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Assessing the effectiveness of retrograde autologous priming of the cardiopulmonary bypass machine in isolated coronary artery bypass grafts

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ABSTRACT

INTRODUCTION Currently, around 35–80% of patients undergoing cardiac surgery in the UK receive a blood transfusion. Retrograde autologous priming (RAP) of the cardiopulmonary bypass circuit has been suggested as a possible strategy to reduce blood transfusion during cardiac surgery.

METHODS Data from 101 consecutive patients undergoing isolated coronary artery bypass grafts (where RAP was used) were collected prospectively and compared with 92 historic patients prior to RAP use in our centre.

RESULTS Baseline characteristics (ie age, preoperative haemoglobin [Hb] etc) were not significantly different between the RAP and non-RAP groups. The mean pump priming volume of 1,013ml in the RAP group was significantly lower ($p<0.001$) than that of 2,450ml in the non-RAP group. The mean Hb level at initiation of bypass of 9.1g/dl in patients having RAP was significantly higher ($p<0.001$) than that of 7.7g/dl in those who did not have RAP. There was no significant difference between the RAP and non-RAP groups in transfusion of red cells, platelets and fresh frozen plasma, 30-day mortality, re-exploration rate and predischarge Hb level. The median durations of cardiac intensive care unit stay and in-hospital stay of 1 day (interquartile range [IQR]: 1–2 days) and 5 days (IQR: 4–6 days) in the RAP group were significantly shorter than those of the non-RAP group (2 days [IQR: 1–3 days] and 6 days [IQR: 5–9 days]).

CONCLUSIONS In the population group studied, RAP did not influence blood transfusion rates but was associated with a reduction in duration of hospital stay.

KEYWORDS

Haemodilution – Coronary artery bypass – Retrograde priming

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Postoperative blood loss and anaemia in surgical patients is a major concern for the surgeon as the former reduces the body's ability to sustain adequate perfusion of the essential organs and is associated with significant postoperative complications such as renal failure, cerebral events and cardiac ischaemia. However, the treatment in the form of allogenic blood and blood products has its own inherent risks including ABO incompatibility along with other antibody antigen reactions (1:10,000), blood borne infections (1:350,000), risk of transfusion-related acute lung injury (1:5,000), brain oedema, renal impairment (around 2%), and the rarer graft versus host syndromes, all of which are devastating to a patient's recovery.[1] There are also issues for some patients regarding religious belief and the use of exogenous blood, which limit treatment options for such patients following significant blood loss.

Haemodilution influences the physiological oxygen carrying capability. Despite this, the first response employed to manage significant blood loss both intra and postoperatively is often the instillation of colloid or crystalloid solution to expand the patient's plasma volume, a practice that causes further haemodilution.

Standard priming techniques of the bypass circuit involve the use of crystalloid solutions such as Hartmann's, which are 'dumped' into the patient's circulation. The volumes of this solution can be in the region of 2,000ml. In addition to the potential 900ml of blood lost, this can overwhelm the body's capacity to maintain homeostasis. Some of the measures (apart from blood donation) employed to reduce the amount of haemodilution intraoperatively include acute normovolaemic haemodilution, cell salvage procedures and homological agents, all of

Table 1 Preoperative patient characteristics

	RAP (*n*=101)	**Control** (*n*=92)	***p*-value**
Mean age	65.6 yrs (SD: 9.7 yrs)	65.5 yrs (SD: 8.4 yrs)	0.9
Mean EuroSCORE	3.9 (SD: 2.6)	3.7 (SD: 2.6)	0.4
Male patients	91%	83%	0.08
Elective	58%	69%	0.1
Impaired LV	31%	41%	0.3

RAP = retrograde autologous priming; SD = standard deviation; LV = left ventricular function

Table 2 Postoperative data

	RAP (*n*=101)	**Control** (*n*=92)	***p*-value**
Mean CPB prime volume	1,013ml (SD: 189ml)	2,450ml (SD: 484ml)	**<0.001**
Mean Hb on CPB	9.1g/dl (SD: 1.4g/dl)	7.8g/dl (SD: 1.4g/dl)	**<0.001**
Mean CPB time	86 mins (SD: 27 mins)	80 mins (SD: 30 mins)	0.1
Blood transfusion	36%	40%	0.3
Platelet transfusion	15%	13%	0.4
FFP transfusion	4%	9%	0.09
Re-exploration for bleeding	4%	7%	0.2
Atrial fibrillation	24%	26%	0.5
Infections	12%	11%	0.5
Renal dysfunction	4%	5%	0.4
30-day mortality rate	2%	3%	0.5

RAP = retrograde autologous priming; CPB = cardiopulmonary bypass; SD = standard deviation; Hb = haemoglobin; FFP = fresh frozen plasma

which are used to maintain haemoglobin (Hb) concentrations.

The above measures are all used in our unit along with retrograde autologous priming (RAP) of the cardiopulmonary bypass (CPB) unit in order to limit the amount of haemodilution caused. This process uses the patient's own blood to prime the bypass machine. The main hypothesis of this study was that RAP actually has an impact on the need for blood transfusion in coronary artery bypass grafting (CABG). Furthermore, the effect of RAP on length of cardiac intensive care unit stay, length of hospital stay, morbidity and mortality was also assessed.

Methods

Overall, 193 patients undergoing first-time, isolated CABG where the CPB machine was used (on pump) were included in this study. Data were collected prospectively on 101 consecutive patients who underwent RAP (study cohort) and 92 historic patients (consecutive patients who underwent surgery within three months prior to institution of RAP) who underwent non-RAP isolated CABG (control group). Data were collected preoperatively and intraoperatively, and included measurements of Hb preoperatively, on-CPB and prior to discharge. A similar dataset for the non-RAP group was retrieved from a prospectively collected database. Exclusion criteria included all non-CABG operations, any operation that was a combined valve and CABG procedure, and all off-pump CABG operations as well as primary operations that were due to complication. Post/intraoperative data included the need for blood and products transfusion, postoperative complications (atrial fibrillation, infection, renal dysfunction, need for re-exploration), cardiac intensive care unit and in-hospital stay, and mortality.

There was no change in clinical practice during that period although our unit did not have a defined care pathway at the time of the study. The transfusion trigger remained at a Hb level of ≤8g/dl as measured on the arterial blood gas on the intensive care unit. The amount of blood product given to each patient was determined by assessment of coagulation by thromboelastography and/or a recent history (≤5 days) of intake of antiplatelet agent (aspirin, clopidogrel). All patients in both groups received tranexamic acid starting prior to skin incision (3–5g). Anaesthesia was with propofol and isoflurane intraoperatively, and propofol and morphine postoperatively. Patients were extubated if they were not bleeding, were warm and responded

appropriately on command after withdrawal of propofol, and no patients in the study failed the RAP process.

CPB Hb refers to the first Hb level once CPB was established. Patients were not transfused during the CPB run. Six surgeons were included in this study. Statistical analysis was performed using SSPS® version 10 (SPSS, Chcago, IL, US), and included the chi-squared test (nominal data) and Mann–Whitney U test or Wilcoxon signed-rank test (interval data). A p-value of <0.05 was considered significant.

Results

Table 1 highlights that baseline characteristics were not significantly different between the RAP and non-RAP groups. The mean preoperative Hb levels were 13.5g/dl (standard deviation [SD]: 1.6g/dl) and 13.9g/dl (SD: 1.3g/dl) respectively (p=0.1). However, the mean pump priming volume in the RAP group (1,013ml [SD: 189ml]) was significantly lower than that of the non-RAP group (2,450ml [SD: 484ml]).

Despite this divergence, there was no significant difference between the RAP and non-RAP groups in transfusion rates of red cells, platelets and fresh frozen plasma, 30-day mortality, re-exploration rates, incidence of postoperative atrial fibrillation and predischarge Hb levels (Table 2). Nevertheless, the median durations of cardiac intensive care unit stay and in-hospital stay were significantly shorter in the RAP group (1 day, interquartile range [IQR]: 1–2 days; and 5 days, IQR: 4–6 days respectively) than in the non-RAP group (1 day, IQR: 1–3 days; and 6 days, IQR: 5–9 days respectively). Moreover, while on bypass, the degree of haemodilution (as judged by the first on-CPB Hb levels) was much less in the RAP group (p<0.001). There were no reported incidents during the RAP process.

Discussion

Over the past decade, many surgical and non-surgical methods have been developed to reduce the need for blood and blood products in cardiothoracic surgery. One of these was the development of RAP of the CPB circuit technique. The evidence pertaining to this technique is scanty at best, with only six randomised controlled trials[2–7] published surrounding the topic, all of which were considered in a meta-analysis[8] to be of low value on the Jadad scale, a scoring system to determine the quality of a study from an evidence standpoint.[9]

There are no existing guidelines from the National Institute for Health and Clinical Excellence related to the practice of RAP so current practice is variable. One study of over 10,000 patients in 70 cardiothoracic centres estimated that the average blood loss per patient was 917ml[10] and other similar studies show the rates of blood transfusion around 86%.[11] This shows the need for effective blood conserving practices.

The meta-analysis[8] of the six randomised controlled trials[2–7] investigating RAP showed a 64% reduction (odds ratio [OR]: 0.36, 95% confidence interval [CI]: 0.13–0.94, p=0.04) in the need for the use of blood intraoperatively and a 74% reduction (OR: 0.26, 95% CI: 0.13–0.52, p=0.0001) in the need for blood during a hospital stay. The mean intraoperative fluid balance was not significantly different in RAP patients (1,574.6ml) compared with the control groups (2,016.2ml) (p=0.44). The majority of these patients underwent primary CABG although other procedures were represented in the studies at a smaller proportion.

Information included in the meta-analysis seems to question the robustness of clinical benefit when RAP is used. This conclusion is derived from the sensitivity analysis of the data in the six trials and the outcome is also reinforced when a retrospective trial of the largest series in the group is scrutinised. That study concluded that there was no clinical effectiveness in the use of RAP.[12]

Our study showed that there was a significant difference in pump priming volumes, which is to be expected when comparing a RAP with a non-RAP procedure, but there was no difference in transfusion rate between RAP and non-RAP patients. Interestingly, there was a significant difference in the on-CPB Hb levels (RAP 9.1g/dl vs non-RAP 7.7g/dl, p<0.001), which may confer an advantage in postoperative recovery to the RAP group. The fact that both groups had similar transfusion rates postoperatively and similar Hb levels at discharge would suggest that the body's homeostatic properties came into play and allowed for some degree of haemoconcentration.

With regard to patient safety, our study indicates that RAP is as safe as non-RAP as there were no reported incidents during the RAP process. Furthermore, there was no difference in 30-day mortality, the need for re-exploration, fresh frozen plasma/platelets transfusion and predischarge Hb levels. Nevertheless, further study is needed to determine a full safety profile.

There was a significantly shorter length of cardiac intensive care unit stay and total hospital stay for the RAP group. A shorter hospital stay has potentially beneficial financial implications as well as increasing patient safety by reducing exposure to hospital acquired infection. Unfortunately, whether the shorter length of stay was due solely to the use of RAP could not be elucidated by the current study.

Conclusions

This study confirmed that RAP is likely to be safe but did not influence postoperative blood transfusion rates. However, there was a shorter in-hospital stay in the RAP group. A large randomised controlled trial that includes a more detailed observation of the pre, intra and postoperative Hb measurements as well as the immediate and day 1 Hb levels is needed. Furthermore, a robust cost–benefit analysis may be required to elucidate the full benefits of RAP from a financial perspective.

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