash cycle in the currently available cell savers, or the change in current transfusion policies, which avoids using arbitrary postoperative 'transfusion triggers' such as 10 g/dl.

There are several studies demonstrating the effects of blood transfusion on the rate of infected complications.[4,25–27]; however, they were retrospective and lacked controls. Our pilot study was prospective and randomised, with those patients receiving autologous blood acting as the control population. The factors which are known to predispose to infection, such as the degree of difficulty of the surgical procedure, anaesthetic time and intraoperative blood loss were well balanced between the study groups.

Our data demonstrate that patients undergoing elective AAA surgery who require 3–4 units of homologous blood are much more likely to develop postoperative infections compared to those patients receiving autologous blood. In the patient receiving more than 4 units of homologous blood, the infection risk was similar between the HBT and IAT groups. Several studies have indicated that haemorrhage contributes to the induction of an overall state of non-

responsiveness of the immune system, resulting in a reduced ability to combat infectious challenges.[28,29] In addition there may be a synergistic effect of haemorrhage and homologous blood transfusion on immunosuppression. In the homologous blood group patients went on to develop overt sepsis, while in the autologous group they developed SIRS only, with a faster resolution of their infectious complication (median stay of 12 days vs. 18 days).

In summary, we found that it is possible to reduce significantly the exposure of patients undergoing elective infrarenal AAA repair to homologous blood using IAT alone. The greater the amount of homologous blood transfused, the greater the risk of infection. We hypothesise that this is due in part to the immunosuppressive effects of homologous blood transfusions,[27] and would recommend that patients undergoing AAA surgery be offered the opportunity of autologous blood transfusion.

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