MULTICENTER NATIONAL STUDY ON CARDIOPULMONARY BYPASS (CPB) PERFUSION PRACTICES DURING ADULT CARDIAC STUDY

Muhammad Saad Yousuf, Mohammad Irfan Akhtar

Aga Khan University Hospital, Karachi Pakistan

ABSTRACT

Objective: To describe the multicenter variations in perfusion practices, which persist nationally and to highlight the non-evidence based practice variations.

Study Design: Multicenter National cross sectional web-based study.

Place and Duration of Study: Multicenter national adult cardiac surgical units, from Jul 2018 to Jan 2019.

Methodology: The web-based questionnaire of the study was sent to 24 adult cardiac anaesthesiologists working in different cardiac centers nationally. Partial or unresponded study were excluded. A convenient sampling technique was done.

Results: The response rate was 15 (62.5%). Sixty percent of the respondents were practicing in heart centers. The study demonstrated that 10 (66.7%) respondents used goal directed perfusion during cardiopulmonary bypass (CPB), with more than 80% used aseptic measures during handling cardiopulmonary bypass machine, consulted with the cardiac anesthesiologist in critical decision making and treatment of complications, and used protocol for trouble shooting during cardiopulmonary bypass. Nine (60%) perfusionists did not monitor continuous arterial blood gases and acid base balance. Thirteen (86.6%) respondents transfused packed red blood cells (PRBC) if hemoglobin ≤7g/dl. Only 5 (33%) centers used the scavenging system to avoid pollution by using volatile agents. Conventional polyvinylchloride (PVC) circuits were used by 13 (86.6%) participants while heparin coated silicon circuits were used by only 2 (13%).

Conclusion: The study revealed that most of the perfusion practices reflect updated guidelines and they try to maintain standards in their institution.

Keywords: Adult cardiac surgery, Cardiopulmonary bypass, Perfusion practices.

INTRODUCTION

Cardiac perfusionists should be updated and should use evidence based information in their clinical practices to provide optimal safe patient care. But unfortunately, practices based on evidences among perfusionists as well as personnel involved in medical profession are very little. In one review article it was found that due to very little use of evidence-based medicine, patients received as little as 54% of the treatment[1]. So in order to assess the perfusion practice, it is important to develop a "structured method of measurement"[2]. The compilation and interpretation of study over time is one research method that is used to assess the compliance of evidence based clinical practice throughout a profession. Such structured reviews, specifically in the perfusion practice, have consistently been in the literature suggesting effective changes in clinical practice.

Currently the evolution in the practices of cardiopulmonary bypass (CPB) has been changed significantly and the evidence which support the practice of cardiac surgery is continued to be revised on the basis of current evidence[3]. Moreover, additional targeted reviews which clearly focus on issues like decreasing the effect of the inflammatory response or neurologic injury, are still warranted[4]. The techniques for conducting CPB varies among perfusionists at national and international level, despite the availability of significant evidence based material[5]. These variations in practices compromised the patient safety and also increased the costs, length of stay, neurologic injury, and overall mortality[6,7]. This varia-

Correspondence: Dr Muhammad Saad Yousuf, Department of Anaesthesiology, Aga Khan University Hospital, Stadium Road, Karachi Pakistan (*Email: saadyousuf22@gmail.com)*

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tion might be attributed to clinical uncertainty or institutional or local practice standards. To reduce these variations, we must have to evaluate our clinical colleagues critically and ensure to utilize evidence-based reviews for conducting CPB.

The objective of the study was to describe the multicenter variations among perfusion practices nationally and to highlight the non-evidence based practice variations in context of the study results.

METHODOLOGY

After the approval from ethical review committee (Reference number: 2019-1267-3877), this cross-sectional study was performed by approaching National adult cardiac surgical centers from July 2018 till January 2019. The questionnaire was made by using the web-based platform (Google forms) comprising of 9 sections including participant's organizational details, standard operating procedures (SOPs) during CPB, monitoring and management standards during CPB, anti-coagulation management, cardioplegia solution details, transfusion trigger during CPB, anaesthesia maintenance during CPB, pharmacological interventions during CPB and CPB circuitry or pump details. A convenient sampling technique was used and total of twenty four invitations were sent. Informed concest was taken from the participants before accessing the study questionnaire.

The addresses were adult cardiac anesthesiologists from the national cardiac surgical centers. A preliminary study was tested on a group of five cardiac anesthesiologists. Several changes were made on the basis of their feedback including addition and deletion of some questions, alterations in question order, corrections of language and text were made before distribution. An invitation e-mail including a short description of the aim of the study with a hyperlink to the online questionnaire was sent to cardiac anesthesiologists working in different cardiac centers nationally. The study was kept open for seven months approximately, during which weekly e-mail reminders were sent to Non-respondents and partial respondents. Non-respondents and partial respondents were excluded from the study. Data were exported from web-based platform to excel for screening and to analyses. Frequency and percentage were computed for all responses which were tabulated into bar chart and tables.

RESULTS

We received 20 responses (5 of which only partial) from the approached adult surgical cardiac centers nationally, with an overall response rate of 62.5% (15/24). The response rate from the participating provinces is illustrated in fig-1. Sixty percent of the respondents were practicing from heart centers while 5 (33.3%) were affiliated with the university hospitals. Almost 14 (93.3%) respondents were involved in almost all complex

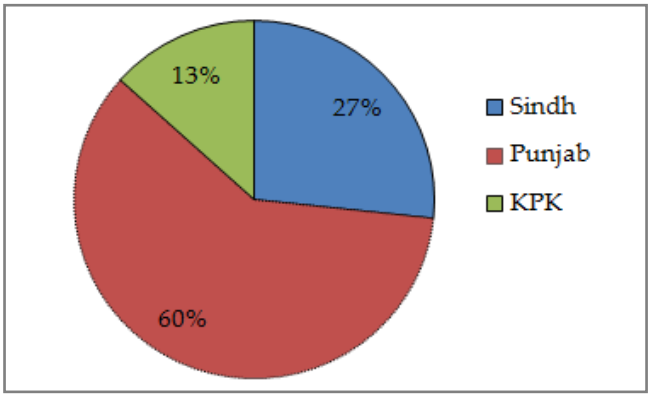

Figure-1: Response rate from different cardiac centers with Provinces.

adult and pediatric open heart surgeries while only 1 (6.7%) was involved in surgeries for grown up congenital heart disease. Perfusionists were running CPB in all cardiac centers.

Most of the participants i.e. 0 (66.7%) used goal directed perfusion. In majority of the centers, the standard operating protocols were followed as mentioned in fig-2 but only 5 (33.3%) were documenting the CPB check list before each case. Most of the participants i.e. 14 (93.3%) target the temperature of rewarming between 36 to 37 degree centigrade before separation from CPB. None of the participants used cell saver routinely during CPB.

The monitoring standards during CPB was variable as presented in fig-3. Fourteen (93%) respondents used nasopharyngeal route to monitor temperature. Continuous venous and cerebral oxygen saturation during CPB were not monitored by 13 (86.7%) and 14 (93.3%) respondents respectively while serum lactate levels was monitored by 11 (73.3%) respondents. There were 9 (60%) perfusionists who did not monitor continuous arterial blood gases (ABGs) and acid base balance, while they do ABGs at every 30 minutes time interval during CPB (fig-3).

Twelve (80%) participants used alpha pH management with maintenance of pH between 7.35 to 7.40. Six (40%) respondents used diuretics routinely during CPB. Hemofiltration was done regularly by 4 (26.7%) participants and out of which 3 (75%) used this strategy in renal failure patients. Nine (60%) participants used ultrafiltration, out of which 6 (66%) were using conventional ultrafiltration and 3 (33%) were using

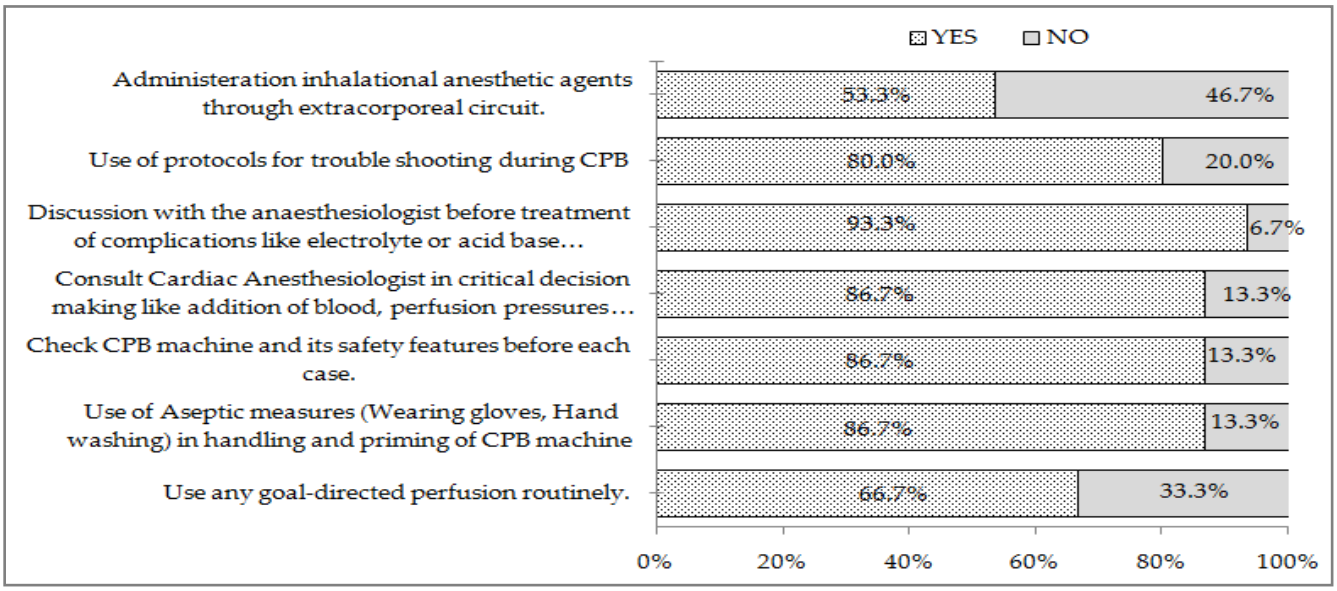

Figure-2: Responses regarding standard operating procedures (SOPs) during cardiopulmonary bypass.

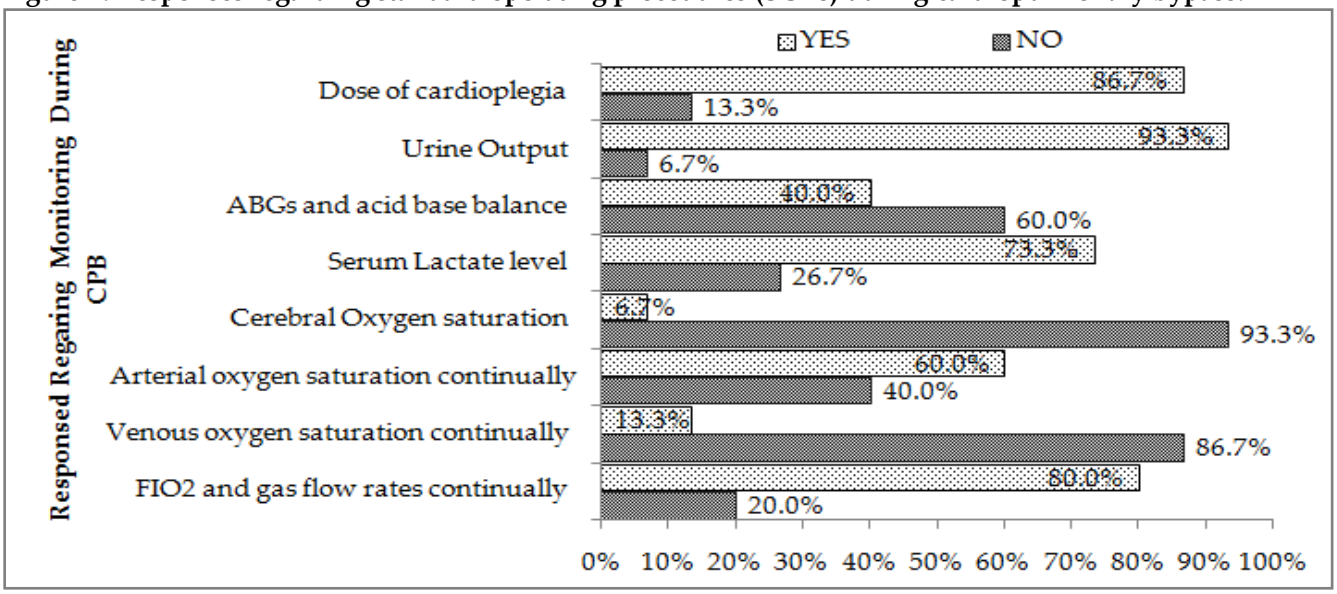

Figure-3: Monitoring standards during cardiopulmonary bypass.

modified ultrafiltration (MUF). Twelve (80%) participants administered sodium bicarbonate during CPB in which 9 (75%) administered at -5 to -7 mEq/L of base deficit.

Seven (46%) participants preferred to maintain partial pressure of oxygen (PaO2) in arterial blood between 150 to 200 mmHg and 6 (40%) maintained PaO2 >200 mmHg during CPB. According to 10 (66%) respondents, target mean arterial blood pressure was maintained between 60 to 70 mmHg during CPB. Seven (46%) participants monitored anesthetic depth via processed electroencephalogram (e.g. Bispectral index, Entropy, others) while 5 (33.3%) monitored it via concentration of the volatile anesthetic agent in the expiratory gas of the oxygenator.

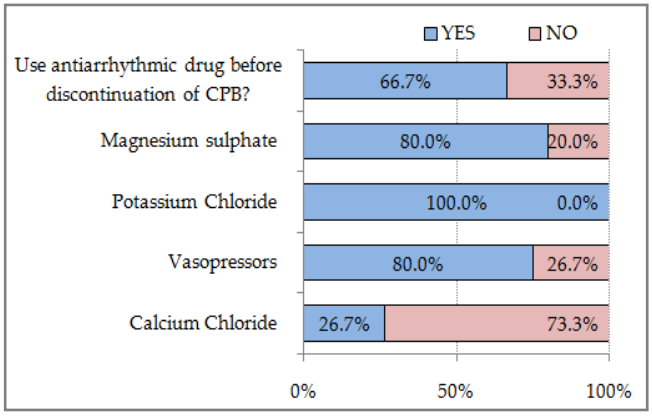

Figure-4: Pharmacological interventions during cardiopulmonary bypass.

Most of the respondents used vasopressors, potassium chloride and magnesium sulphate during CPB (fig-4). In vasopressors administration, norepinephrine was preferred by 8 out of 12 (66.7%) participants while only 4 (33.3%) used phenylephrine.

Most of institutions have protocol for management of patients with heparin-induced thrombocytopenia (HIT) as presented in table-I. Nine (60%) respondents were not using antifibrinolytic agent (transamine) routinely. Responses regarding the cardioplegia solution are elaborated in table-I.

All participants cross check the packed red blood cells (PRBC) with patients identity before its administration during CPB. Majority of the respondents 13 (86.7%) transfused PRBC if Hb≤7g/dl.

Most of the perfusionists i.e. 8 (53.3%) preferred sevoflurane during CPB and only 5 (33.3%) used the scavenging system to avoid pollution during volatile agents usage. Nine (60%) participants used apnoeic oxygenation technique to ventilate the lungs during CPB (table-II).

Membrane oxygenators and roller blood pumps were used in all centers. Non-pulsatile flow was maintained by 14 (93.3%) participants during CPB while only 1 (6.6%) maintained

Table-I: Anti-coagulation management and cardioplegia solution details.

Anti-Coagulation Management:	**n (%)**
Heparin dose calculation during cardiopulmonary bypass?	
Any formula (age/wt)	11 (73.3%)
Rough estimate	4 (26.7%)
Dose response slope	-
Optimal ACT (seconds) maintain during cardiopulmonary bypass?	
>350	1 (6.7%)
>400	6 (40%)
>480	8 (53.3%)
Protocol for management of patients with heparin-induced thrombocytopenia (HIT) at your institution?	
Yes	10 (66.7%)
No	5 (33.3%)
Routinely or occasionally use anti-fibrinolytic during cardiopulmonary bypass?	
Yes	6 (40%)
No	9 (60%)
Cardioplegia Solution Details:	
Cardioplegia solution use in your setup?	
Del Nido	6 (40%)
Other specify	3 (20%)
St. Thomas	6 (40%)
Combination of cardioplegia solution use during cardiopulmonary bypass?	
Blood Cardioplegia	10 (66.7%)
Crystalloid Cardioplegia	5 (33.3%)
How to administer cardioplegia at your institution?	
Antegrade	12 (80%)
Intermittent	3 (20%)

pulsatile flow. Conventional PVC circuits were used by 13 (86.6%) respondents while heparin coated silicon circuit was used by only 2 (13%).

DISCUSSION

The aim of this first ever conducted CPB Perfusion practices national study was to describe the multicenter variations in perfusion practices and to highlight the non-evidence based practice variations in context of the study results. We focused on multiple aspects regarding standard operating procedures (SOPs) during CPB, monitoring or management standards during CPB, anti-coagulation management, cardioplegia solution details, transfusion triggers, pharmacological interventions during CPB and CPB circuitry or pump details.

Table-II: Anesthesia maintenance during cardiopulmonary bypass.

Anesthesia Maintenance	n (%)
In average, how many cardiac surgeries with cardiopulmonary bypass are performed with the use of volatile agents during cardiopulmonary bypass per year at your Institution?	
<50%	4 (26.7%)
100%	3 (20%)
60%	1 (6.7%)
80%	3 (20%)
Don't Know	4 (26.7%)
Preferred volatile anesthetic agent during cardiopulmonary bypass?	
Isoflurane	3 (20%)
Sevoflurane	8 (53.3%)
Other	1 (6.7%)
Don't Know	3 (20%)
Use of scavenging system whiles any volatile anesthetic agent during cardiopulmonary bypass?	
Yes	5 (33.3%)
No	10 (66.7%)
Techniques to ventilate the lungs during cardiopulmonary bypass?	
Apnoeic oxygenation	9 (60%)
Continuous positive airway pressure (CPAP)	1 (6.7%)
Low tidal volume ventilation	3 (20%)
Other, specify	2 (13.3%)

According to the results of our study, the goal directed perfusion being practiced by 66.7% of the respondents, while 33.3% still practicing conventional perfusion in most of their centers. Ranucci *et al*[8] found that the goal-directed perfusion (GDP) strategy aimed at main-taining oxygen delivery at ≥280 mL·min-1·m-2 is effective in reducing Acute Kidney Injury Network (AKIN) stage 1 acute kidney injury (AKI)[8].

In most of the cardiac centers, aseptic measures (Wearing gloves, Hand washing) were used in handling and priming of CPB machine, and they checked CPB machine safety features before each case, while majority of the respondents did not document it. According to the American Society of Extra-Corporeal Technology (AmSECT) Standards and Guidelines For Perfusion Practice 9 the Perfusionist must use a checklist for all cardiopulmonary bypass (CPB) procedures and log it in patient's permanent medical record[9]. Moreover, the patient-specific management plan for the CPB procedure should be prepared and discussed with the physician-in-charge and the surgical team before the procedure. In our study, the majority of the respondents (86.7%) consults Cardiac Anesthesiologist in critical decision making and also had protocols in their center (80%) for trouble shooting.

Mild (32 to 35°C), moderate (28 to 32°C) and deep (<28°C) hypothermia is used as a protective strategy for the vital organs, especially brain, during CPB for many cardiac surgical procedures[10]. In our study, 46% of the respondents maintained minimum temperature between 32-34 degree centigrade while in other centers it was varied as per the complexity of the case. The nasopharyngeal temperature site serves as the in vivo monitor of brain temperature and is typically higher than other sites due to the proximity of the aortic cannula to the great vessels and head. The majority of the centers in this study monitored temperature via nasopharyngeal route during CPB.

Tinegate *et al*[11] in a meta-analysis found that the routine use of cell salvage during cardiac

surgery reduced the transfusion of red cells by 40%[11]. None of the centers in our study used cell salvage routinely during CPB as well. This was found out to be major variation in context of the standard CPB perfusion practice.

In adults, the target flow rate during CPB is 2.2 to 2.4 litre/min/m^2 in normothermic patients to approximate a normal cardiac index[12]. All the respondents maintained target flow rate between 2.2 to 2.4 L/min/m^2 during CPB in normothermic patients while in hypothermic patients, majority (80%) maintained target flow rate less than 2.2 litre/min/m^2.

The mean arterial pressure (MAP) is generally targeted at ≥65 mmHg, but the target may be higher in older patients and those with cerebrovascular disease[12]. The majority of the centers (66.7%) in this study maintained the target MAP between 60 to 70 mm Hg while 20% maintained MAP between 50 to 60 mm Hg. In many institutions, small bolus doses of phenylephrine (40 to 100 mcg) were administered directly into the CPB reservoir to treat hypotension. Majority of the respondents in this study preferred norepinephrine as vasopressor during CPB while others used phenylephrine.

Adequacy of endorgan perfusion is determined by arterial blood gas analysis[12] and the mixed venous oxygen saturation (SvO2), which is continuously monitored and maintained at ≥75 percent throughout CPB. Persistent SvO2 values <75 percent may indicate inadequate oxygen delivery and are associated with poor outcomes including postoperative delirium and decreased long-term survival[13]. Arterial blood gases, base deficit, and lactate levels should be checked intermittently (approximately every 30 minutes), as rising levels of lactate during CPB represent anaerobic metabolism at the cellular level due to inadequate tissue oxygen delivery, and may reflect hypoperfusion particularly if sustained or associated with low mixed venous oxygen saturation values (SvO2 <70%)[14]. It is common practice to administer sodium bicarbonate for base deficit lower than -5, or lactate level >4 mEq/ litre, but excessive sodium bicarbonate administration can cause postoperative hypernatremia[15]. In our study, majority of the centers (86.7%) did not monitor mixed venous oxygen saturation continually during CPB while in 40% of the centers continuous arterial oxygen saturation was also not monitored. Serum Lactate level during CPB was monitored according to 73.3% of the respondents.

Heinrichs *et al*[16], found that there was a little difference in outcome when a hyperoxic rather than a normoxic oxygenation strategy was used during cardiac surgery, but these trials were small and heterogenous[16]. In this study, some of the respondents (46.7%) preferred to maintain PaO2 during CPB between 150 to 200 mmHg while others (40%) maintained PaO2 >200 mmHg.

Ventilation of the lungs during CPB has not been demonstrated to improve pulmonary function and may increase technical difficulty for the surgeon[17]. Most of the institutions in this study used apnoeic oxygenation technique to ventilate the lungs during CPB while some centers used low tidal volume ventilation technique.

Maintenance of renal blood flow is achieved by maintaining adequate CPB pump flow to minimize the risk of acute kidney injury (AKI). There are no data supporting the efficacy of pharmacologic agents (eg, mannitol, furosemide, or low "renal dose" dopamine infusion) for prevention of AKI after CPB[18]. Majority of the respondents monitored and maintained minimum urine output of 1 ml/kg/hr during CPB. Routine use of diuretics is not being inferred in context of the responses.

Anesthetic agent selection is unlikely to effect clinical outcomes during CPB[19]. It is reasonable to monitor processed electroencephalogram (EEG) indices (e.g., bispectral index) or an unprocessed EEG to provide data that may detect inadequate anesthesia during CPB[20]. Sevoflurane was preferred as volatile agent during CPB in most of the institutions but in majority of the centers they do not utilize scavenging system to

avoid pollution of the room caused by volatile agents during CPB. Most of the centers in this study used Processed Electroencephalogram (e.g. Bispectral index, Entropy, others) to monitor the depth of anaesthesia during CPB.

Hemofiltration is used to remove extra fluids as well as to induce haemoconcentration and elevation of haematocrit value to minimize blood transfusion[21]. In the present study, hemofiltration was not used regularly; instead they used it in patients having renal failure only.

Torina *et al*[22] concluded that the blood loss and transfusions requirement was decreased but the inflammatory response was increased by the use of modified ultrafiltration (MUF) in adults undergoing CABG. Most of the centers in this study used conventional ultrafiltration (CUF) while some were using MUF.

A 2018 meta-analysis suggested that it was reasonable to maintain hemoglobin threshold of 7.5 to 8g/dl by using restrictive transfusion strategy in patients undergoing cardiac surgery with CPB[23]. In the present study, the majority of the respondents transfused PRBC at hemoglobin of <7g/dl.

Metabolic abnormalities (eg, hyperglycemia, hypocalcaemia, hyperkalemia, hypokalemia, hypomagnesaemia) are common during CPB. Administration of calcium is avoided while the aortic cross-clamp is in place and for at least 10 to 15 minutes after the aortic cross clamp removal, thus allowing a period of myocardial reperfusion[24]. Calcium chloride was not administered in most of the centers in this study.

Hypokalemia may contribute to increased cardiac automaticity, leading to development of atrial or ventricular arrhythmias. Most of the centers in this study administered potassium chloride during CPB if it was <3.5meq.

Hypomagnesaemia is common during and after CPB due to diuresis and hemodilution. It is associated with dysarrhythmias, myocardial ischemia, and ventricular dysfunction. Most of the respondents administered magnesium sulfate (30 mg/kg).

After removal of the aortic cross-clamp, cardiac dysrhythmias are initially common (e.g., heart block, ventricular fibrillation, junctional rhythm). A lidocaine bolus of 1.5 mg/kg is often administered immediately prior to aortic cross-clamp removal to decrease the risk of ventricular fibrillation. In this study, almost half of the respondents did not used antiarrhythmic drug before discontinuation of CPB while others administered amiodarone in majority of their cases.

Harmand *et al* found that the silicone and PVC tubings were both shown to be non-hemolytic[25]. Heparincoated PVC tubing causes certain degree of cytotoxicity especially when in direct contact. Thrombosis was found to be significantly lower with the same heparincoated material. In this study, Conventional PVC circuit was utilized in most of the centers while Heparin coated Silicon circuit also been used in some centers.

LIMITATION OF STUDY

It was difficult to assess clinical practice among physicians working in different institutes or even in the same division. Due to less number of respondents, the results cannot be applied to suggest any changes in perfusion practices. As perfusionists were not the primary `respondents, so study results can be biased.

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CONCLUSION

We did not find any significant variation among perfusion practices nationally in adult open heart surgeries except that the routine use

of cell salvage was not done during CPB and this was found out to be major variation in context of the standard CPB perfusion practice. Overall their practice trends showed that they are following updated guidelines and maintaining standards in their institution.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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