Autotransfusion of washed shed mediastinal fluid decreases the requirement for autologous blood transfusion following cardiac surgery: a prospective randomized trial

Malcolm J.R. Dalrymple-Hay*, Louise Pack, Charles D. Deakin, Stuart Shephard, Sunil K. Ohri, Marcus P. Haw, Steven A. Livesey, James L. Monro

Wessex Cardiothoracic Centre, Department of Cardiothoracic Surgery, Southampton General Hospital, Tremona Road, Southampton SO16 6YD, UK

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Abstract

Objectives: The National Blood Service issues 2.2 million units of blood per year, 10% of these (220,000) are utilized in cardiac procedures. Transfusion reactions, infection risk and cost should stimulate us to decrease this transfusion rate. We test the efficacy of autotransfusion following surgery in a prospective randomized trial.

Methods: One hundred and twelve patients undergoing CABG, valve or CABG + valve procedures were randomized into two groups. Group A received washed postoperative drainage fluid and group C were controls. The indication for transfusion was a postoperative haemoglobin (Hb) < 10 g/l or a PCV < 30. There was no significant difference in preoperative and operative variables between the groups.

Results: Twenty-eight patients in group A and 46 in group C required homologous transfusion (P = 0.0008). Group A patients required 298 ± 49 ml of banked blood per patient, group C 508 ± 49 ml (P = 0.003). There was no difference in total blood required (volume autotransfused + volume banked blood transfused) between the groups (group A 404 ± 50 ml, group C 508 ± 50 ml) or in mean total mediastinal fluid drainage (group A 652 ± 51 ml, group C 686 ± 50 ml). The mean Hb concentration was significantly higher in group A on day 1 (11 ± 2 g/dl ± 51 vs. 10 ± 13 g/dl ± 13 (P = 0.002)). No morbidity was associated with autotransfusion.

Conclusion: Autotransfusion can decrease the amount of homologous blood transfused following cardiac surgery. This represents a benefit to the patient and a decrease in cost to the health service. © 1999 Elsevier Science B.V. All rights reserved.

Keywords: Autotransfusion; Blood transfusion; Mediastinal drainage fluid

1. Introduction

The National Blood Service in the UK issues approximately 2.2 million units of blood per year [1] and about 10% of these are utilized in cardiac procedures [2]. Despite ever-improving blood conservation techniques, 75% of patients undergoing coronary artery bypass graft operations (CABG) receive at least one transfusion [3]. There are a number of adverse effects associated with the use of banked blood, the most clinically relevant being transfusion reactions and infection [4].

Screening tests are employed to ensure that the risk of transmitting human immunodeficiency virus (HIV), human T cell lymphotrophic virus (HTLV), hepatitis-C virus (HCV), hepatitis-B virus (HBV) is small and Schreiber et al. estimated an aggregate risk for these diseases of one in 34,000. Infection with unidentifiable or unknown infectious agents following transfusion still, however, represents a risk [5]. Recently, the possibility of transmitting spongiform encephalopathies, a notably new variant CJD (Creutzfeldt-Jacob Disease), via blood transfusions has been recognized. Despite the World Health Organization concluding that there is no proved transmission of CJD by blood, lack of evidence of risk is not evidence of absence of risk [6,7].

The use of homologous transfusion has also been associated with an increased risk of bacterial infection following CABG and a decrease in immune function, which may increase the severity of an infection [4]. These immunosuppressive changes include an increase in numbers of suppressor T-lymphocytes, a decrease in numbers of helper T-lymphocytes, a decrease in natural killer cell function, a decrease in the function of macrophages and monocytes, reduced responses in mixed lymphocyte culture and decreases in cytokine production [8].
While blood donors in Britain are unpaid, the collection, processing, testing, inventory and administration of each unit of blood adds incrementally to its ultimate cost [9], with the price of one unit of packed red cells currently being at least £40 [2].

Attempts to minimize transfusion and avoid as many of these associated risks and costs as possible are therefore sensible. We test the efficacy of autotransfusion of washed postoperative mediastinal fluid in a prospective randomized trial.

2. Methods

Ethics committee approval was granted and informed consent obtained from all patients. One hundred and twelve adult patients undergoing either coronary artery bypass grafting, valve replacement/repair operations or a combination of the two were randomized preoperatively into two groups using a binary random number table. Exclusion criteria for the study were; previous cardiac surgery, emergency operations, patients anticoagulated with warfarin and Jehovah Witness patients.

Surgery was performed using membrane oxygenators and the preferred myocardial preservation technique of the individual surgeons. If the Hb fell to less than 7 g/dl or PCV to less than 0.2 during cardiopulmonary bypass, banked blood was transfused in both groups.

At the end of surgery, mediastinal and, if applicable, pleural drains were connected to a blood collection reservoir.

Postoperatively, patients returned to Cardiothoracic ITU where drainage loss was recorded half hourly for 4 h and then hourly. Hb and PCV measurements were performed on all patients on arrival in the unit and then at 2-h intervals, or as clinically indicated. The indication for transfusion was a Hb less than 10 g/dl or PCV less than 0.3. At these Hb and PCV thresholds, banked blood was transfused in group C patients and washed mediastinal fluid in group A. In such circumstances for group A patients, the autotransfusion program was operated (Fresenius C.A.T.S.® – continuous autotransfusion system) and the washed drainage fluid transfused.

The mediastinal drainage fluid undergoes a washing process which comprises three successive stages and takes place in a centrifuge disc. The initial separation stage concentrates the fluid of blood to a haematocrit of approximately 0.8 and the removal of blood plasma, cellular debris, white blood cells, platelets, anticoagulant, other liquid constituents and non-emulsified fat. The next phase involves the washing of the red blood cells by resuspension in saline. The final phase entails the removal of saline, consequently concentrating the red cells to a haematocrit of 0.6 [10].

Following autotransfusion, if the Hb or PCV became or remained below 10 g/dl or 30, respectively, homologous blood was transfused.

2.1. Statistical analysis

Fifty patients per arm (total 100) were selected because it enabled statistical power of 0.8, based on a 25% decrease in the volume of allogeneic blood transfused. Statistical analysis was performed using unpaired t- and χ²-tests, with significance taken as P < 0.05.

3. Results

There were no significant differences in gender (male:female group A 36 (64%):20 (36%), group C 41 (73%):15 (27%)) or age (mean ± SEM group A 67.4 ± 1.2 years, group C 65.3 ± 1.4 years) between the two groups. The operations performed in each group are shown in Table 1.

Cardiopulmonary bypass (CPB) and cross-clamp (XC) times were the same in both groups (group A 81 ± 3.8 and 53 ± 2.8 min, group C 77 ± 3.5 and 47 ± 2.8 min).

There was no significant difference in mean total mediastinal drainage (A: 652 ± 51 ml, C: 686 ± 50 ml) between groups (P = 0.6310) (Fig. 1).

Forty six group C patients required banked blood. Ten patients in group C and 16 patients in group A did not receive any blood. Five group A patients met the criteria for autotransfusion, but as there was no mediastinal drai-
nage these patients went directly to receive banked blood. Twelve group A patients were autotransfused and did not need a further transfusion. Twenty three group A patients, were autotransfused and did require subsequent banked blood transfusion (Table 2).

The number of patients therefore requiring banked blood transfusion in group A (28, 50%) was significantly less than those in group C (4, 82%) ($P = 0.0003$). This remained the case when patients undergoing CABG alone were compared (group A 18/40 (45%), group C 29/37 (78%) ($P = 0.002$).

The volume of banked blood transfused in the first 24 h following surgery was also significantly less in group A (298 ± 49 ml) compared to group C (508 ± 50 ml) ($P = 0.0028$).

There was no significant difference in total blood requirement (i.e. volume autotransfused + volume of banked blood transfused) between each group; group A (403 ± 50 ml) compared to group C (508 ± 50 ml) ($P = 0.0028$) (Fig. 2).

Day 1 postoperative haemoglobin concentrations were significantly higher in group A patients, mean 11.2 ± 0.1 g/dl compared to group C mean 10.6 ± 0.1 g/dl. The Hb concentration on days 1, 2 and 5 and length of hospital stay are shown in Table 3. The length of hospital stay for patients in the autotransfusion group was significantly less, it is unwise to draw immediate conclusions due to the number of confounding factors (concomitant disease, social situation, etc.) associated with this variable. Similarly, attempts by others to link banked transfusions with outcome such as length of stay or mortality in surgical patients have been unsuccessful [9].

Five of the subjects in group A required autotransfusion according to the protocol but did not receive any of their own packed red cells. This was because, according to the protocol they required blood on arrival in ITU, at which time there was no mediastinal drainage. It was also noted that some patients in group A returned from the operating theatre with a haemoglobin concentration which merited autotransfusion but with a relatively small volume of postoperative shed mediastinal fluid (less than 200 ml) in the

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Post-operative blood requirements</th>
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<tbody>
<tr>
<td>Group A/C</td>
<td>Autotransfusion used</td>
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<tr>
<th>Table 3</th>
<th>Day 1, 2 and 5 Hb concentration and length of hospital staya</th>
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<td>Day</td>
<td>Group A</td>
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<tr>
<td>Day 1 Hb (g/dl)</td>
<td>11.19 ± 0.12</td>
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<tr>
<td>Day 2 Hb (g/dl)</td>
<td>11.61 ± 0.12</td>
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<tr>
<td>Day 5 Hb (g/dl)</td>
<td>11.94 ± 0.14</td>
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<td>Length hospital stay (days)</td>
<td>7.3 ± 0.39</td>
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* Data presented as mean ± standard error.

4. Discussion

These data demonstrate that selective postoperative autotransfusion significantly decreases the requirement for banked (allogeneic) blood, both in terms of the mean volume transfused and the number of patients requiring a transfusion. In addition, day 1 postoperative haemoglobin and packed cell volume levels are also higher in patients following autotransfusion.

There was no significant difference between the two study groups with respect to cardiopulmonary bypass (CPB) time or type of operation. These variables were initially believed to have an affect on transfusion requirements [11], however, Cosgrove et al. demonstrated that neither number of grafts nor duration of CPB correlated with transfusion requirements [12]. In the same way, a number of studies have suggested that postoperative chest tube drainage no longer differs after revascularization, valvular or combined surgical procedures [13].

Although the length of hospital stay for patients in the autotransfusion group was significantly less, it is unwise to draw immediate conclusions due to the number of confounding factors (concomitant disease, social situation, etc.) associated with this variable. Similarly, attempts by others to link banked transfusions with outcome such as length of stay or mortality in surgical patients have been unsuccessful [9].

Five of the subjects in group A required autotransfusion according to the protocol but did not receive any of their own packed red cells. This was because, according to the protocol they required blood on arrival in ITU, at which time there was no mediastinal drainage. It was also noted that some patients in group A returned from the operating theatre with a haemoglobin concentration which merited autotransfusion but with a relatively small volume of postoperative shed mediastinal fluid (less than 200 ml) in the
collection reservoir. Washing of this fluid produced a low yield (<50 ml) and banked blood transfusions were required. However, 1–2 h postoperatively, there was enough in the reservoir to warrant autotransfusion. Modifications to the indications for transfusion would further decrease the number of patients receiving banked blood.

Prospective and controlled trials have disagreed over the efficacy of intra- and postoperative blood salvage in conserving blood in cardiac surgery patients. This disparity of results may be explained, in part, by differences in transfusion practices [9]. Different institutions function using varying combinations of the blood conservation techniques, many of which were not applied in the earlier prospective randomized studies [14–16], hence it is difficult to compare results.

Morris et al. [17], allowed the Hb to fall to 7.5 g/dl before transfusing. Intraoperative autotransfusion was also administered to all patients in the autotransfusion group, and postoperative autotransfusion volumes were determined by the volume of mediastinal drainage. However, the conclusions that were drawn are in accordance with the findings in this study, i.e. addition of routine autotransfusion to a current practice of aggressive blood conservation further reduces the requirement for postoperative allogeneic banked blood transfusion in cardiac surgery patients [17].

In 1978, Schaff et al. studied postoperative autotransfusion in 114 patients undergoing cardiac surgery [15]. Only 52% of patients randomized to receive autotransfused blood, however overall, a 50% reduction in the amount of banked blood received by this group was demonstrated. The criteria for receiving autotransfusion was more than 400 ml of blood lost in the initial 4 h following surgery, and the threshold for banked blood transfusion was a postoperative haematocrit of less than 0.35, a higher level than is generally accepted in today’s practice [15,17].

One year later, Thurer et al. reported on a comparable study which also involved additional blood conserving techniques [16]. Reinfusion of shed mediastinal fluid was based on clinical evaluation of the patient and 83% of patients randomized into this group received autotransfused blood. However, on analysis of the results there was no significant reduction either in the amount of banked blood transfused or the number of patients requiring a transfusion, and it was concluded that there is no incremental benefit of reinfusion of shed mediastinal fluid when other attempts to conserve blood are used [16,17].

Page et al. made similar observations in patients with a low level of postoperative bleeding [18], but found that autotransfusion of patients with bleeding sufficient to yield more than 500 ml blood reduced the requirements for banked blood by nearly 50%, an observation similar to that of Schaff et al. [15,17,18].

More recently, Kochamba et al. combined an autotransfusion protocol with intra-operative haemodilution and found that this group of patients had 45% less homologous blood transfused and that 52% of the group required no blood products [19]. De Varenes et al. also demonstrated that reinfusion of shed mediastinal fluid reduces exposure to homologous blood transfusion. In addition, it was observed that autotransfusion reduces the number of re-exploration operations for coagulopathy-related postoperative haemorrhage [20].

Autotransfusion of washed mediastinal fluid is safe and the packed red cells it generates have definite advantages over allogeneic blood with respect to the risks of disease transmission or transfusion reaction.

Normovolaemic anaemia after cardiac surgery is well tolerated [12,21–23]. An algorithm approach for use of autotransfusion that accounts for the volume of blood in the collection reservoir and haemoglobin level and clinical condition of the patient may further maximize benefits of autotransfusion.

This study was conducted to determine whether the use of postoperative autotransfusion reduced the requirement for banked blood transfusion following cardiac surgery. It was formulated as a single centre, randomized, controlled trial, each group containing 56 patients. The results showed that postoperative autotransfusion significantly decreased both the number of patients requiring allogeneic transfusion and the volume of banked blood transfused. We recommend that it is routinely offered to patients undergoing cardiac surgery.

References


