Antegrade rapid prime displacement in elective coronary artery surgery is associated with lower perioperative blood transfusions and a shorter hospital stay

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Abstract

OBJECTIVES: Haemodilution during cardiopulmonary bypass is associated with increased perioperative blood transfusions and is thought to reduce intraoperative oxygen delivery to the brain. We sought to evaluate our method of rapid antegrade prime displacement in the context of the perioperative blood transfusion rate, intraoperative cerebral saturations and postoperative hospital stay.

METHODS: Retrospective analysis of 160 propensity-matched patients undergoing elective coronary artery bypass grafting was performed comparing different perfusion strategies on perioperative blood transfusion and length of postoperative stay. Eighty patients who had rapid antegrade prime displacement and vacuum-assisted venous drainage (RAD-V AD) were compared with 80 patients who had conventional cardiopulmonary bypass with gravity drainage (CB). RAD-V AD involved displacing all or most of the prime in the circuit with the patient's own blood prior to the initiation of cardiopulmonary bypass within a 15–20 s window. Within each group, 10 patients had intraoperative cerebral saturation measurements.

RESULTS: There were no differences in the baseline characteristics between the groups. Both groups had a significant fall (P < 0.05) in haematocrit during cardiopulmonary bypass from preoperative values, however, the fall in haematocrit was significantly less in the RAD-V AD group (P < 0.05). There was significantly (P < 0.05) less intraoperative and postoperative homologous blood transfusions in the RAD-V AD group (47.892 ml ± 8.14 and 76.58 ml ± 21.58) compared with the CB group (229.06 ml ± 105.03 and 199.91 ml ± 47.13). There was a significant fall in cerebral saturations within both groups (P < 0.05) but it was not significant between the groups. The postoperative stay was significantly (P < 0.05) shorter in the RAD-V AD group compared with the conventional group (7.74 days ± 0.51 vs. 10.13 days ± 0.95).

CONCLUSIONS: RAD-V AD is associated with a significantly lower blood transfusion rate perioperatively and shorter hospital stays compared with CB.

Keywords: Cardiopulmonary bypass • Blood transfusion

INTRODUCTION

Although the cardiopulmonary bypass (CPB) circuit has been dramatically refined since its conception by Gibbon, it still carries many imperfections [1, 2]. One such shortcoming is haemodilution during CPB, a significant determinant of postoperative blood transfusion. Both are significant risk factors for morbidity following cardiac surgery [3, 4].

Prime displacement during CPB is used to reduce the prime volume delivered to the patient, thus reducing haemodilution and preserving the haematocrit during bypass [5]. Various methods have been trialled, including retrograde autologous priming. However, the effectiveness and safety of antegrade approaches have yet to be fully discerned.

In this study, we compared our technique of rapid antegrade prime displacement using vacuum-assisted venous drainage (RAD-V AD) against conventional bypass using gravity drainage (CB). We explored the impact of these methods on haematocrit, cerebral saturations during CPB and postoperative outcomes.

METHODS

Study design

This study was approved by our institution’s Audit Review Board. Retrospective analysis of data registered prospectively on to our database (Patient Analysis Tracking System) for patients...
undergoing only elective coronary artery bypass surgery (CABG) between January 2009 and January 2010 was undertaken. Patients were excluded from the analysis if they were in renal failure or had an intra-aortic balloon pump inserted preoperatively.

Patients were divided into two groups: those undergoing conventional gravity drainage CB and those undergoing RAD-VAD. Propensity scores were assigned to each preoperative patient characteristic and matched 1:1 between the two groups of patients. The propensity score represented the probability of a patient being assigned to the case group given the covariables of that patient. It was calculated for each patient using a logistic regression model from the following variables: age, body mass index, logistic EuroSCORE, left ventricular ejection fraction, New York Heart Association (NYHA) functional class, chronic obstructive pulmonary disease (use of bronchodilators or steroids due to lung disease), previous myocardial infarction, diabetes, smoking, previous cardiac surgery, peripheral vascular disease and previous stroke/transitory ischaemic attack. Patients were randomly selected from the RAD-VAD group and matched with a partner in the CB who had the nearest logit-transformed propensity score. Balance of matching variables was assessed by formal statistical comparison (Kolmogorov–Smirnov test for continuous variables and Fisher’s exact test for categorical variables). A P-values of >0.05 were considered as evidence for balance of the quantity.

After propensity matching, we identified a final cohort of 140 patients: those using CB (n = 70) or RAD-VAD (n = 70).

Ten further matched patients in each group had intraoperative cerebral saturation measurements.

Perfusion systems and common strategies

Three oxygenators were used; Admiral (Eurosets, Italia), D903 (Sorin Biomedica) and EOS (Sorin Biomedica), which were integral oxygenator/cardiotomy systems with the facility to separate the cardiotomy blood from the venous blood and were designed to allow vacuum-assisted venous drainage (VAVD). The size of the oxygenator was determined by the ideal mid flow value based on the patient’s body surface area. The D903 has a prime volume of 250 ml, the Admiral has 190 ml and the EOS has 160 ml prime volume.

All tubing and oxygenators were phosphorylcholine (PC) coated. The cardiectomy reservoir was connected to a cell saver (Medtronic Autolog or Sorin Electa) to allow the removal of excess prime and cardiectomy suction blood.

Bypass circuits were flushed with carbon dioxide before priming with ~1250–1500 ml of Hartmann’s solution in the CB group and 1000 ml of prime in the RAD-VAD group. Both groups had circuits primed with 5000 IU heparin.

Perfusion strategies

Conventional bypass with gravity drainage. The conventional circuit consisted of an integral oxygenator/cardiectomy system, a ½ venous line and a ⅛ arterial line incorporating an arterial filter (Sorin D734 or Eurosets Sherlock). CPB was established using gravity venous drainage and maintained as described above. The arterial line filters had the same pore size.

RAD-VAD method. The circuit used for our Cottingham RAD-VAD technique (Fig. 1) was the same as for CB with the following modifications:

(i) A regulated vacuum was applied to the venous reservoir (max −100 mmHg, Amvex Corporation) to augment the venous return. The negative pressure in the venous reservoir was measured and maintained at more than −40 mmHg.

(ii) A ¼ ‘prime displacement line’ was inserted into the arterial line, distal to the arterial line filter and connected to the cardiectomy reservoir.

VAVD facilitated a reduction in prime volume by; allowing the oxygenator to be placed closer to the operating field at the level of the patient, which reduced the length of the arterial and venous lines by 40%, and enabling the ½ venous line to be replaced with a ⅛ venous line.

The venous reservoir (under vacuum) was emptied and cleared of prime before opening the venous line.

When the surgeon had cannulated and attached the arterial and venous lines to the patient and when both the perfusionist and anaesthetist were satisfied that the patient was ready for CPB, the order for commencement of CPB was given. Immediately following this order, antegrade prime displacement was performed in a rapid manner before the initiation of full bypass: the arterial line was clamped distal to the prime displacement line. The venous line clamp was then removed. The prime displacement line was opened and prime pumped into the cardiectomy reservoir. When the patient’s blood had displaced the clear prime, the prime displacement line was clamped and the arterial line opened to establish full CPB. This whole process from the verbal order for CPB to the rapid antegrade prime displacement to the initiation of full CPB takes under 15 s. The displaced prime in the cardiectomy was transferred to the cell saver.

Common strategies. CPB was maintained with a cardiac index of 2.2–2.4 l/min/m², mean arterial pressure (MAP) of 60–70 mmHg, partial pressure of oxygen (PO2) of 150–225 mmHg and partial pressure of carbon dioxide (PCO2) of 36–39 mmHg.

![Figure 1: Schematic for Cottingham rapid antegrade prime displacement and vacuum-assisted venous drainage technique.](https://academic.oup.com/icvts/article-abstract/17/3/485/1087177)
Pressures were maintained by altering pump flow, administrating intravascular volume administration when necessary (Hartmann’s Crystalloid or Volplex Colloid solutions) or by the vasoconstrictor, metaraminol. We used an alpha-stat perfusion strategy with all our patients.

Patients were transfused with red cells if the haemoglobin on the arterial blood gas fell <6.5 g/dl.

All cardiomy suction blood was separated from the venous return and washed with the cell saver before being returned to the patient.

At the end of all procedures the residual blood in the perfusion circuit was flushed to the cell saver and concentrated before being returned to the patient.

Following the administration of protamine and discontinuation of CPB, patients had a thromboelastogram test to determine if any clotting products were required.

**In vivo optical spectroscopy technique.** In vivo optical spectroscopy (INVOS) (Somanetics) allows for the measurement venous-weighted regional saturations of the brain using a disposable oximeter sticker placed on the skin of the patient’s head. This is useful because although peripheral pulse oximetry or blood gases may indicate adequate oxygen saturations, regional inadequacies, particularly in the brain, may concurrently exist. INVOS, therefore, allows for regional brain oxygen saturation(rSO2) to be measured so as to act rather like a real-time early warning system for cerebral under-perfusion.

If cerebral saturations fell 20% below the baseline, the following strategies were implemented to increase the rSO2:

1. Increase the MAP during CPB to >50 mmHg.
2. Increase the cardiac index to >2.5 l/m2/min.
3. Increase FIO2.
4. Decrease cerebral O2 demand by increasing anaesthesia.

**Statistical analysis.** Our primary endpoint was perioperative blood transfusion rates. Secondary endpoints were morbidity and length of postoperative hospital stay. Morbidity was defined as: (a) cardiac (confirmed myocardial infarction or sustained reduction in ventricular function), (b) renal (confirmed reduction in glomerular filtration rate/new dialysis), (c) neurological (confirmed cerebrovascular accident or hypoxic brain injury) and (d) wound infection (confirmed graft site or sternal wound infection). Data were analysed using SPSS statistics 19. The continuous variables with a normal distribution were compared by means of the unpaired Student’s t-test. Those without a normal distribution were compared by means of the Mann–Whitney U-test. Categorical variables were analysed using the χ2-test or Fisher’s exact test when sample size or expected results were too small. For time trends analysis of haematocrit during CPB, three consecutive periods were considered (initiation of CPB, lowest mean values during CPB and termination of CPB), and repeated measurement analysis of variance was used to evaluate changes in haematocrit between groups. Multivariate regression analysis was used to assess the association of base-line variables with perioperative blood transfusion and postoperative stay. P-values ≤0.05 were considered statistically significant.

**RESULTS**

**Baseline characteristics**

The baseline demographic data for the prime displacement (PD) vs conventional CPB (CB) study is given in Table 1. As can be seen, the groups were closely matched. There was also no significant difference between the patients in the INVOS cohort.

**Intraoperative characteristics**

The mean cross-clamp time, cumulative bypass time and number of coronary anastomoses did not vary between the groups (Table 2).

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**Table 1:** Preoperative patient characteristics

<table>
<thead>
<tr>
<th></th>
<th>Conventional CPB</th>
<th>Prime displacement</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age in years (±SD)</td>
<td>67.64 (9.649)</td>
<td>65.01 (9.886)</td>
<td>0.114</td>
</tr>
<tr>
<td>Female (prop) (%)</td>
<td>20 (14/70)</td>
<td>14.3 (10/70)</td>
<td>0.373</td>
</tr>
<tr>
<td>CCS I (prop) (%)</td>
<td>11.4 (8/70)</td>
<td>8.6 (6/70)</td>
<td>0.631</td>
</tr>
<tr>
<td>CCS II (prop) (%)</td>
<td>50 (35/70)</td>
<td>54.3 (38/70)</td>
<td></td>
</tr>
<tr>
<td>CCS III (prop) (%)</td>
<td>27.1 (19/70)</td>
<td>30 (21/70)</td>
<td></td>
</tr>
<tr>
<td>CCS IV (prop) (%)</td>
<td>7.1 (5/70)</td>
<td>7.1 (5/70)</td>
<td></td>
</tr>
<tr>
<td>NYHA I (prop) (%)</td>
<td>31.4 (22)</td>
<td>35.7 (25/70)</td>
<td>0.978</td>
</tr>
<tr>
<td>NYHA II (prop) (%)</td>
<td>57.1 (40/70)</td>
<td>50 (35/70)</td>
<td></td>
</tr>
<tr>
<td>NYHA III (prop) (%)</td>
<td>10 (7/70)</td>
<td>14.3 (10/70)</td>
<td></td>
</tr>
<tr>
<td>NYHA IV (prop) (%)</td>
<td>1.4 (1/70)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>With chronic obstructive pulmonary disease (prop) (%)</td>
<td>12.9 (9/70)</td>
<td>10 (7/70)</td>
<td>0.598</td>
</tr>
<tr>
<td>No previous myocardial infarctions (prop) (%)</td>
<td>40 (28/70)</td>
<td>37.1 (26/70)</td>
<td>0.731</td>
</tr>
<tr>
<td>Insulin dependent diabetes mellitus (prop) (%)</td>
<td>11.4 (8/70)</td>
<td>4.3 (3/70)</td>
<td>0.711</td>
</tr>
<tr>
<td>Chronic kidney disease (prop) (%)</td>
<td>0</td>
<td>0</td>
<td>0.854</td>
</tr>
<tr>
<td>Peripheral vascular disease (prop) (%)</td>
<td>11.4 (8/70)</td>
<td>11.4 (8/70)</td>
<td>N/A</td>
</tr>
<tr>
<td>Three-vessel disease (prop) (%)</td>
<td>81.4 (57/70)</td>
<td>80 (56/70)</td>
<td>0.832</td>
</tr>
<tr>
<td>Ejection fraction &lt;30% (prop) (%)</td>
<td>10 (7/70)</td>
<td>5.7 (4/70)</td>
<td>0.863</td>
</tr>
<tr>
<td>Mean body mass index (±SD)</td>
<td>28.94 (4.66)</td>
<td>29 (4.44)</td>
<td>0.295</td>
</tr>
<tr>
<td>Mean body surface area (±SD)</td>
<td>1.97 (0.22)</td>
<td>2.02 (0.21)</td>
<td>0.120</td>
</tr>
<tr>
<td>Mean logistic EuroSCORE I</td>
<td>4.86 (8.22)</td>
<td>4.83 (4.83)</td>
<td>0.295</td>
</tr>
</tbody>
</table>

CCS: Canadian Cardiovascular Society scoring system; NYHA: New York Heart Association scoring system; prop: proportion out of 70.
The Admiral oxygenator was used significantly more in the CB group than the RAD-VAD ($P = 0.007$). However, this did not influence the blood transfusion rate or the postoperative stay.

The intraoperative (asanguineous) prime delivered was confirmed to be significantly more in the CB group compared with the RAD-VAD group (1429.29 ml ±25.098 vs 363.57 ml ±32.37, $P < 0.001$).

There was no significant difference ($P > 0.05$) observed between RAD-VAD and the CB in the total volume of crystalloid (372.06 ml ±56.50 vs 386.43 ml ±52.51) or colloid (252.86 ml ±35.58 vs 292.15 ml ±38.83) given during CPB.

There was a significant initial fall in haematocrit (%) from the initiation of CPB to the mean of the lowest [Hb] through CPB in both the CB (37.03 ±4.093–24.66 ±3.540) and the RAD-VAD group (39.91 ±4.599–28.76 ±4.325) ($P < 0.001$). This is followed by an increase at the end of CPB. This fall and rise was significantly less ($P < 0.001$) in the RAD-VAD group compared with the CB group (Fig. 2).

**Postoperative outcomes**

There was no mortality in either group, nor were there any postoperative cardiac, renal, neurological or wound complications in either group. However, the postoperative stay was significantly less in the RAD-VAD group compared with the CB group (7.74 days ±0.519 vs 10.13 days ±0.959, $P = 0.030$) (Table 3). When evaluating whether intraoperative and postoperative blood transfusions were independent predictors of length of postoperative stay, only a higher postoperative transfusion amount of red cells was a significant ($P < 0.001$) predictor of a longer postoperative stay. Homologous ($P = 0.389$) and autologous ($P = 0.465$) were not predictors of hospital stay.

**Haematological and transfusion characteristics of PD vs conventional CPB study**

Table 2: Operative characteristics

<table>
<thead>
<tr>
<th></th>
<th>Conventional CPB</th>
<th>Prime displacement</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients using Avant oxygenator (%)</td>
<td>92.86 (65/70)</td>
<td>77.14 (54/70)</td>
<td>0.007</td>
</tr>
<tr>
<td>Mean CPB time (min) (SD)</td>
<td>88.20 (25.71)</td>
<td>81.16 (23.49)</td>
<td>0.093</td>
</tr>
<tr>
<td>Mean cross-clamp time (min) (SD)</td>
<td>52.01 (16.29)</td>
<td>49.94 (14.1)</td>
<td>0.302</td>
</tr>
<tr>
<td>Mean Pre-CPB HCT (SD)</td>
<td>37.03 (4.093)</td>
<td>39.41 (4.599)</td>
<td>0.078</td>
</tr>
<tr>
<td>Mean lowest CPB HCT (SD)</td>
<td>24.66 (3.540)</td>
<td>28.76 (4.325)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean post-CPB HCT (SD)</td>
<td>28.259 (3.4997)</td>
<td>31.080 (5.1323)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean volume of prime delivered (ml) (SD)</td>
<td>1429.29 (209.985)</td>
<td>363.57 (270.79)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean intraoperative crystalloid delivered (ml) (SD)</td>
<td>386.43 (52.51)</td>
<td>372.06 (56.50)</td>
<td>0.861</td>
</tr>
<tr>
<td>Mean intraoperative colloid delivered (ml) (SD)</td>
<td>252.86 (35.58)</td>
<td>292.15 (38.83)</td>
<td>0.457</td>
</tr>
<tr>
<td>Mean intraoperative autologous blood transfusion (ml) (SD)</td>
<td>62.658 (10.09)</td>
<td>105.116 (33.49)</td>
<td>0.112</td>
</tr>
<tr>
<td>Mean intraoperative homologous blood transfusion (ml) (SD)</td>
<td>229.06 (105.03)</td>
<td>47.892 (8.14)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mean amount of blood retrieved from cell saver (ml) (SD)</td>
<td>268.50 (57.30)</td>
<td>271.111 (29.176)</td>
<td>0.853</td>
</tr>
<tr>
<td>Mean amount of metaraminol given during CPB (mg) (SD)</td>
<td>12.65 (11.12)</td>
<td>14.50 (7.80)</td>
<td>0.743</td>
</tr>
<tr>
<td>Mean cerebral saturation % (L and R) pre-CPB (%) (SD) n = 10</td>
<td>75.16 (6.1)</td>
<td>69.2 (4.3)</td>
<td>0.841</td>
</tr>
<tr>
<td>Mean cerebral saturation % (L and R) during CPB (%) (SD) n = 10</td>
<td>66.11 (5.47)</td>
<td>62.58 (4.06)</td>
<td>0.08</td>
</tr>
</tbody>
</table>

INVOS data

Within the INVOS groups, there was a significant fall in the mean rSO2 during CPB ($P < 0.05$) over time. Although not statistically significant, the percentage fall in mean rSO2 from pre-bypass baseline was less in the prime displacement group than in the conventional bypass group ($−6.7 ± 4.8$ vs $−9.0 ± 3.0$ rSO2).
the patient, thereby reducing the exposure of the patients
pared with gravity drainage where the oxygenator is well below
level of the patient and thus shorten the table lines com-
flation that takes under 15 s.
the patient during CPB by displacing all/most of the prime with
ques are 2-fold. First, we are able to prevent the haemodilution of
 advantages of our low cost RAD-V AD method over other techni-
centre to centre and is very much operator dependent [6, 7]. The
method of perfusion for over a decade. The technique varies from
Prime displacement CPB has been practiced as an alternative
s own blood prior to commencing CPB in a rapid
blood transfusion is an independent predictor of hospital costs
any clear identi
the anaemia is further negated by the lack of any difference in the
requirement of clotting products (Fresh Frozen Plasma, Platelets
or Cryoprecipitate) after the operation.
Blood transfusion in itself is an expensive commodity associated
with adverse postoperative outcomes. Our study shows a clear
saving in blood transfusion costs in using PD over CB.
Our study did not demonstrate any clear differences in post-
operative complications, including neurological disturbances,
following cardiac surgery between the groups. We did not
compare biochemical markers associated with morbidity such as
inflammatory markers. Despite this, the PD group spent sig-
nificantly fewer days postoperatively in our hospital. It is diffi-
cult to explain this prolonged hospital stay in the absence of
any clear identifiable morbidity but studies have shown that
blood transfusion is an independent predictor of hospital costs
and morbidity [9]. Further to this, the lowest haematocrit on
bypass was significantly more pronounced in the CB group
compared with the RAD-V AD group and this is also an important
determinant of outcome [10].
INVOS monitoring allows for implementing measures that
have been shown to restrict the damage of persistently cerebral
low saturations during CPB [11]. Our INVOS data show an inter-
esting pattern over time of how well the brain is oxygenated
during CPB. Both groups demonstrated a significant fall in cere-
bral saturations during CPB (P < 0.05), indicating that on-pump

Further to this, during this rapid prime displacement period,
there is a risk of reducing perfusion to the brain, which is demon-
strated by our INVOS tracing. However, also from our INVOS
 tracing, it can be seen that this drop in cerebral sats is rapidly cor-
rected within 5–10 s, again with no neurological sequalae.
Finally, the clamping and unclamping of the arterial line prior
to prime displacement may cause the cardiotomy reservoir to
become pressurized as it is a sealed chamber in a closed circuit.
All our reservoirs are fitted with an over and under safety pressure
release valve to prevent this from happening.

**Effectiveness in lowering the requirement of red cell transfusion**

Our method demonstrates a clear reduction in blood transfusion
rate during CPB. This is likely due to the haemodilution effects of
normal CB as there is no significant difference in the blood loss of
our patients between the groups. A haemorrhagic explanation for
the anaemia is further negated by the lack of any difference in the
requirement of clotting products (Fresh Frozen Plasma, Platelets
or Cryoprecipitate) after the operation.

Our study did not demonstrate any clear effects of
haemodilution on postoperative outcomes. Our study shows a clear
saving in blood transfusion costs in using PD over CB.

**Value units**. Representative INVOS traces for the conventional
bypass group and PD group and are shown in (Figs 3 and 4),
respectively.

**Cost analysis**

There was no cost incurred in including the prime displacement
line into the CB circuit to create the RAD-VAD circuit as this was
covered in the manufacturer’s costs.
The cost of intraoperative blood transfusion for the CB group
was £64.76 (±16.88) per patient compared with £5.02 (±3.53) for
the RAD-VAD group (P < 0.001).
The cost of postoperative blood transfusions for the CB group
was £123.25 (±29.06) per patient compared with £47.22 (±13.31)
for the RAD-VAD group (P < 0.001).

**DISCUSSION**

**Uniqueness of our method**

Prime displacement CPB has been practiced as an alternative
method of perfusion for over a decade. The technique varies from
centre to centre and is very much operator dependent [6, 7]. The
advantages of our low cost RAD-VAD method over other techni-
ques are 2-fold. First, we are able to prevent the haemodilution of
the patient during CPB by displacing all/most of the prime with
the patient’s own blood prior to commencing CPB in a rapid
fashion that takes under 15 s.
Secondly by having VAVD, we are able to raise the oxygenator
to the level of the patient and thus shorten the table lines com-
pared with gravity drainage where the oxygenator is well below
the patient, thereby reducing the exposure of the patients’ blood
to the foreign surfaces of the tubing, thus reducing any possible
inflammatory response to this [8].

**Safety concerns of our protocol**

The period of haemodynamic instability during the time of prime
displacement may present itself as a theoretical risk. However, the
rapid displacement time of <20 s does not demonstrate any nega-
tive sequalae in our patients.

**Table 3: Postoperative complications**

<table>
<thead>
<tr>
<th></th>
<th>Conventional CPB</th>
<th>Prime displacement</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total blood loss (ml)</td>
<td>864.74 (616.23)</td>
<td>774.2 (443.29)</td>
<td>0.320</td>
</tr>
<tr>
<td>Postoperative blood transfusion (ml)</td>
<td>199.91 ± 47.137</td>
<td>76.58 ± 21.583</td>
<td>0.022</td>
</tr>
<tr>
<td>Total clotting factor replacement (IU)</td>
<td>341.274 (112.93)</td>
<td>229.872 (60.06)</td>
<td>0.284</td>
</tr>
<tr>
<td>Mortality (%)</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Acute renal failure (%)</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Deep sternal wound infection (%)</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Reoperation (%)</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Intra-aortic balloon pump (%)</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Neurological complications (%)</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Myocardial infarctions (%)</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Mean postoperative hospital stay (days) (SD)</td>
<td>10.13 (8.025)</td>
<td>7.74 (4.349)</td>
<td>0.030</td>
</tr>
</tbody>
</table>
CABG surgery may be associated with a reduction in cerebral saturations.

Although there was no difference between the groups, there is a trend \((P = 0.08)\) towards improved saturations in the RAD-VAD group. Perhaps with a greater number of patients, this trend may have transpired into significant differences.

**Limitations**

This study suffers from the weakness inherent in any retrospective study, including potential inconsistency of the data acquired over time. Although we used a propensity-matched method it does not fully control or exclude confounding factors.

Secondly, we are comparing a hybrid procedure (VAVD and prime displacement) with conventional gravity-assisted CPB. Hence, one could argue that the effects seen could be either due to VAVD or prime displacement or both. Hence, a prospective study comparing VAVD with and without prime displacement may be useful.

Further to this, although we used the D903 oxygenator for the vast majority of our cases in both the PD and CB groups, we used it significantly more in the conventional bypass group. However, this did not significantly affect outcomes.

Finally, our patient cohort was a select group with a relatively low mean Logistic EuroSCORE, encompassing routine elective CABG operations. Hence, we cannot extrapolate the results for valve and complex non-CABG surgeries. Further studies would need to be done to evaluate the role of RAD-VAD in those patients.
Variations in techniques and results, between centres and studies, as well as the reliance on retrospective data precipitates a need for multicentre randomized control trials to compare different methods of prime displacement with each other as well as with conventional bypass.

CONCLUSION

Rapid antegrade prime displacement with VAVD is not associated with an increased perioperative risk to the patient undergoing elective CABG only. It is, however, associated with a significantly lower blood transfusion rate perioperatively and shorter hospital stays.

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