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From the Editor's Desk

My dear friends, first and foremost, my sincere gratitude goes to you for electing me as the Editor of IJECT. I also owe you my earnest apologies for not bringing out the journal in time. It's a kind of schism within the society regarding the release of funds for the immediate expenditures that retarded the initiation of this work. Deo volente! (God willing!), I will execute my duties to the best of my ability in bringing forth good journals during my tenure. I am very much grateful to the former Editors for the valuable advice and encouragement that they have rendered to me.

On behalf of ISECT, I also convey my best wishes to the organising committee of ISECTCON 2014 in Thiruvananthapuram, the capital of Kerala for all its success. I feel that everyone attending the conference would surely feel the elegant and serene atmosphere of the city and witness the heritage of its past glory.

Thanks and Regards,
Editor
MESSAGE

Dear Friends

On behalf of the Indian Society of Extra Corporeal Technology and ISECT CON 2014 TRIVENDRUM, it is a great pleasure and honour to welcome you to the 14th National Conference of the Indian Society of Extra Corporeal Technology on 21st -22nd February, 2014 Trivendrum.

The main goal of the Conference thanks to its Scientific Programme is to enable Perfusionists to communicate with one another. This Conference will provide an excellent platform for exchanging views and encouraging the evolution of new research in regards to the future of Extra Corporeal Technology in the coming years.

Friends for the formation of Perfusion Council we five members of our Association appeared before the Department related Parliamentary Standing Committee on Heath and Family Welfare and made presentation. A short film presentation and necessary support material was also place before the said Committee showing them the status of Perfusion around the Globe. Recently we met Directorate General Health and Family Welfare with supporting documents for getting the Perfusion Profession recognise in the Government of India. In short as per Director of Medical Council, Paramedical Council and Allied Health Services and Directorate General Health and Family Welfare Perfusion Profession will be soon registered under Allied Health Services. I am continous in touch with Director of Medical Council and other Authorities in this regard and try my best for Registration of Perfusion Profession in Government of India.

The ultimate success of the Conference depends on you and your active participation in discussion. I hope many delegates from all over the world will come to Trivendrum to participate in 14th National Conference to make it a successful and memoral view.

I look forward to see you all in ISECT CON 2014 TRIVANDRUM.

DR KAMLA RANA
PRESIDENT - ISECT
Message from the General Secretary, ISECT

Dear Colleagues,

I am happy to present yet another issue of our Journal, this time under the stewardship of Mr. Albert J. Davis.

Great care has been taken in preparing this issue, and I am sure that it will be interesting and informative. Perfusionists are constantly innovating and adapting newer techniques. We request you to come forward and share the results of such modifications as also your research / study.

Let me also take this opportunity to welcome all the delegates to the 14th Annual Conference of ISECT to be held in Trivandrum on 21st and 22nd February, 2014. Our conferences have been organized very well and we have national and international delegates and faculty. This conference too promises to be educative and innovative.

Finally a big "Thank U" to all of you members who have participated in the activities of our society and made it grow from strength to strength.

With best wishes for the New Year,

RAVINATH SWAMI
General Secretary, ISECT
Role of Ultrafiltration in Paediatric Cardiopulmonary Bypass
Alok Kumar*, S.C. Yadav**, Yogender S Chauhan**, Lokendra Kumar**,
A.K. Bisoi***, Sandeep Chauhan@, Balram Airan@@.

A comparative study of Albumin versus 6 % Hydroxyethyl starch used as
priming solution for Cardiopulmonary Bypass in adults undergoing Coronary Artery Bypass Grafting
Namita Mishra*, Alok Kumar* S.C.Yadav**, Lokendra Kumar**, Minati Choudhury@, Milind Hote***,
Sandeep Chauhan@, Balram Airan***

Case Report
Senthil Kumaran.D**, P.V.S.Prakash***, Sunil Mekala***, Sunil.L.G*, Dr.Binoy***,
Dr.Devi Prasad Shetty****

REVIEW ARTICLE:
Perspectives in Vascular Surgery and other Non-cpb Protocols a perfusionist can involve
Hareendran A

FOR YOUR KIND ATTENTION!
Editor IJECT

Blood Conservation During CPB - Role Of Perfusionist without ↑Cost
Saurav Sengupta

Modified Cardioplegia for Neonates and Infants' Cardiac Surgery
Mr. Sunderrajan, Mr. Senthil.
Dr. Neville Solomon, Dr. Swapna
Role of Ultrafiltration in Paediatric Cardiopulmonary Bypass

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Abstract

Background: Cardiopulmonary bypass (CPB) is associated with a “whole body inflammatory response” characterized by capillary leak and increased total body water (1). The development of tissue edema may cause dysfunction of vital organ systems leading to significant morbidity and mortality (2,3).

Aim: This prospective, randomized study was designed to investigate the effects of conventional ultrafiltration in paediatric patients undergoing corrective surgery for congenital heart disease using CPB.

Material & Method: One fifty children aged between 2-14 years with Tetralogy of Fallot (TOF) undergoing intra cardiac repair on CPB were divided into two groups. Group-I comprised of 75 children in whom conventional ultrafiltration (CUF) was performed intraoperatively and during rewarming period of cardiopulmonary bypass. Group-II comprised of 75 children in whom no ultrafiltration was performed.

Intraoperative urine production, fluid overload (net pump balance after CPB), electrolyte disbalance, and postoperative chest tube drainage, ventilation time, blood and blood component transfusion requirement from the end of bypass procedure until 24 hours in intensive care unit were studied in both groups. Results were analysed by students paired ‘t’ test, Mann-Whitney test and Wilcoxon Signed Ranks.

To maintain haematocrit level 30% during CPB, in group-I (n=74) conventional ultrafiltration was performed and in group-II (n=73) packed red blood cells were added.

In group-I: Urine output (159.77ml ± 69.3ml) during CPB was not significantly different from group-II where urine output was (243.2ml ± 85ml). The mean total haemofiltrate (444.19 ml ± 169.17 ml) volume were removed only in group-I during intraoperative period of cardiopulmonary bypass.

Results were analysed by students paired ‘t’ test, Mann-Whitney test and Wilcoxon Signed Ranks.

Conclusion: We conclude from our study that the use of conventional ultrafiltration can effectively concentrate blood, reduce postoperative ventilation time and decrease postoperative blood transfusion requirements in children undergoing corrective surgery on cardiopulmonary bypass. It was concluded that routine use of ultrafiltration is beneficial for paediatric patients.

KEY WORDS: cardiopulmonary bypass, conventional ultrafiltration, postoperative blood loss and blood transfusion requirements, ventilation time.
Introduction

Paediatric cardiopulmonary bypass (CPB) is associated with an increase risk of complications. The “Capillary leak syndrome” occurs because of increased capillary permeability as an inflammatory responses to CPB leading to sequestration of excess fluid in tissue interstitial space causing increase in total body water. The resultant multiorgan dysfunction remains the single most important post CPB complication in paediatric cardiac surgery (4,5). Lower body weight, low body temperature, long duration of bypass and haemodilution are few of the recognized factors implicated for the capillary leak syndrome.

Pre bypass use of intravenous crystalloid and Colloidal solutions CPB circuit prime, and use of cardioplegic solution put cardiac surgery patients at risk of fluid overload. Ultrafiltration is a useful method to reduce the risk of fluid overload after CPB.

The concept of removal of this excess body water by ultrafiltration during CPB was introduced by Ramegnoli et al (8,9) and popularized by Magilligan (10), in order to protect the patient from fluid overload and electrolytic imbalance. Ultrafiltration also helps to reduce various inflammatory and complimentary activators resulting in early and better postoperative recovery.

Unlike the popular upsurge of ‘no pump’ techniques in adult cardiac surgery, CPB remains necessary for most congenital heart defect repairs and these difficult surgeries are being accomplished with significantly reduced mortality and morbidity (2,3).

The systemic inflammatory response evoked by CPB are the ultimate pathophysiological mechanism responsible for immunological disorder. There can be as much as more than 20% increase in body weight, which is well evident in children because of loose aereolar tissue and is described as ‘Michline baby’ effect (6,7). It is the clinically significant multiorgan dysfunction as a result of the capillary leak, which is responsible for the most of the CPB related morbidity and mortality (2,3).

There are various methods to treat established fluid overload during and in the early post bypass period. These include, administering diuretics and steroid for capillary leak. However use of diuretics is not reliable, is not consistent, and may be ineffective during CPB.

We decided to study the beneficial aspects of haemofiltration during CPB to minimize capillary leak syndrome in paediatric surgery by reducing haemodilution and fluid overload.

MATERIAL AND METHODS

After approval from the institute’s ethics committee and informed parental consent, this prospective randomized and controlled clinical study was planned at All India Institute of Medical Sciences, New Delhi in the department of Cardiothoracic Vascular Surgery.

Inclusion Criteria

This study included 150 children aged between 2-14 years with Tetralogy of Fallot (TOF) undergoing intra cardiac repair on CPB. The patients were randomly divided into two equal groups.

Group-I comprised of 75 children in whom conventional ultrafiltration (CUF) was performed during the rewarming period of CPB.

Group-II comprised of 75 children in whom no ultrafiltration was performed.

Exclusion Criteria

Patients with a preoperative renal dysfunction, or who were preoperatively on inotropic and ventilatory support or who had neurological dysfunction and emergency surgery were excluded from the study.

Conduct of Anesthesia and Surgery:

Patients in both group received same premedication and anesthetic management. Both group had standardized and surgical management by the same team.

Perfusion techniques performed during cardiopulmonary bypass

Conduct of CPB was also standardized and similar in the both groups, The pump was primed with Crystalloid (Ringer’s solution) 20 ml/kg, Starch (HES) 10 ml/kg, Mannitol 5 ml/kg, Heparin 50 mg/l of prime, NaHCO3 1 ml/kg and Packed Red Blood Cell were added, whenever the estimated HCT came down to less than 30% during CPB in the both group. A non pulsatile flow (150-250ml/min/m²) was maintained during CPB using a twin roller pump (Sarns, 9000, USA) and a hollow membrane oxygenator (Capiox SX 10, Terumo corporation, Japan) with a 40 micron arterial line filter.

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Myocardial preservation protocol included moderate systemic hypothermia (Nasopharyngeal temperature, 32°C-33°C), intermittent cold (4°C) antegrade St. Thomas crystalloid blood cardioplegia solution dose was 20 ml/kg followed by half of the initial dose every 20 minute and topical cooling of the myocardium was done with ice slush in the pericardial sac.

Arterial blood gas analysis was done every 15 to 30 minutes to maintain \( pO_2 \), \( pCO_2 \), pH, BE to normal value. Urine output and electrolyte composition was noted in perioperative period.

The only difference in management of CPB between the two group was use of ultrafiltration in group-I.

After completion of surgery, patients were rewarmed to 37°C. During rewarming phase of cardiopulmonary bypass Conventional Ultrafiltration (CUF), (circuit diagram shown in fig-1) was performed in group I using a paediatric haemofilter (Terumo corporation). The mean haemofiltration rate of 10 ml/min was maintained. The venous reservoir level was kept adequately by the addition of replacement volume as required. CUF was not performed in group II.

At the termination of CPB in both groups, 1.3mg of protamine sulfate for every 100 IU of total heparin dose was administered and confirmed by the return of activated clotting time to baseline values.

In both the groups, patients received Epsilon amino caproic acid (EACA) 100 mg/kg during pre CPB, CPB and post CPB period.

Patients were weaned off from bypass with inotropic support of injection Dopamine (5-10 µg/kg/min) and Nitroglycerin (0.5-1 µg/kg/min) which were started on initiation of rewarming.

After surgery patients were transferred to intensive care unit (ICU). In the ICU, postoperative ventilation time, urine output, blood and blood product requirement and chest tube drainage at intervals of 6 hr was recorded for first 24 hr.

Statistical analysis:

Statistical comparison of results was made using analysis of variance for non-parametric data. The results were expressed as mean ± standard deviation. The changes in variables within a group were evaluated with paired 't' test, Mann-Whitney test and Wilcoxon Signed Ranks test. A probability value of less than 0.05 was regarded as statistically significant.
slightly lower values during the intraoperative period but failed to reach statistical significance. No complication related to the practice of CUF was encountered in any of the patients.

Postoperative data is shown in table-3 and graph-3 shows that HCT, (39.03% ± 11.1% in group-I increased significantly (p<0.001) after CUF compared to group-II where HCT was 29.04% ± 7.1% on CPB. K+, Na+ and Ca2+ were not significantly different during the postoperative period.

The two groups showed similar base line oxygenation parameters.

Postoperative data shown in table-4 shows that the HCT increased significantly (p<0.001) after CUF in group-I. Chest tube drainage was significantly greater (p<0.05) in the group-II (136.80ml ± 41.1ml) as compared to group-I. (41.6ml ±12.1ml) No obvious surgical cause for increased bleeding was found in these cases. Due to the increased postoperative bleeding, more number of patients in the group-II required blood 39/74 in group-II and 13/73 in group-I & blood products (11/74 in group-II and 00/73 in group-I).

All patients were discharged from the hospital without the occurrence of impaired organ function.

Table 1: Demographic data and baseline parameters

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group-I (n=74) (CUF)</th>
<th>Group-II (n=73) (NO CUF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>3.29 ± 1.79</td>
<td>4.19 ± 2.01</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>6.83 ± 2.1</td>
<td>7.43±2.2</td>
</tr>
<tr>
<td>Male: Female</td>
<td>61:13</td>
<td>59:14</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>53.34 ± 8.79</td>
<td>57.68 ± 11.91</td>
</tr>
<tr>
<td>ACT</td>
<td>140.73 ± 11.25</td>
<td>148.12 ± 18.76</td>
</tr>
<tr>
<td>K+</td>
<td>4.33 ± 0.5</td>
<td>4.11 ± 0.4</td>
</tr>
<tr>
<td>Na+</td>
<td>130±4.1</td>
<td>127.68 ± 5.1</td>
</tr>
<tr>
<td>Ca2+</td>
<td>0.93 ± 0.25</td>
<td>0.91 ± 0.25</td>
</tr>
<tr>
<td>Priming volume</td>
<td>705.38 ± 69.8</td>
<td>711.20 ± 96.6</td>
</tr>
</tbody>
</table>

Values are in mean ± S.D.
Abbreviations: HCT - haemtocrit, ACT - Anticoagulation time, K+ - ionized potassium, Na+ - ionized sodium, Ca2+ - ionized calcium, CUF-Conventional Ultrafiltration.

Table 2: Perioperative Data

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group-I (n=74) (CUF)</th>
<th>Group-II (n=73) (NO CUF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCT (%)</td>
<td>23.96 ± 80</td>
<td>27.32 ± 7.0</td>
</tr>
<tr>
<td>ACT</td>
<td>922.24 ± 271.14</td>
<td>989.00 ± 50.00</td>
</tr>
<tr>
<td>K+</td>
<td>4.1 ± 1.3</td>
<td>4.9 ± 0.53</td>
</tr>
<tr>
<td>Na+</td>
<td>123.23 ± 27.4</td>
<td>129.28 ± 6.4</td>
</tr>
<tr>
<td>Ca2+</td>
<td>1.40 ± 0.98</td>
<td>1.14 ± 0.019</td>
</tr>
<tr>
<td>Blood Added (ml)</td>
<td>0.00 ± 0.00</td>
<td>395 ± 69.9</td>
</tr>
<tr>
<td>Haemofilterate (ml)</td>
<td>444.19 ± 169.1</td>
<td>0.00 ± 0.00</td>
</tr>
<tr>
<td>Urine output (ml)</td>
<td>159.77±693</td>
<td>243.2±85.0</td>
</tr>
</tbody>
</table>

*P<0.05 (significant)
Values are in mean ± S.D.
Abbreviations: HCT - haemtocrit, ACT - Anticoagulation time, K+ - ionized potassium, Na+ - ionized sodium, Ca2+ - ionized calcium, CUF-Conventional Ultrafiltration.

Table 3: Postoperative Data

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group-I (n=74) (CUF)</th>
<th>Group-II (n=73) (NO CUF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCT (%)</td>
<td>39.03 ± 11.1</td>
<td>29.04 ± 7.1</td>
</tr>
<tr>
<td>ACT (sec)</td>
<td>131.08 ± 39.1</td>
<td>144.8 ± 21.9</td>
</tr>
<tr>
<td>K+</td>
<td>4.3 ± 1.4</td>
<td>4.6 ± 1.2</td>
</tr>
<tr>
<td>Na+</td>
<td>121.26 ± 25.1</td>
<td>130.12 ± 5.7</td>
</tr>
<tr>
<td>Ca2+</td>
<td>1.14 ± 0.8</td>
<td>1.08 ± 0.1</td>
</tr>
</tbody>
</table>

*P<0.05 (significant)
Values are in mean ± S.D.
Abbreviations: HCT - haemtocrit, ACT - Anticoagulation time, K+ - ionized potassium, Na+ - ionized sodium, Ca2+ - ionized calcium

Table 4: Data Measured in Intensive Care Unit

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group-I (n=74) (CUF)</th>
<th>Group-II (n=73) (NO CUF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest tube drainage (ml)</td>
<td>41.6 ± 12.1</td>
<td>136.80 ± 41.1</td>
</tr>
<tr>
<td>Ventilation time (min)</td>
<td>593.80 ± 151.1</td>
<td>802.2 ± 214.8</td>
</tr>
<tr>
<td>Urine output (ml)</td>
<td>1032.8 ± 282.9</td>
<td>904.23 ± 300.0</td>
</tr>
<tr>
<td>Temperature</td>
<td>35°C</td>
<td>38°C</td>
</tr>
<tr>
<td>pRBC (ml)</td>
<td>111.0 ± 17.1</td>
<td>357.21 ± 91.1</td>
</tr>
<tr>
<td>FFP,PC (ml)</td>
<td>91±12.1</td>
<td>00.00</td>
</tr>
</tbody>
</table>

Values are expressed as Mean ± S.D.
*P<0.05 (significant), pRBC- Packed red blood cells, FFP- Fresh frozen plasma, PC- Pletelets Count
Discussion

The principle finding of this study was an improvement in postoperative clinical state associated with a reduction in postoperative bleeding, postoperative blood transfusion, ventilation time, anticoagulating time and lower incidence of marked rise in body temperature after ultrafiltration in children undergoing CPB. Several studies have already reported improvement in biologic end-points that are believed to reflect beneficial clinical effects. These improvements have been achieved by different techniques such as haemofiltration (12,13), administration of anti-inflammatory agents (14) or use of heparin-coated CPB circuits (15).

We found that there was an increase in HCT level postoperatively in group-I in which ultrafiltration was performed during rewarming phase of CPB as compared to Hct values in group-II where no ultrafiltration was performed. Our results are similar to the work done by Frisen RH, Cambell DN, Clark DR, et al (19) who conducted an experiment by prophylactic haemofiltration during CPB and concluded that haemofiltration increase the HCT, reduce some inflammatory markers and may increase the variability of heparin levels. It may also reduce postoperative blood transfusion and possibly increase blood pressure and cardiac index immediately after haemofiltration, although no difference in morbidity and mortality has ever been shown.

Our findings were also confirmed by the study of Huang H et al.(11). They took 30 patients with congenital heart defects who were divided into two groups. In the study group I conventional ultrafiltration, balanced ultrafiltration plus modified ultrafiltration was used throughout CPB. Pulmonary function, serum albumin, some inflammatory mediators where measured. They found that after ten to fifteen minute MUF the HCT, and serum albumin increased by 40% and 48% and concede that the combined use of balanced ultrafiltration and modified ultrafiltration can effectively concentrate the blood.

The decrease in postoperative blood loss in our study in ultrafilterate group-I may be due to the hypercoagulable state at the microvascular circulation level produced by haemodilution. Ramegboli A, Hacker J, Keats AS et al (9) in his report on effect of haemodilution on coagulation demonstrated that a hypercoagulable state at the microvascular circulation level is produced by haemodilution. They attributed this hypercoagulable state to a decrease in concentration of the coagulation inhibitors and lowering of threshold for positive feedback occurring in the coagulation pathway.

Although our findings were similar Didier J et al (11); who concluded that haemofiltration can reduce postoperative blood loss in the absence of major changes in coagulation factor concentrations (11). They postulated that this effect is not due to haemoconcentration alone. Cytokines have been implicated in altered coagulation and fibrinolysis, and a reduction in their production may be the mechanism involved in reducing blood loss.

Postoperative high body temperature was more often present during ICU stay even in the absence of infection in group-II (38°C, 23/73) as compared to group-I (35°C, 5/74 because some pyrogenic substance eg. Cytolucine, interleukins may have been filtered out during haemofiltration on CPB in group-I. Casey LC: (16) In his study showed the role of cytokines in the pathogenesis of CPB-induced multisystem organ failure. They concluded that this phenomenon is attributed to the effects of various endogenous pyrogens, including IL-1 beta IL-6 & IL-8 (17,18). The lower peaks and mean postoperative temperature observed in the-ZBUF group may reflect a globally reduced inflammatory response.

Our study, shows that the value of electrolytes did not show significant changes postoperatively and it was similar to the baseline value in both groups due to the slow rate of haemofiltration in which electrolytes are filtered out and this findings is similar to that reported by Magilligan DJ et al (10), who conducted the study in 10 patients with clinical evidence of fluid over-load. Ultrafiltration was employed during CPB, and they observed a decrease in extra vascular lung water from 1,132 ± 183 m1 to 919 ± 267 ml (p>0.209). It was concluded that the value of electrolytes and urea nitrogen did not show significant changes postoperatively.

The principal findings of our study was the reduction in the ventilation time seen in group-I due to increased haematocrit along with a reduction in lung water which can significantly (p<0.05) improve oxygenation parameter and improvement in the postoperative \( P_{O_2} \).

Conclusion

We have used conventional ultrafiltration in children with Tetralogy of Fallot (TOF) undergoing intra cardiac repair on cardiopulmonary bypass, and found it useful to:

- Improve postoperative HCT.
- Reduce bleeding and blood/blood products usages.
- Reduce postoperative ventilation time in the ICU,
as compared to children where ultrafiltration was not performed, and we conclude that ultrafiltration provides valuable benefits where used in this situation.

Acknowledgement

I would like to thank Dr. Guresh, Senior Scientist, Department of Biostatistics, AIIMS New Delhi for his valuable cooperation in data analysis.

References


A comparative study of Albumin versus 6 % Hydroxyethyl starch used as priming solution for Cardiopulmonary Bypass in adults undergoing Coronary Artery Bypass Grafting

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Abstract

Background: The issue of optimal priming solution for cardiopulmonary bypass is unclear. Colloids have the advantages of maintaining the colloid oncotic pressure and reducing tissue edema. However the use of colloids during coronary bypass surgery has been limited due to associated increase incidence of anaphylactoid reactions and clinical coagulopathy.

Aim: In this study we compared the effects of using 20 % Albumin versus 6 % Hydroxyethyl starch (HES) in the ratio of 1:5 and 1:2 respectively for the priming of CPB circuit in adult patients undergoing coronary artery bypass grafting (CABG).

Methodology: Sixty patients of either sex in the range of 40-70 years of age undergoing CABG with the use of CPB were studied. The patients were randomly divided in following two groups (A & B). In group A (n=30), 20 % Albumin solution with lactated Ringer’s solution and in group B (n=30), 6 % HES solution with lactated Ringer’s solution was used for priming the CPB circuit.

All the surgeries were conducted by using same surgical, anesthetic and perfusion techniques. Various parameters compared between the two groups were Hb/HCT, PaO₂, PaCO₂, SO₂ (%), urine output, serum Creatinine, blood urea, blood sugar, requirement of blood/ blood products and requirement of any other additions like hemostatic agents.

Conclusion: Hospital mortality rate was zero in both the groups. However it was found that 6 % hydroxyethyl starch can be used as an alternative along with Ringer’s lactate in the ratio of 1:2 for priming the CPB circuit without any adverse effect or any contradiction. 6 % HES is a safe alternative colloid for priming the cardiopulmonary bypass circuit and volume replacement in patients undergoing coronary artery bypass surgery as compared to 20 % Albumin.

Key Words: Cardiopulmonary Bypass, Priming solution, crystalloids and colloids, Albumin, Hydroxyethyl starch, inflammatory responses.
Introduction

The main objective of Cardiopulmonary bypass (CPB) is to provide a still and bloodless heart with blood flow temporarily diverted to an extracorporeal circuit that functionally replaces the heart and lung (1). Priming of the CPB circuit is an important task for the perfusionist. Generally the main objectives of priming are to deair the CPB circuit, check for any leaks in the circuit, for providing sufficient haemodilution and to keep the volume level of the reservoir towards the safer side, while on CPB.

It is a standard practice to use a non blood CPB prime because of benefits of haemodilution and concerns about blood borne diseases (2). Haemodilution works to limit the complications related to CPB (neurological, renal, and pulmonary), by significantly reducing blood viscosity during bypass. A haemoglobin concentration of 10g/dl was traditionally accepted as adequate for patients undergoing non cardiac surgery (3). There are three major factors which should be considered by the perfusionist when selecting a solution to prime the cardiopulmonary bypass circuit (4):

- **Osmolarity:** isotonic solution preserves the interstitial-intravascular fluid balance.
- **Electrolyte:** The concentration of the important electrolytes in the prime fluid should approach normal plasma levels.
- **Dilution:** Priming volume should be sufficient to allow for adequate flow rates.

Generally priming solutions can be classified into two categories which are as follows:

**Crystalloids (5)** are electrolyte solutions with small molecules that can diffuse freely throughout the extracellular space. In general crystalloids are simple volume expanding solutions that mimic the normal plasma electrolyte concentration but they lack oncotic activity. Various crystalloids generally used are dextrose, mannitol, balanced crystalloid fluid, ringer’s lactate solution etc.

**Colloids (6)** are large molecular weight solutions. They are important in capillary fluid dynamics because they are the only constituents which are effective at exerting an osmotic force across the wall of the capillaries. This helps in keeping water in the vascular space and prevents tissue edema. Colloids have the advantage in maintaining the colloid oncotic pressure (7). Various colloid solutions commonly used are hydroxyethyl starch (HES), albumin, dextran, gelatin etc. There is no general consensus with regards of selecting the priming solution for CPB circuit.

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**Table 1 : Physicochemical characteristics of priming solutions for cardiopulmonary bypass (colloids) (8)**

<table>
<thead>
<tr>
<th></th>
<th>ALBUM 5%</th>
<th>DEXT RAN-40 10%</th>
<th>DEXT RAN-70 6%</th>
<th>GELA TIN-U 3.5%</th>
<th>GELA TIN-S 3%</th>
<th>HES 6%</th>
<th>HES 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mw(Daltons)</td>
<td>69,000</td>
<td>40,000</td>
<td>70,000</td>
<td>35,000</td>
<td>35,000</td>
<td>450,000</td>
<td>264,000</td>
</tr>
<tr>
<td>Mn(Daltons)</td>
<td>69,000</td>
<td>25,000</td>
<td>39,000</td>
<td>15,000</td>
<td>14,000</td>
<td>71,000</td>
<td>63,000</td>
</tr>
<tr>
<td>Osmolality (mmol/kg)</td>
<td>300</td>
<td>308</td>
<td>308</td>
<td>302</td>
<td>310</td>
<td></td>
<td>354</td>
</tr>
<tr>
<td>COP(mmHg)</td>
<td>19-20</td>
<td>160</td>
<td>78</td>
<td>-</td>
<td>-</td>
<td>25-30</td>
<td>55-60</td>
</tr>
<tr>
<td>T1/2(hr)</td>
<td>2-5</td>
<td>25.5</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
<td>25.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Duration of PVE (h)</td>
<td>2-8</td>
<td>2-12</td>
<td>6-48</td>
<td>2-4</td>
<td>-</td>
<td>6-24</td>
<td>2-12</td>
</tr>
<tr>
<td>Elimination(h)</td>
<td>17</td>
<td>12-45</td>
<td>-</td>
<td>168</td>
<td>168</td>
<td>24-67</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Mw = Weight average molecular weight; Mn = Number average molecular weight; COP = Colloid osmotic pressure; T1/2 = Half life of concentration; PVE = Plasma volume expansion; Gelatin-U = urea linked gelatin; Gelatin-S = succinyl-linked gelatin; HES = hydroxyethyl starch.

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Material and Methods

In this randomized prospective study we included 60 adult patients of either sex in the range of 40-70 years old of age undergoing coronary artery bypass grafting (CABG) with use of cardiopulmonary bypass.

Exclusion criteria: Patients with a preoperative serum albumin level of 30g/l or less and Patients with the history of renal or pulmonary disease, known bleeding disorder and liver dysfunction were excluded from the study. We also did not include patients with severe LV dysfunction, patients who had undergone repeat CABG or patients who had undergone CABG incidental to heart valve repair or replacement, resection of a ventricular aneurysm, or some other surgical procedure.

Study protocol: The patients were randomly divided into two groups (A & B). In group A (n=30), the CPB circuit was primed with crystalloid (Ringer’s Lactate) and colloid solution (Albumin) in 1:5 ratio. Whereas in group B (n=30), the solution used for priming the CPB circuit consisted of crystalloid prime (Ringer’s lactate) along with a colloid solution (6 % HES) in the ratio 1:2.

Conduct of CPB: A standardized protocol for the selection of CPB circuit components was followed throughout the study period. The surgical, anesthetic techniques, pump flows, conduct of bypass, hypothermia was similar in both groups except for the choice of priming solution used in the CPB circuit.

Before CPB was initiated, anticoagulation was achieved by the administration of 300 IU/kg heparin sodium with the goal of achieving an activated clotting time of >480 seconds. The myocardial preservation done with St. Thomas based blood cardioplegia solution was infused after cross clamp in an induction dose of 20 ml/kg and was repeated at an interval of 20-30 minutes as required.

Arterial blood gas samples were done before, during CPB at intervals of 15 to 20 minutes and after CPB to maintain pO2, pCO2, pH, BE to the normal value. Urine output and electrolyte composition was noted in perioperative period.

After the corrective surgery the patients were rewarmed to a nasopharyngeal temperature of 37°C. At the termination of CPB, anticoagulation was reversed with protamine sulphate. After surgery patients were shifted to intensive care unit (ICU).

Study Analysis: The following data was recorded intraoperatively: the type and volume of priming, blood/blood products administered, duration of aortic cross clamp, and duration of CPB. Postoperatively, following data was documented: requirement of transfusion, diuretic usage, urine and chest tube output. Postoperative adverse events such as renal events like acute renal failure, hemodynamic events like bleeding, re-exploration and need of extracorporeal membrane oxygenation were recorded. The duration of ventilator support, length of ICU stay was also recorded.

Statistical analysis: Statistical comparison of results was made using analysis of variance of non-parametric test. All the results are expressed as mean ± standard deviation. Inter group comparison between variables was made by the unpaired ‘t’ test and Mann-Whitney. A probability value of less than 0.05 was regarded as statistically significant.

Results

The two groups (A & B) were comparable in terms of demographic specifications such as age, height, weight, BSA, and the risk factors like diabetes, hypertension, number of grafts and left internal mammary artery (LIMA) usage.

Table 2: Showing demographic data

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>GROUP A</th>
<th>GROUP B</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE (years)</td>
<td>56.20±7.321</td>
<td>55.40±9.356</td>
<td>0.80</td>
</tr>
<tr>
<td>HEIGHT (in cm)</td>
<td>163.87±8.48</td>
<td>163.97±9.39</td>
<td>0.98</td>
</tr>
<tr>
<td>WEIGHT (in Kg)</td>
<td>64.6±10.39</td>
<td>68.88±13.91</td>
<td>0.36</td>
</tr>
<tr>
<td>BSA (m2)</td>
<td>1.83±0.10</td>
<td>1.70±1.66</td>
<td>0.021</td>
</tr>
<tr>
<td>DIABETES</td>
<td>0.67±0.49</td>
<td>0.60±0.51</td>
<td>0.71</td>
</tr>
<tr>
<td>HYPERTENSION</td>
<td>0.47±0.52</td>
<td>0.60±0.51</td>
<td>0.74</td>
</tr>
<tr>
<td>NO. OF GRAFTS</td>
<td>4.22±5.60</td>
<td>4.22±5.60</td>
<td>1.00</td>
</tr>
<tr>
<td>LIMA USAGE</td>
<td>1.00±0.00</td>
<td>1.00±0.00</td>
<td>NS</td>
</tr>
</tbody>
</table>

Mean ± standard deviation values are taken for analysis; P value<0.05 is considered significant; NS: Non Significant

Both the groups were comparable regarding the preoperative specifications and the analysis of these baseline parameters showed no statistically significant differences (P value >0.05). But base excess was found statistically significant (P=0.010). Need for correcting
base deficit was also found significant pre bypass in group A (Figure 3).

Table 3: Showing Preoperative data

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>GROUP A</th>
<th>GROUP B</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP (mm Hg)</td>
<td>141.73±19.33</td>
<td>134.53±21.21</td>
<td>0.340</td>
</tr>
<tr>
<td>PULSE</td>
<td>78.67±9.74</td>
<td>78.00±11.81</td>
<td>0.870</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>16.53±8.84</td>
<td>14.15±2.77</td>
<td>0.334</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>40.79±12.18</td>
<td>39.87±5.73</td>
<td>0.793</td>
</tr>
<tr>
<td>PLATELET COUNT</td>
<td>195.47±91.280</td>
<td>196.80±51.70</td>
<td>0.961</td>
</tr>
<tr>
<td>WBC COUNT (COUNT * 10^3/ìl)</td>
<td>8773.33±3756.42</td>
<td>9853.73±2512.23</td>
<td>0.364</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>39.17±3.82</td>
<td>37.81±3.71</td>
<td>0.333</td>
</tr>
<tr>
<td>pH</td>
<td>7.41±0.06</td>
<td>7.44±0.043</td>
<td>0.093</td>
</tr>
<tr>
<td>PaO2 (mmHg)</td>
<td>186.39±72.47</td>
<td>188.93±79.11</td>
<td>0.928</td>
</tr>
<tr>
<td>PaCO2 (mmHg)</td>
<td>37.63±4.778</td>
<td>36.89±4.27</td>
<td>0.661</td>
</tr>
<tr>
<td>HCO3 (mmol/l)</td>
<td>24.13±3.51</td>
<td>25.45±2.04</td>
<td>0.221</td>
</tr>
<tr>
<td>BE (mmol/l)</td>
<td>-0.92±2.45</td>
<td>1.34±2.06</td>
<td>0.011</td>
</tr>
<tr>
<td>K+ (mmol/l)</td>
<td>3.73±0.56</td>
<td>3.85±0.544</td>
<td>0.569</td>
</tr>
<tr>
<td>Na+ (mmol/l)</td>
<td>135.71±3.39</td>
<td>136.40±0.38</td>
<td>0.594</td>
</tr>
<tr>
<td>BLOOD SUGAR (mg/dl)</td>
<td>133.80±43.65</td>
<td>122.60±42.05</td>
<td>0.480</td>
</tr>
<tr>
<td>CREATININE (mg. %)</td>
<td>0.84±0.23</td>
<td>0.89±0.23</td>
<td>0.581</td>
</tr>
<tr>
<td>UREA (mg. %)</td>
<td>29.53±7.63</td>
<td>27.53±9.50</td>
<td>0.530</td>
</tr>
<tr>
<td>URIC ACID (mg. %)</td>
<td>6.27±0.74</td>
<td>6.18±0.94</td>
<td>0.782</td>
</tr>
<tr>
<td>PHOSPHATE (mg. %)</td>
<td>3.07±0.748</td>
<td>3.53±0.94</td>
<td>0.150</td>
</tr>
<tr>
<td>SGOT (AST) IU</td>
<td>38.53±10.70</td>
<td>50.00±28.73</td>
<td>0.165</td>
</tr>
<tr>
<td>SGPT (ALT) IU</td>
<td>28.00±9.43</td>
<td>37.53±26.86</td>
<td>0.212</td>
</tr>
<tr>
<td>TOTAL PROTEIN (gm %)</td>
<td>7.55±0.60</td>
<td>7.37±0.44</td>
<td>0.341</td>
</tr>
<tr>
<td>ALBUMIN (gm %)</td>
<td>4.00±0.36</td>
<td>3.71±0.48</td>
<td>0.051</td>
</tr>
<tr>
<td>GLOBULIN (gm %)</td>
<td>3.56±0.48</td>
<td>3.72±0.51</td>
<td>0.385</td>
</tr>
<tr>
<td>BILIRUBIN (mg %)</td>
<td>0.84±0.46</td>
<td>0.93±0.67</td>
<td>0.706</td>
</tr>
<tr>
<td>OSMOLARITY (mOsm/Kg)</td>
<td>272.07±4.49</td>
<td>270.6±6.10</td>
<td>0.489</td>
</tr>
<tr>
<td>COP (mmHg)</td>
<td>16.15±0.78</td>
<td>15.82±0.36</td>
<td>0.152</td>
</tr>
<tr>
<td>SAT (%)</td>
<td>98.90±1.60</td>
<td>99.14±1.51</td>
<td>0.676</td>
</tr>
<tr>
<td>URINE OUTPUT (ml)</td>
<td>256.67±129.38</td>
<td>248.00±145.07</td>
<td>0.864</td>
</tr>
</tbody>
</table>

BP- blood pressure, Hb- Hemoglobin, HCT-Haematocrit, COP- colloid oncotic pressure. Mean ± standard deviation values are taken for analysis.  P value < 0.05 is statistically significant.

The two group were comparable regarding the parameters during CPB such as the bypass time, aortic cross clamp time, total cardioplegia delivery and urine output which on analysis showed no statistically significant differences. It was observed that there was no requirement of ultrafiltration during bypass in both the groups.

Operative data was collected at 30 minutes, 60 minutes and 90 minutes of onset of cardiopulmonary bypass. No statistically significant difference was observed while considering the mean perfusion pressure (MPP) (mmHg), pH, PaCO3 (mmHg), PaO2 (mmHg), HCO3 (mmol/l), Na+ (mmol/l), K+ (mmol/l) and sugar (g/dl) at perioperative period of bypass (Table 4).

Table 4: perfusion pressure, acid base status and biochemical parameters at 30 minutes of onset of CPB

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>GROUP A</th>
<th>GROUP B</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPP (mmHg)</td>
<td>55.07±11.42</td>
<td>63.27±16.79</td>
<td>0.131</td>
</tr>
<tr>
<td>Ph</td>
<td>7.41±0.06</td>
<td>7.42±0.05</td>
<td>0.639</td>
</tr>
<tr>
<td>PaO2 (mmHg)</td>
<td>290.80±53.42</td>
<td>261.15±61.14</td>
<td>0.168</td>
</tr>
<tr>
<td>PaCO2 (mmHg)</td>
<td>36.34±3.47</td>
<td>37.19±5.25</td>
<td>0.650</td>
</tr>
<tr>
<td>HCO3 (mmol/l)</td>
<td>23.27±2.11</td>
<td>23.88±2.75</td>
<td>0.495</td>
</tr>
<tr>
<td>BE (mmol/l)</td>
<td>-0.94±2.29</td>
<td>-0.41±2.80</td>
<td>0.578</td>
</tr>
<tr>
<td>K+ (mmol/l)</td>
<td>4.37±0.77</td>
<td>4.53±0.87</td>
<td>0.602</td>
</tr>
<tr>
<td>Na+ (mmol/l)</td>
<td>130.90±2.30</td>
<td>132.00±2.75</td>
<td>0.248</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>8.38±1.22</td>
<td>7.36±0.99</td>
<td>0.019</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>24.45±3.54</td>
<td>20.11±2.79</td>
<td>0.010</td>
</tr>
<tr>
<td>SAT (%)</td>
<td>99.73±0.42</td>
<td>99.99±0.02</td>
<td>0.034</td>
</tr>
<tr>
<td>BLOOD SUGAR (mg/dl)</td>
<td>140.07±40.42</td>
<td>138.20±39.04</td>
<td>0.899</td>
</tr>
<tr>
<td>OSMOLARITY (mOsm/Kg)</td>
<td>264.58±5.88</td>
<td>271.53±5.39</td>
<td>0.002</td>
</tr>
<tr>
<td>COP (mmHg)</td>
<td>15.51±0.35</td>
<td>15.93±0.32</td>
<td>0.002</td>
</tr>
</tbody>
</table>

* Mean ± standard deviation values are taken for analysis

However osmolarity (mOsm/Kg) was found statistically significant at 30 minutes of onset of bypass. The group B showed higher mean osmolarity (mOsm/Kg) values than group A but the mean values were within the normal range.
Also the hemoglobin, haematocrit and saturation (%) were significant statistically at each of the time intervals during CPB. However Group B showed lower mean Hb (g/dl) and HCT (%) values than group A but these mean values were within the normal range. Whereas Group B showed higher mean SO₂ (%) values than group A but again these mean values were also within the normal range.

Postoperative data analysis at the 1st, 6th, 12th and 24th hour showed no statistically significant difference between the two groups with respect to PaO₂ (mmHg), PaCO₂ (mmHg), hemoglobin (g/dl), haematocrit (%), saturation (%), osmolarity (mOsm/l), COP (mmHg) and urine output (ml) at these time intervals. K⁺ (mmol/l) also showed statistically significant difference at 1st hour postoperatively (P value<0.05), but the mean values were within the normal range. Blood pressure (BP) (mmHg) showed statistically significant difference at 1st and 6th hour post operatively (P value<0.05). Though the mean values were within the normal range, it tended towards the lower limit in group B. But it became nonsignificant at 12th and 24th hour postoperatively. Bicarbonate, sodium, base excess and Phosphate showed statistical significant difference between the two groups at 24th post operative hour (Table.5).

The mean value for bicarbonate was higher for group A and lower in group B, but these values were within the normal range.

The need for correcting base deficit was also found significant at 24th postoperative hour in group B. The mean value for sodium was higher in group B and lower in group A but these mean values were within the normal range.

The phosphate level in the preoperative period was higher in the B (6 % HES) group which continued to be higher in the postoperative 24th hour as compared to group A (Albumin). However the preoperative phosphate level was higher as compared to postoperative 24th hour levels of phosphate in group A and B respectively. Phosphate showed statistical significant difference (P value<0.05) between the two groups in the postoperative 24th hour.

Table 5: Postoperative data at 24th hour

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>GROUP A</th>
<th>GROUP B</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP (mmHg)</td>
<td>126.00±18.49</td>
<td>114.40±16.51</td>
<td>0.081</td>
</tr>
<tr>
<td>pH</td>
<td>7.42±0.03</td>
<td>7.43±0.07</td>
<td>0.883</td>
</tr>
<tr>
<td>PaO₂ (mmHg)</td>
<td>152.52±43.87</td>
<td>163.30±64.42</td>
<td>0.597</td>
</tr>
<tr>
<td>PaCO₂ (mmHg)</td>
<td>37.27±4.13</td>
<td>34.18±6.92</td>
<td>0.152</td>
</tr>
<tr>
<td>HCO₃⁻ (mmol/l)</td>
<td>24.80±2.05</td>
<td>23.02±2.33</td>
<td>0.035</td>
</tr>
<tr>
<td>BE (mmol/l)</td>
<td>0.91±1.76</td>
<td>-0.51±2.11</td>
<td>0.055</td>
</tr>
<tr>
<td>K⁺ (mmol/l)</td>
<td>3.53±0.40</td>
<td>3.67±0.38</td>
<td>0.361</td>
</tr>
<tr>
<td>Na⁺ (mmol/l)</td>
<td>134.14±3.93</td>
<td>139.06±5.65</td>
<td>0.010</td>
</tr>
<tr>
<td>Hb (g/dl)</td>
<td>11.34±2.15</td>
<td>10.94±1.56</td>
<td>0.560</td>
</tr>
<tr>
<td>HCT (%)</td>
<td>33.77±6.45</td>
<td>32.86±4.32</td>
<td>0.653</td>
</tr>
<tr>
<td>SAT (%)</td>
<td>98.73±1.87</td>
<td>98.24±2.21</td>
<td>0.295</td>
</tr>
<tr>
<td>SUGAR (mg/dl)</td>
<td>157.53±46.83</td>
<td>177.20±54.96</td>
<td>0.301</td>
</tr>
<tr>
<td>COP (mg/dl)</td>
<td>15.73±0.57</td>
<td>15.85±0.35</td>
<td>0.496</td>
</tr>
<tr>
<td>URINE OUTPUT (ml)</td>
<td>443.33±236.56</td>
<td>410.73±288.95</td>
<td>0.784</td>
</tr>
<tr>
<td>BLEED (ml)</td>
<td>74.67±50.26</td>
<td>51.00±34.85</td>
<td>0.145</td>
</tr>
<tr>
<td>OSMOLARITY (mOsm/Kg)</td>
<td>269.80±9.52</td>
<td>270.47±5.90</td>
<td>0.819</td>
</tr>
</tbody>
</table>
Use of furosemide in 24th hour postoperatively for renal support was more in group B (6 % HES) as compared to the group A (Albumin) although it was statistically non significant (p=0.619).

WBC count was higher in group A (Albumin) as compared to group B (6 % HES) at 24th postoperatively hour, but the mean values were within the normal range. It was also statistically nonsignificant (p=0.946).

A similar finding was also observed for the platelet count among the two groups. Time of ventilation postoperatively and ICU stay was statistically non significant. There was no mortality in either of the two groups.

Discussion

A recent systematic review of randomized clinical studies on the use of fluid therapy in various types of surgical procedures found no evidence to recommend one type of fluid therapy over another. There was not sufficient evidence to provide guidance on the optimal amount of fluid to use in elective surgical procedures (9). Despite the absence of clear recommendations for any particular fluid therapy, there is plentiful debate about the relative merits of crystalloid or colloid, and even about different types of colloids. As recently remarked by Boldt in an editorial, “Researchers who show crystalloid to be superior always find crystalloid superior, whereas colloid supporters always favor colloids” (10). Adequate restoration of intravascular volume remains the crucial therapeutic maneuver in managing the surgical patient. It is generally believed that three to four times more crystalloid than colloid volume is needed to achieve an equivalent plasma volume expansion. However, in the SAFE trial, (11) in which fluid administration was blinded, the ratio of albumin to saline was 1:1.4 and thus much less than expected. While the choice between colloid and crystalloid solutions continues to generate controversy, the dispute has been enlarged to a colloid/crystalloid debate (e.g., Dextrans, gelatins, HES solutions).

Colloid fluid solutions are frequently used as plasma volume expanders in the critically ill. Intravascular volume overload, dilutional coagulopathy, extravascular, extravasations across leaky capillary membranes, and anaphylactic reactions may all occur with administration of any colloid. In addition, individual agents have unique toxic effects. Renal dysfunction has been associated with dextran 40, myocardial depression with albumin, hypotension with purified plasma protein, and hyperamylasemia with hetastarch. Because no ideal colloidal solution exists, knowledge of type, severity, and clinical significance of adverse effects is important in determining the appropriate plasma volume expander and monitoring its effects. HES130/0.4 is effective for volume therapy and is less expensive than human albumin. Its effects on coagulation and renal function are manageable; it may ameliorate pulmonary permeability and reduce inflammation and lipopolysaccharide-induced myocardial dysfunction (12).

In contrast, colloids may decrease pulmonary fluid extravasation and the formation of pulmonary edema because of their capacity to increase Colloidal Oncotic Pressures (COP).

The so-called colloid-crystalloid controversy includes the relative propensity of fluid types to evoke pulmonary edema, which is not yet settled in the absence of direct permeability and edema measurements in most studies (13).

Our study did not show any difference in duration of ventilation in both the groups. As with all forms of trauma, surgery triggers a systemic inflammatory response with the release of inflammatory mediators into the systemic circulation. It was found that 6% HES proved to be better regarding the additional volume requirement during CPB as compared to Albumin. There was no significant difference established between the two groups regarding the intensive care duration and mortality rate. Nevertheless it was demonstrated that the mean value of ICU stay was shorter in group B (6% HES).

The Hemoglobin and Haematocrit values tended towards the lower limits in the group B (6% HES) during CPB. Although the mean values were within the normal range, this significant difference between the two groups favours the use of Albumin along with Ringer’s Lactate on CPB.

The difference in post operative chest tube drainage although not statistically significant, was more in group A (Albumin) as compared to group B (6% HES). The difference in the platelet count between the two groups was not statistically significant but the count was found lower in group A (Albumin) as compared to group B (6% HES). The platelet count was decreased after the surgery in both the groups but it was much lower in group A (Albumin) as compared to group B (6% HES). Whereas the WBC count was more in group A (Albumin) as compared to Group B (6% HES) but it was not statistically significant. The WBC count was
increased after the surgery in the 24th postoperative hour, and it was found higher in group A (Albumin) patients than in group B (6 % HES) patients showing inflammatory responses of the body to the natural colloid (Albumin) to be more as compared to that of synthetic colloid (6 % HES). This may be because of the large molecules of Albumin being retained in the reticuloendothelial system of the body. But the mean values for WBC count was within the normal range so it may not cause any serious deleterious effects to the patients.

The effect of colloidal solutions on the renal function is a point of discussion. In our study, it was found that mean values for Urea and Creatinine were within the normal range in both the groups and were comparable as the difference was not statistically significant. However cautions must be taken while using it in patients with renal insufficiency.

The cost of Albumin has lead to an increase in an overall expenditure of the surgery in group A, where as the cost of 6 % HES though high as compared to the cost of crystalloid but was much lower than that of Albumin.

Conclusion

6% HES can be used as an alternative along with Ringer’s Lactate in the ratio of 1:2 for priming the Cardiopulmonary bypass circuit without any adverse effect or any contradictions. 6 % HES is safe to use for plasma substitution next to albumin for CPB circuit. Albumin because of its high cost and possibility of the anaphylactic reaction that it may cause is not used frequently for priming the CPB circuit. 6 % HES helps to maintain osmolarity during CPB and preserve platelet count after the surgery. Anaphylactoid reactions are not observed with 6 % HES as compared to albumin. Use of 6 % HES is found cost effective as compared to albumin. But cautions must be taken while using it in patients in acute or chronic renal failure.

References


Case Report

Novel technique for managing intrapulmonary massive haemorrhage, following Pulmonary Thrombo Endarterectomy

Senthil Kumaran.D**, P.V.S.Prakash***, Sunil Mekala***, Sunil.L.G*, Dr.Binoy***, Dr.Devi Prasad Shetty****

Abstract

A 58yr old gentleman with chronic pulmonary embolism underwent PTE. While weaning off CPB, he had a massive and intractable bleeding which was observed through the endotracheal tube. ET suction was done and weaning off CPB was tried, but the saturation was not being maintained and bleeding persisted. Hence CPB was reinstated.

The only option to get the patient out of CPB was to first stop the bleeding and this was not possible because the ACT was maintained above 480 seconds. It needs to be brought down to less than 200 sec. So the patient was put on ECMO with same cannulation and protamine was given to neutralise heparin. ACT was brought down to 150 seconds. The patient was stabilised on ECMO and the ECMO support was continued to rest the lungs till the bronchial bleeding totally stopped. After 24hrs patient was taken to OT and re-explored, bronchoscopy showed a clear field. No bleeding was found in the endotracheal tube. Patient was weaned off, ECMO shifted to ITU.

Key Words: Management of intrapulmonary massive haemorrhage, ECMO.

Introduction

A 58 yr old man was taken for elective pulmonary thrombo endarterectomy.

On technically the procedure was straight forward and all the thrombus from both sides were removed, while coming off CPB severe bleeding from ET tube was noticed, hence a double lumen tube was placed to isolate the lungs. As the bleeding was torrential, it was decided to put him on VA ECMO and give full dose protamine, this brought down the ACT level to 176 sec. Then the bleeding stopped within the 12 hrs and the patient was weaned off from ECMO after 24 hours.

Although the refinement in technique of cardio pulmonary bypass has progressively improved the current surgical trends yet the outcome of diseases and post operative CPB induced lung problems still remain as a serious complication that could lead to life threatening problems

Case Report:

A 58 yr old man was diagnosed with- chronic thrombo embolic pulmonary hypertension (CTEPH) and severe right ventricular dysfunction. Severe tricuspid regurgitation, H/O DVT, normal LV and normal coronaries, was admitted for pulmonary thrombo endarterectomy surgery. Regular central cannulation was planned for this patient Aortic-24Fr Edwards cannula, 20Fr and 24 Fr Rt angled metal tip DLP venous cannulae were used. CPB was initiated and cooling was started. When patient’s temperature reached 22°C, aortic cross clamp was applied. 20ml/kg blood cardioplegia was given by using blood cardioplegia delivery system.
at 8°C. Myocardium was protected well, patient was cooled to 19°C, arterial blood gases were maintained in alpha stat (higher PCO2). Cerebral protective drugs were given (barbiturates like thiopentone-2-5mg/kg) and intermittent TCA was performed, all the thrombi from both sides were removed and rewarming was started and continued up to normal temperature.

- Blood froth flooding in the ET tube was making ventilation difficult.
- On bronchoscopy-it was identified that the right lung was bleeding massively, the source of bleeding could not be found.
- The right lung was first isolated with a double lumen tube-but it was difficult to come off bypass due to profuse bleeding and there was a loss of volume in the right lung and PA pressures were high. (Haemodynamics were alright)
Perfusionist was getting ready to wean OFF CPB as per anaesthetist protocols with ET tube suctioning. At that time they encountered massive bleeding via the endotracheal tube. ET suction was done. Once again weaning off CPB was tried but pressures and saturation were not holding. Bleeding was persistent, so CPB was restored. There was only one option to get the patient out of CPB, this was to stop the bleeding and bring down the ACT levels to less than 200 sec. Patient was put on ECMO with the same cannulae and partial protamine was given.

**Management**

- Balance must be maintained below anticoagulation to avoid circuit thrombi and coagulation to avoid bleeding.
- 2 units of packed cells and 1 unit of whole blood were given to bring up Hct from 19.2% to 32%.
- 8 units of cryoprecipitate were used
- 1V dose-1-10 units (1 units/5 kg)

**Discussion**

Various techniques had been followed in order to tackle post cardiotomy bypass bleeding, especially that which follows pulmonary endarterectomy poses a bigger challenge because of persistent hypothermia, uncorrected hemodilution, low platelet count and fibrinogen levels leading to DIC, prolonged CPB, prolonged ACT>220 sec.

Finding out reason for bleeding and treating the same would be a correct treatment for the patients with the abovementioned symptoms.

Hence ECMO with low level ACT was maintained and hemodynamics was taken care of. ECMO was successfully weaned off.

- After 22hrs the patient was taken to OT and re-explored.
- Bronchoscopy was done. No bleeders were found in endotracheal tube. Patient was successfully weaned off ECMO, he was hemodynamically stable and shifted to ITU.

**What would be the causes of intrapulmonary bleeding:**

- Endothelial injury
- SIRS-(leukocyte mediated)
- Pulmonary hypertension
- Catheter induced (Swan Ganz and vents)

**Conclusion**

- Pulmonary arterial bleeding after pulmonary thrombo endarterectomy is a difficult problem.
- Early recognition inside the OR and prompt management of pulmonary artery bleeding is important in rectifying the situation.
- ECMO offers an additional strategy to face pulmonary and circulatory failure, reducing the risk of recurrent bleeding and avoiding pulmonary resection.
- This technique can provide favourable support in the management of such a complication.
Perspectives in Vascular Surgery and other Non-CPB Protocols a perfusionist can involve

Hareendran A, BSc, DPTech.

Abstract:

Advent of Heart Lung Machine and the innovations in CPB variegated the concept of Cardio-thoracic into Cardiac Surgery and Vascular Surgery. Many veteran surgeons continued to practise both the specialties either on academic interest or limited number of cardiac cases admitted in a general hospital or even some medical college hospitals having a few hundreds of cases per annum. Perfusionist also may take care of Intra-Aortic Balloon Pump in the post-operative period. Ultrafiltration continued after the termination of CPB was a turning point in clinical involvement. Even though Offcab and interventional procedures of septal closures and even valve replacements took away the role of a perfusionist, reeding to standby, various vascular surgical procedures demand require our service. Perfusionists gained insight in other fields such as Life support systems viz. Intra-aortic Balloon Pump, RV and LV Assist Devices, Extracorporeal Membrane Oxygenation, Isolated Organ Perfusion etc. Analysis of Blood Gases and Activated Clotting Time became a part of the perfusion protocol. Some perfusionists assisted the surgeon in various procedures like Doppler study etc. With the development of Heart Transplant for which donor heart has to be fetched from distant place, a new category as Transplant coordinator paves more insight for a perfusionist.

Key words: Aortic Arch Aneurysm, Assist Devices, Auto transfusion system, Bacillary Artery Aneurysm, Extra-corporeal Life Support, Hemoconcentrator, Intra-Aortic Balloon Pump, Isolated Organ Perfusion, Modified Ultrafiltration, Off cab, Retrograde Cerebral Perfusion, Selective Ante-grade Cerebral Perfusion, Ultrasonic Doppler Study.

Introduction:

Innovations in Cardiopulmonary Bypass that took place during the middle of the 20th century opened new avenues in cardiac surgery. With the advent of Heart Lung Machine and Blood oxygenator, intra cardiac repairs and heart valve replacements became possible. In a conventional setup; cardiothoracic surgery had to be contented either one operating room or had to share on weekday basis with other specialties; mostly with Neurosurgery. Cases done under cardiopulmonary bypass (CPB) were a few and there were instances that a perfusionist was assigned as a physician assistant who assisted the surgeon in minor procedures as well as attend clinic or assist investigations on non-operating days.

Major vascular surgeries like Excision of Aneurysm of the Aortic Arch, cranial surgeries involving Bacillary Artery Aneurysm etc. opened a broad avenue for perfusion management beyond the horizons of open heart surgery. Involvement of vasculature makes the task of a perfusionist more conspicuous. Excision and Repair of aortic arch aneurysm often demands total shut down of blood flow to vital organs still continues as a great challenge to the perfusion team. I recall that, some thirty years back, a perfusionist required a six module pump while even Cardioplegia was not a standard practice; and many surgeons followed intermittent clamping and administering potassium solution. Perfusionist had to set up the multiple bifurcation circuits for Aortic Arch Aneurysm Repairs (AAAR), where, the upper and lower portions required to be perfused separately [1].

Later on, Total Circulatory Arrest (TCA) under deep hypothermia also referred as Deep Hypothermic Circulatory Arrest (DHTCA) got adopted, incorporating...
a recirculation line to the then prevailing bubble oxygenator circuit to avoid platelet aggregation in the stagnated blood. Another challenge was the ischemic safety period where there had been arguments on safe duration without circulation. Introduction of Continued Retrograde Cerebral Perfusion which was first instituted in 1997 for removal of massive air embolism became a charm for AAAR for a few years, but the distribution of blood flow into both arms made a second thinking on the adequacy of blood flow to cerebral area and its quantitation methods like Internal Jugular venous Pressure, frequent assessment of desaturation level in carotid artery etc. gave a second thought [2] and Selective Ante-grade Cerebral Perfusion incorporated with axillary [3] / innominate artery cannulation [4] which has been used when pathology precludes standard cannulation of the ascending aorta. Moreover, cannulation of the left common carotid artery technique for proximal aortic repair was followed in the patients in whom a femoral cannulation was not feasible [5] came back into practice.

Thoraco-Abdominal Surgical Procedures generally do not require the service of a perfusionist. Supra-renal abdominal aortic aneurysm (AAA) having a great risk factor of postoperative renal dysfunction/acute renal failure is overcome by renoplegia [6] administered by the anaesthesiologist. Whereas, depending the magnitude of bleeding, either a cell saver or an Auto Transfusion System (ATS) is set up to minimize allogenic perioperative transfusion. Use of a conventional cardiotomy reservoir (BCR) which had been established for post-operative re-infusion of mediastenal blood [7] whereas a BCR, can be used for perioperative collection and transfusion. Since the outlet is 3/8”, it can be converted to appropriate size using 3/8” x ¼” reducer and a ¼ x Luer male Cardioplegia connector. Blood can be transferred into citrated bags via 3 way for cell wash. Partially citrated blood may be used for immediate transfusion. Gravity collection to blood bag can be managed by an assistant, whereas, rapid transfusion through a pump requires an experienced perfusionist. Hemodynamic effects of cardiotomy blood may result vasodilation which is proportional to the inflammatory activation of suction blood. This can be reduced by processing suction blood with a cell-saving device before re-transfusion [8].

III POST-BYPASS PROCEDURES:
Modified Ultrafiltration

Ultrafiltration (UF) differs from dialysis which is a passive that works on the principle of gradient of components using a dialysate; whereas a Hemofilter functions by pressure difference. Even though ultrafiltration conforms to an optional component in the CPB circuit, where, Zero balance Ultrafiltration (ZBUF) used for replacing prime with blood as well as inflammatory media removal during CPB [9] or Conventional Ultrafiltration (CUF) performed during CPB to remove excess circulating fluid, its modified use after termination of CPB has been dealt here.

Modified Ultrafiltration (MUF) is an established method in removing inflammatory mediators, reducing the need for homologous donor blood and decreasing pulmonary vascular resistance after CPB [10]. MUF circuit excludes the venous reservoir and the oxygenator has been summarized herein. Arterial blood is withdrawn at a speed of less than 10 ml/kg. Body weight, and passed through the Ultra filter. Either a partial resistance with overpressure cutoff or a controlled vacuum of is applied. Hemoglobin improves as the water is removed. This concentrated blood in infused back to the venous line through the cardioplegia system to maintain the patient temperature [11].

Figure 1: CPB Circuit Diagram of Modified Ultrafiltration

IV LIFE SUPPORT SYSTEMS:

CPB is a Life support that temporarily substitutes the
functions of heart and Lungs while the patient is under general anesthesia for cardiac surgery. Retrograde Cerebral Perfusion (RCP) and Selective Antegrade Cerebral Perfusion (SACP) comes as a portion of the procedure under Circulatory Arrest. Other Life Support systems include Intra-Aortic Balloon Pump (IABP), Extra-corporeal Membrane Oxygenation (ECMO), Circulatory Support devices like Left / Right Heart Assist Devices (LVAD), Isolated Organ Perfusion etc. which may be under local anesthesia.

1. Isolated Organ Perfusion

The lung is the site of many neoplasms including sarcoma, melanoma, renal cell cancer, and metastatic gastrointestinal disease that, because of location, size, or multiplicity, are un-resectable. ILuP is conducted after cannulation of the concerned Pulmonary Artery and two pulmonary veins and done under Normothermia or hyperthermia of 42°C. Staged thoracotomies are done for bilateral disease, staged with an interval of 4-8 weeks [12]. Hyperthermic isolated limb perfusion (HILP) in locally advanced soft tissue sarcoma and progressive desmoid-type fibromatosis with TNF 1 mg and melphalan (T1-M HILP) is safe and efficient. Some patients were previously irradiated or had received systemic chemotherapy before HILP [13].

2. Intra-Aortic Balloon Pump

Intra-Aortic Balloon Pump IABP and Left Ventricular Assist Devices (LVAD) are viewed as escalating methods along with hydraulic considerations which allow non-invasive determination of stroke volume [14]. Intra-aortic balloon pump counter-pulsation (IABP) is currently the most commonly used mechanical assist device for patients with cardiogenic shock due to acute myocardial infarction [15]. IABP Console triggers from the ECG or Pressure wave and inflate the balloon inserted percutaneously into the descending aorta. The Balloon inflated by Helium and squeezes 40 ml volume of blood out of the aorta. Heart Muscles dilated during diastole takes up more blood. Owing to low solubility in aqueous medium, it was a chosen to minimize decompression syndrome, and became the chosen gas due to the diffusion properties. It cannot safeguard an event of Balloon Rupture, and only precaution is to avoid reuse of the Balloon. Picture shows the screen displays all parameters including the amount of Helium in the tank.

3. Extra Corporeal Membrane Oxygenation

Since a positive pressure needs to be maintained during the use of an oxygenator, the pump in a Veno-Venous ECMO (VV-ECMO) functions as a supportive device, and this type of ECMO provides only respiratory support. It has been reported that ECMO via subclavian...
catheter has been successfully performed for severe postoperative bacterial pneumonia unresponsive to conventional treatment following a failed renal transplant, and the patient was placed on low flow VV-ECMO as an adjuvant to antibiotic therapy and maximal ventilatory support. Venous ECMO resulted in rapid improvement and the patient was successfully weaned after 48 hours [16]. Sometimes VV ECMO may exert some disadvantages such as a longer operative time to place the cannulas, groin wound problems, and persistent leg swelling necessitate conversion to VA ECMO. [17]. ECMO is said to be superior to Right Heart assist devices [18].

4. Left Ventricular Assist devices

Left ventricular assist devices (LVAD) are analyzed as extravascular in-series or parallel volume-capturing / ejecting devices and as true blood pumps which can be implanted. Centrifugal Blood Pump (Heart Ware) can be implanted as LVAD by hemi-sternotomy combined with antero-lateral thoracotomy [19]. The abdominal left ventricular assist device (ALVAD) is implanted in the abdomen, and is driven by a pneumatic pump [20]. The LVAD functions as a bridge for heart transplant until suitable donor heart is obtained [21]. Sometimes, a LVAD may impair RV function [22]. Extracorporeal life support (ECLS) is indicated following left ventricular assist device (LVAD) implant for right heart failure or pulmonary dysfunction [23].
V CLINICAL / LABORATORY INVESTIGATIONS:

1. Ultrasound Doppler

Ultrasound Doppler is non-invasive equipment that can be used for Blood flow Studies and Blood Pressure measurement when Echo lab or pressure transducers were uncommon. Ether stand required Patient's arm in caudad position (opposite to head end) making the brachial region inaccessible for stethoscope or palpation of pulse. has a pair of peizo-electric crystal among which one vibrates at a frequency of 10 MHz. (20 kHz is inaudible to human ears, and termed as Ultrasonic) whereas the second one detects blood flow velocity by Doppler shift (Change in in frequency caused by the moving medium).

![Ultrasound Doppler](image)

Figure 8: Ultrasound Doppler made by Parks Medical Electronics Inc, USA

Adult and Pediatric models of flat probes used for operating room use, whereas a pencil probe used for Doppler studies. The study includes the Assessment of Blood flow Velocity in Axillary, Brachial and radio-ulnar regions of the upper extremities, and femoral, popliteal, dorsalis pedis and Posterior Tibial Arteries; as well as upper and lower limb pressure assessments. Owing to various reasons such as resonance and higher readings caused by standard pressure cuff, a 12 cms wide cuff as recommended by the manufacturer may be used [26]. Since vascular diseases involve blockage of blood vessels, a drop in temperature is detected in case of arterial diseases, whereas an increase in ankle temperature of returning blood, stated as an important nursing assessment parameter to evaluate worsening or impending CVI complications [27].

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Figure 9: Chart: Doppler study Chart

2. Activated Clotting (Coagulation) Time

Activated Clotting Time (ACT) was first established by Hattersly in 1966 based on the principle of contact activation using glass beads to detect hemorrhagic diatheses [28]. Many Cardiothoracic procedures require the patients to be anticoagulated to prevent clotting and thrombotic complications. Blood Clotting is time is artificially prolonged using Heparin. ECMO) therapy also require anticoagulation. There are several bedside whole blood microcoagulation systems available to determine activated clotting time (ACT) levels. Hemocron ACT
machines have Celite Glass Mixture [29]. Kaolin used in many other models are proven to be superior in accuracy and reproducibility [30]. Even though ACT have been a standard protocol in Cardiovascular surgery for over three decades, Thromboelastography became a turning point in coagulation management [31].

VI Conclusion:

Developments in pediatric heart surgery diversified the specialty of Cardiovascular and Thoracic surgery into three groups namely, Acquired Heart Surgery, Congenital Heart Surgery and Vascular & Thoracic Surgeries. Further developments took place in Coronary Artery Bypass Graft (CABG) Surgery. Coronary Artery, being the Blood Vessel catering the walls of the heart is categorized as a major cardiac procedure. Aortic Arch Aneurysm Repair, considered as a Thoracic procedure, the involvement of Coronary Root Replacement are done with the support or guidance of coronary surgeons. Thoraco-abdominal procedures, even though do not require cardiopulmonary bypass; chances of massive bleeding requiring auto-transfusion is managed by the perfusion team. The perfusionist gets involved with Auto-transfusion for vascular procedures; where the shed blood is transfused after getting the cells washed and concentrated in the Blood Bank. Blood collected in a Reservoir is either transfused through pump or transferred into blood bags and sent to blood bank with entries for dispatch and follow up. Continuous Cell and Plasma Separators brought the whole work into the operation room.

Development of tissue stabilizers made CABG feasible without CPB that derived a term OPCAB reduced the functional role of a perfusionist into standby. Impact of interventional procedures further reduced the need for cardiopulmonary bypass took the major portion of work out of the hands of the perfusionist. A Modern perfusionist has to take of advanced equipment and newer concepts. Apart from CPB, a perfusionist may get involved with various means of life support system. Some are circulatory support systems. Intra-Aortic Balloon Pump, which is sometimes required for CABG patients who cannot be weaned off, is often managed by the perfusion team. The system functions on the principle inflation of a balloon which is inserted into the descending aorta. The inflation is synchronized with diastolic so that more blood flows through the coronaries.

Extra Corporeal Life Support (ECLS) became a new means of therapy for failing lungs, especially in patients suffering from avian flu. Extra Corporeal Membrane Oxygenation and Left Heart support Devices which is a bridge for Heart Transplantation became a new tool for the modern perfusionist. With development of Heart Transplant for which donor heart has to be fetched from distant place, a new category as Transplant coordinator came to exist. Perspectives of organ preservation with emphasis to the beneficial effects of normothermic perfusion over hypothermic storage is an awesome topic for a perfusionist [32]

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FOR YOUR KIND ATTENTION!

This is for your kind notice that there is an article that had been published in VOLUME 22 of the Indian journal of extra corporeal technology (IJECT) of 2012 which is calling for remedy now. The article entitled “Modified circuit for 1:4 blood cardioplegia delivery” whose authorship or co-authorship is perhaps controversial and demands rectification or even deletion. An email is addressed to me by DR.SHIV CHOWDHARY whose name was in the list of co-authors in the aforesaid article. I received this mail on 13th February 2014. He disclaims his co-authorship from the article as his consent according to him, was not sought before its publication. The past editor and co-author of the article MR.RAJEEV GUPTA also sent me an email with regret asking for DR.SK CHOUDHARY’S name to be removed from its coauthor’s list on the 14th February. However, I sent a reply to DR.SK CHOUDHARY promising him that I would do the needful very soon. Although this incident which is claimed by them happened during the previous tenure and now a new editor and editorial committee has assumed office and we are neither directly nor indirectly implicated in that issue, yet we cannot connive at it. After a serious discussion with some experienced members in the editorial committee, a decision is taken to remove or exclude DR.SK CHOUDHARY’s name from the co-authors list from the above article (the article is republished in the next page with the rectifications) for everyone’s notice.

Thus it makes inevitable that in future the signatures of the author and co-authors are indispensable for an article before its publication. This discipline would be stringently reviewed henceforth. Moreover it would help to avoid further undesirable precipitation of matters in these kinds of issues.

Thank you

Regards

Editor IJECT

(N.B.: This is the first issue of the journal during my tenure, please refer to the letter from the editor’s desk)
Modified Circuit for 1:4 Blood Cardioplegia Delivery

Rajeev Gupta**, Santosh*, Brijesh*, Parag Gharde®, Balram Airan$  
Department of Perfusion Technology, CTVS, CT Centre, All India Institute of Medical Sciences, New Delhi, India

Abstract

Blood cardioplegia has emerged as the preferred cardio protective strategy, since its invention by Dr. Gerald D. Buckberg. Beside, classic ‘standard technique’ of blood cardioplegia delivery, several modifications have evolved and are used in different centres. Author describes an alternative cardioplegia circuit designed to deliver blood cardioplegia in the ratio of 1:4 (blood: crystalloid). (Ind J Extra Corp Technol 2011;21:51–52)

Key words: Blood cardioplegia, circuit, technique, myocardial protection

Introduction

The primary objective of cardioplegia is to provide optimal operating condition & maintaining integrity of myocardial cell during the ischemic period. Adequate distribution of cardioplegia solution in the myocardium and adaptable strategies for its delivery in various clinical situations are two prerequisite for myocardial protection [1]. Currently, blood cardioplegia (4:1, blood to crystalloid) is the preferred cardio protective strategy in our institution. A decade ago, author first used novel cardioplegia solution namely, del Nido solution [2] in a ratio of 1:4 (1 part blood: 4 part of crystalloid cardioplegia solution) with simple modification in standard cardioplegia circuit with enormous success. Recently, at AIIMS, we again started using del Nido cardioplegia solution in wide spectrum of open heart surgery. Evidences are growing with more and more centre using this single dose myocardial protection technique utilizing del Nido cardioplegia solution[3].

Technique

The conventional blood cardioplegia device (Sorin CS14 blood cardioplegia system, Sorin Group USA, INC.) used in our institution allows distribution of blood cardioplegia in 4:1 ratio, it has two different tubing diameters 1/4"x1/16" for oxygenated blood transport from the oxygenator and 3/16"x1/16" tubing for crystalloid cardioplegia solution mixed together using single pump. In order to deliver delNido cardioplegia solution in 1:4 ratio, divide the 1/4"x1/16" diameter tubing (A) and connect it with 3/16"x1/16" tubing to deliver cardioplegia solution (4 part cardioplegia solution) using 1/4"x3/16" straight reducer connector. Similarly 3/16"x1/16" tubing (B) is connected with 1/4"x3/16" tubing for oxygenated blood transport (1 part blood) from oxygenator (Figure 1 and 2).

Comment

The goals of myocardial protective strategies are to provide preservation of myocardial function, a bloodless

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*Perfusionist, **Senior Perfusionist, ***Consultant Cardiac Surgeon, ºConsultant Anaesthesiologist,Professor & Head CTVS
Blood Conservation During CPB - Role Of Perfusionist without ↑Cost

Saurav Sengupta,
Sr Clinical Perfusionist Desun Hospital & Heart Institution Kolkata, Westbengal

Abstract:

Objectives: In cardiopulmonary bypass Extreme haemodilution due to crystalloid priming? transfusion of stored Blood in small adult cardiac surgical patients. And homologous blood transfusion during cardiac surgery?morbidity and mortality. Therefore we examined whether some modification of four self to reducing hemodilution and red cell transfusion.

Modifications are:
1. ↓Prime volume by Circuits design & Oxygenator Placement;
2. ↓Prime volume by retrograde/anterograde autologous priming;
3. Ultrafiltration with Cost Effective Method.
4. Microplegia.

And also use the devises i.e. Vacuum assist device, Ultrafiltration. But In the view business accept, introduce the modern device is directly effect to ↑cost of Surgery-Package that’s why Patient is also suffer for same. Our aim, without ↑Surgery cost blood should be conserve for patient benefit.

METHODS: 96 patients of 2011-2012 with a body surface area of ~ 1.3m² - 1.5m² undergoing first-time, cardiac surgery were randomized to either the Standard group or the Modified group.

1. Reduction in prime volume using a reduced bypass circuit

Reduction in prime volume is a major factor in blood conservation.

Phase – I Before Reduce the Circuit

We assume a blood volume of adult patient is 70 mL/kg & in general Priming volume is around 1650(Circuit + Oxygenator+ Heat-exchanger+ filter+ with 200 ml minimum Reservoir level)

The two membrane oxygenators Sorin EVO & Affinity NT are in major use in our institute.
Phase – II After Reduce the Circuit

We assume a blood volume of adult patient is 70 mL/kg & in general Priming volume is around ↓ 300, total PV is 1350(Circuit + Oxygenator+ Heat-exchanger+ filter+ with 200 ml minimum Reservoir level), But here drastically ↓ the circuit volume due to the Plegia Technique.

2. Plegia Technique.

*Microplegia:*The original composition of blood cardioplegia described by Buckberg was a 4:1 ratio (BCD Chamber) blood -crystalloid; this has become the standard for cold blood cardioplegia. And also some use the Kolies Chamber but both the methods are ↑ volume related. Alternatively we proposed to use a type of solution which can ↓ volume requirement & also the ↓ prime which is Microplegia.

Microplegia is one type of blood plegia and its Classical technique for continuous or discontinuous with perfusion temperature is identical for ↓ Priming.

**TECHNIQUE:**

The cardioplegia circuit is very simple. The cardioplegic line is composed of pvc tubing with an internal diameter of 1/4inch. Make with a Y connector (fig 1).

Figure 1 - Cardioplegic circuit made by ¼ inch PVC with Y connectors.

The total prime volume of the cardioplegia circuit is between 25 ml for neonates and 35 ml for older Adult. Oxygenated warm blood is withdrawn directly from the oxygenator or from the origin of the arterial line by an occlusive roller pump. The cardioplegic solution is delivered by an electrical syringe pump that is connected to the cardioplegic circuit via a Y type connector downstream of the occlusive roller pump (fig 2).

Figure 2 - Cardioplegic circuit. Roller on the left is the arterial pump, performing the total bypass flow. Roller on the right is the cardioplegia pump, diverting the blood component of the warm blood microplegia. The syringe pump injects the CP solution.

The crystalloid component each ml Contain / Flow ratio:
3. Autologous priming

Retrograde or antrigrade autologous priming consists of total or partial replacement of the crystalloid prime by using the patient’s blood being drained from the arterial and venous lines (mean volume withdrawal: 650 ±100 ml). During this drainage, the bloodless prime is collect to Empty RI/RL bottle.

Thus, the total crystalloid Priming Volume became is average 700 ±100 ml.

Perfusion and anesthetic techniques were otherwise identical for the two groups.

Why try to Reduce Surgery Cost?

World Economic Status shows that India is a poor Country & Rheumatic Heart Disease is most common cause for Valve Surgery.

RESULTS:

Patient characteristics and operative parameters were equal for patients in both groups. With autologous priming, a mean crystalloid Priming Volume is 700 ±100 ml. This allowed a significantly higher hematocrit value during cardiopulmonary bypass. Red blood cell transfusion was necessary in approx. 78% of patients of the standard priming group on pump; whereas only 16.5% of patients of the modified group required transfusion. The overall transfusion rate of the modified group was significantly less than that in the standard priming group during the hospitalization.

CONCLUSION

There are many ways to ↓ the number of stored blood transfusions.

The major techniques are as follows:

1. ↓bypass circuit which decreases dilution and dilutional coagulopathy;
2. Microplegia;
3. Retrograde or antrigrade autologous priming.

These three techniques are simple, inexpensive, safe and efficient in all patients regardless of age or weight. The other techniques (cell-salvage, ultrafiltration, Vacuum assist device) could be used in combination with the major techniques but it may effect in the Cost of Surgery.

Another positive effect of the miniaturized circuit is reduced blood contact with the surface of the CPB circuit; this contact is thought to activate the systemic inflammatory response.

However, the aim of blood conservation is not only linked to the perfusionist’s it also depends on the all factors involved in the patient’s care before, during and after surgery.
Modified Cardioplegia for Neonates and Infants' Cardiac Surgery

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Abstract:

In our institute, we have formulated a regimen in cardioplegia which is a modified version of St. Thomas' that facilitates a prolonged duration in the electromechanical arrest of the myocardium. We have obtained fairly good results.

Key words: Blood cardioplegia, modified, prolonged duration.

Cardioplegia is an integral and essential method of myocardial protection wherein the heart is stopped for the performance of cardiac surgery. Numerous methods of delivery of cardioplegia which vary in their composition, route and frequency of delivery, are available.

We briefly describe the protocol we follow in our unit for neonatal and infant cardiac surgery. By using this method ischemic time of up to 60 minutes is well tolerated because paediatric myocardium has low 5-nucleotidase activity which increases ischaemic tolerance. We have observed a reduction in the ionotrophic requirement, myocardial oedema and better myocardial contractility in the post ischaemic period. The frequency of repetition of cardioplegia is also reduced. Children with preoperative risk factors like myocardial dysfunction, serve ventricular hypertrophy and severe cyanosis have also done well with this technique.

The constituents of this Cardioplegia are

1. Kcl- The potassium concentration in the solution reduces the resting membrane potential, the intracellular calcium is sequestered by the sarcoplasmic reticulum using ATP dependent Calcium pumps, the Na+ channels are inactivated which results in diastolic arrest of the heart. The Chloride helps maintain the electrical neutrality.

2. Hypothermia- It is employed to further lower down the myocardial energy requirement, According to Vant Hoff’s equation there is 50% reduction in oxygen consumption with every 10 degree reduction in temperature. We administer CP at 8-10 degree which causes the heart to cool down to 12-18 degree thus slowing the metabolism of the heart. Diastolic arrest using Potassium and Hypothermia are the key factor which reduce the metabolic requirement during the ischaemic period. It has been shown that cold blood cardioplegia reduces the ischemic and reperfusion injury in cyanotic hearts.

3. Lodocaine- Is an anti-arrhythmic sodium channel blocker which reduces the myocardial irritability during and in the post ischaemic period. The half life is about 100 minutes and it’s onset of action is within 40 sec.

4. Mannitol- Is a polyol also known as sugar alcohol. Because of its high molecular weight it acts as an osmotic agent causing reduction in myocardial oedema and as a diuretic. It also acts as a free radical scavenger by reducing reperfusion injury.
Infants have reduced activity of free radical scavenging system. In addition, it reduces the intracranial pressure and also acts as a nephroprotective agent.

5. Magnesium- Is a membrane stabilizer which helps to preserve high energy phosphates. It reduces the injury caused by the Calcium during reperfusion and is also essential for the functioning of many Cardiac enzymes(like CPK(MB)). Paediatric myocardium has increased sensitivity to calcium. It has been shown to reduce the incidence of post operative arrhythmia and improve cardiac function in animal models.

6. Blood- has a number of useful properties which makes it the ideal vehicle for carrying the cardioplegia. It has osmotic, oxygen carrying capacity, free radical scavenging and anti-oxidant property. It has inherent oncotic property and also has the necessary nutritions and substrates for myocardial metabolism.

7. NaHCO3- It acts as a buffer to reduce the acid-base imbalance. It prevents the acidosis that builds up during the ischaemic period. This acidosis can impair the myocardial contractility and can cause cell damage.

8. Glucose (25%)- Addition of glucose helps to preserve glycogen stores and maintains the energy levels of myocardial cells. Paediatric myocardium unlike adults depends on glucose for metabolism while adult myocardium can utilise long chain fatty acids.

Dosage Calculation

For 2-8 Kg infants and neonates

1. 0.9% NaCl 100ml(4 degree celsius).
2. NaHCO3- 1ml/Kg/Body wt.
3. Lidocaine 2.4ml or 35mg
4. Mannitol- 0.5ml/Kg/Body wt
5. MgSO4- 0.8ml
6. Blood- 100ml
7. KCl- 0.75ml/Kg/Body wt
8. Glucose 25%-5ml

The solution is prepared and kept in a cool bath and administered under 50 mmHg pressure.

The initial dose is 30ml/Kg and subsequent doses are given at 20ml/Kg/Body wt

This is administered through a 50mi syringe using 200cm line, by placing a 3 way stop cock on either end with a pressure monitoring line to assess and to ensure that cardioplegia is given under adequate pressure.

We have used this mode of preparation and administration in around 350 children weighing<10Kg, and have made the following observations.

1. Ischaemic time up to 70 minutes are tolerated especially in the presence of hypothermia(around 22 degree celsius)
2. The frequency of administration is reduced which helps in uninterrupted surgical procedures.
3. The requirement of postoperative ionotrops are reduced, most children are on just 5mcg/Kg of dopamine and dobutamine which is usually tapered in a couple of days.
4. After removal of the cross clamp the resumption of cardiac activity is prompt, the incidence of arrhythmias is significantly reduced.
5. The visible appearance of the myocardium- the appearance and contractility is improved.
6. Myocardial oedema is less and reperfusion injury appears to be minimized.
7. The lactate levels and acid base balance is well maintained in the postoperative period.
8. Manual administration makes this technique cost effective and using pressure monitoring lines, the delivery pressures can easily be controlled.

In brief, we have presented our experience of this technique practised regularly in our institute with modified cardioplegic solution for cardiac surgery mainly for infants and children, which has given satisfactory results in our unit.