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Not So Cool! Peri-Operative Hypothermia and Its Complications in Cardiac Surgery: Insights from an Indian Study

Dr. Nikhil PJ Theckumparampil[1], Sumithra R[2], Angel E[3], Dr. Paul R Ponraj[4], Dr. PSN Raju[5], Dr. D Janardhana Reddy[6]

Apollo Speciality Hospital, Vanagaram

Abstract: ***This study investigates the prevalence of peri-operative hypothermia in cardiac surgery patients and its associated complications, particularly focusing on the Indian context. We analyzed data from patients undergoing both on and off-pump cardiac surgeries, tracking temperature changes and their correlation with bleeding and blood transfusion requirements. Our findings highlight a significant occurrence of hypothermia and its potential complications, underscoring the need for improved peri-operative temperature management in cardiac surgery patients. Purpose: The purpose of this study is to evaluate the prevalence and consequences of peri-operative hypothermia in patients undergoing cardiac surgery in India, with a specific focus on bleeding and blood transfusion requirements. Methods: The data set included with sixty seven patients which are observed and recorded by our perfusion students prospectively. Temperature was recorded at 3 time points, once prior to entering the operating room, and once at incision and once after chest closure. The estimated blood loss volumes were obtained from anesthesia charts. Results: Of the 67 patients, 1 was excluded due to error in data collection. One mortality was recorded. The average temperature of the entire cohort at pre-op, incision and closure were 36.6^{o}C, 35.1^{o}C, 34.6^{o}C respectively. The OPCABG gp, experienced a significantly higher average drop in temperature than in ON PUMP gp (2.44^{o}C vs. 0.95^{o}C). The average estimated blood loss (EBL) in the OPCAB gp (726ml) was slightly more than ON PUMP gp (675 ml). The average blood product transfusion (Prod-Tfn) of the entire cohort was 1.9 Units (0-10). The OPCABG gp received significantly less Prod-Tfn compared to ONPUMP group (1.4 units vs.3.4 units). We further divided our cohort into two groups as >3^{o}C drop in temperature (>3°Gp) and <3^{o}C drop in temperature (<3°Gp). An EBL in the >3^{o}Gp, 820ml (259ml-1900ml) was significantly more than <3^{o}Gp, 667ml (300ml-1500ml). Among the OPCABG patients, the EBL in >3^{o}Gp was also significantly higher than the <3^{o}Gp (836ml vs 658ml). Similarly, in among the OPCABG patients, the average Prod-Tfn in>3°Gp was significantly more the <3°Gp (2.25units vs. 1.78 units). Conclusion: The magnitude of hypothermia was associated with increased risk of bleeding and blood product transfusions. This seems to affect OPCABG patients more. Maintaining normothermia might be useful in peri-operative management of patients undergoing cardiac surgery.***

Keywords: Peri-operative Hypothermia, Cardiac Surgery, Blood Transfusion, Bleeding Complications, Indian Medical Research

1. Background

Hypothermia in the peri-operative period is defined as core body temperature below 36 °C and this condition is further classified as mild (34°C-36°C), moderate (32°C-34°C), and severe (<32°C) depending on the lowest recorded temperature [1, 2]. Previous studies indicate that peri-operative hypothermia could lead to complications, such as coagulopathy, increased transfusion requirement, surgical site infection, delayed drug metabolism, extended duration of action of muscle relaxants, prolonged postoperative awakening time, prolonged recovery, shivering, thermal discomfort and increase metabolic demands during re-warming [3, 4]. Patients undergoing cardiac surgery are at particular risk of hypothermia. Patients admitted with a temperature of <36°C, in the intensive care unit (ICU), after cardiac surgery, both on and off pump were at greater risk of complications [5]. As most of this literature is from outside the Indian subcontinent we explored the relationship of hypothermia and cardiac surgery at our Institution as a pilot project.

2. Methods

Between October 2022 to April 2023, two perfusion students were designated to our unit. We included all consecutive patients they observed and documented during their time at our institution. Temperature was recorded at 3 time points; Once prior to entering the operating room, once at incision and once after chest closure. Age, sex, height, weight, BSA, BMI, temperature, blood loss and blood transfusions data was collected. Patient outcomes were recorded from the medical records. Both on and off pump cardiac surgeries were included in this study. All of the cardiac surgeries were performed under general anesthesia using standard techniques. Preoperative temperature was taken trans-orally in the ward. After anesthesia induction, a nasopharyngeal temperature probe was lubricated and inserted through the nasal cavity to continuously monitor the core temperature. The operating room temperature was set and maintained around 20°C with 40-60% humidity. The same team of anesthesiologists and surgeons treated all patients. The Estimated Blood Loss (EBL) volumes were obtained from anesthesia charts. The normal distribution of the data was determined using T-Test. Normally distributed quantitative variables were presented as the mean ± SD, while medians and ranges were used for non-normal variables. Categorical variables were compared using T Test. A p-value less than 0.05 is taken into consideration for statistically significant. We used a freely available online SPSS calculator to perform statistical analysis. (SPSS calculator www.socialstatistics.com)

3. Results

A total of 183 patients were operated on at our institution from October 2022 to April 2023. The mortality rate was 1% (2 out of 183 patients). Of these only 67 patients were observed and documented by the perfusion students. One patient was excluded due to error in data collection. The study therefore included 66 patients. Eighty three percent (55/66) were male. Average age was 59 (39-79) years. Off-Pump Coronary Artery Bypass Grafting (OPCAB) constituted the majority of the cases, accounting for 75.75% (50/66). Surgeries done on cardio-pulmonary bypass (ONPUMP) constituted 24.25%. Of these, On Pump Coronary Artery Bypass Grafting (CABG) accounted for 12.12**%** **(**8/66) cases, while valve surgery constituted 12.12% (8/66). Aortic Valve Replacement (AVR) & CABG (4), Mitral Valve Replacement (3) and Isolated AVR (1). One patient died in this study group (1.5%).

Average temperatures of the entire cohort at pre-op, incision and closure were 36.6°C, 35.1°C and 34.6°C respectively. The average drop of temperature from pre-op to incision was 1.5°C. The average drop of temperature from pre-op to closure was 2°C. Of the 66 patients 52 (78.8%) met the definition of hypothermia or <36°C at skin closure. In the OPCAB the average drop of temperature was more than in ONPUMP (2.44°C vs. 0.95°C) and this was found to be statistically significant ($p<0.05$).

The Average EBL of the entire cohort was 713.63ml (250ml-1900ml). Though the average EBL in the OPCAB group (726 ml) was slightly more than ONPUMP group (675ml), this did not achieve statistical significance. The Average blood product transfusions (Prod-Txn) of the entire cohort were 1.9 Units (0-10). There was a statistically significant reduction in Prod-Txn in the OPCAB group compared to the ONPUMP group (1.4 units vs. 3.4 units $p < 0.05$).

The one mortality in the study group was in the hypothermia group. To further determine the effects of intra-operative hypothermia we decided to divide our cohort into 2 groups based on degree of hypothermia. The 66 patient cohort was divided into 2 groups as >3°C (moderate and severe hypothermia) and <3°C drop in temperature (Normal and mild hypothermia) from baseline to skin closure. The >3°C group (>3°Gp) consisted of 20 patients. Nineteen of these patients were OPCAB with only 1 patient done ONPUMP. The remaining 46 patients in the <3°C group (<3°Gp) had 31 OPCAB patients and 15 ONPUMP.

The patient mortality was in the >3°Gp. The Average EBL in the >3°Gp was 820ml (250ml-1900ml) was significantly more than <3°Gp 667 ml (300ml-1500ml). Further the average EBL for off pump CABG cases in >3°Gp was 836 ml and <3Gp was 658 ml. This also reached statistical significance. Though the average Prod-Txn in >3°Gp was more the <3°Gp, it was not statistically significant (2.25units vs. 1.78 units). However when we compared Prod-Txn in OPCABG patients we saw a statistically significant increase in Prod-Txn in the >3°Gp compared to the <3°Gp (1.95 units vs. 1.13 units)

	>3°C temperature drop	<3°C temperature drop	P value
Avg. Overall Blood Loss	820ml (250-1900)	667.39ml (300-1500)	0.04
Avg. OPCAB Blood Loss	836ml (250-1900)	658.06ml (300-1500)	0.038
Avg. OPCAB Prod-Txn	1.95 units (0-9)	1.13 units (0-4)	0.04

4. Discussion

Hypothermia is commonly associated with surgery [6]. ICU admission temperature was <36°C is associated with adverse post operative outcomes [5]. Previous studies report a 50% to 90% incidence of hypothermia in surgery patients [7]. A recent multicentre study, of more than 2000 patients having off-pump coronary artery surgery, found that 50% patients were hypothermic on arrival to the ICU [8]. No studies from India have reported on hypothermia in cardiac surgery. We decided to do a pilot project to evaluate this relationship.

In our study more than 2/3rd of the patients suffered from post operative hypothermia (<36°C). This was within limits of previous studies pertaining to surgery in general [7]. But when looking specifically at cardiac surgery patients our incidence seem to be on the higher side [8]. Compared with on-pump CABG, patients receiving off-pump CABG experienced greater drops in body temperature post surgery. And this also is in line with the existing literature [9]. Of note all our ONPUMP patients were cooled to 32°C and re-warmed prior to separation from cardio pulmonary bypass (CPB). The CPB with a heat exchanger, seems be able to maintain appropriate temperatures compared to the circulating warm water blankets we use for OPCAB.

The Wang study also showed that post operative hypothermia was an independent risk factor for prolonged ICU stay. This finding was especially significant in off-pump CABG patients [9]. Though not causal, our mortality was in the hypothermia group and OPCAB. When we investigated the patients with moderate to severe hypothermia, they revealed some of the previously reported adverse outcomes. Our patients showed an increase in blood loss, in patients with moderate to severe hypothermia. This was particularly severe in OPCAB patients.

As in the literature we did observe more Blood product transfusion in the ONPUMP group [8]. But when we reclassified the cohort into the temperature groups, we found that the Moderate to Severe hypothermia (>3°Gp), in spite of having 19/20 OPCAB patients, had more blood transfusions than Norm/Mild hypothermia group (<3°Gp), though this was not statistically significant. In the OPCAB subgroup itself, the blood loss and need for transfusion were both significantly more in patients with Moderate to Severe hypothermia (>3°Gp).

There are reports of benefits from hypothermia in cardiac surgery patients. Mild hypothermia has been proven to hold myocardial feature and decrease postoperative neurological dysfunction [10]. Conflictingly, hypothermic CPB temperatures in some studies have been associated with numerous peri-operative complications [11]. Moreover,

there is evidence that mild hypothermia during CPB does not offer any benefit regarding neuro-protective effects compared to normothermia [12]. Though there is controversy about intra-operative hypothermia, post-operative hypothermia has been considered a common but preventable, unfavorable event, in order that its avoidance has been endorsed and integrated into various clinical guidelines [13]. The Surgical Care Improvement Project suggested a final intra-operative temperature above 36°C and/or use of active over-body warming whether or not core temperature reached 36°C [14]. In the United States, practice guidelines recommend that all surgical patients be actively warmed [15].

Typically patients are being exposed to cold ambient air in the preoperative period; nearly all arrive in the operating theater with peripheral vasoconstriction and cold peripheral tissues. Though the thermoregulation keeps the core warm, redistribution after anesthesia induction will cause the initial drop in core temperature as was seen in our study [16, 17]. The best management of peri-operative temperatures include measurement of core temperature, to pre-warm the patients actively before induction of anesthesia, to warm the patients during anesthesia, to use fluid warming for intravenous fluids, increased room temperature, warming blankets and hot packs intra and post operatively [16, 17]. Infusion warming device with short tubing after heat exchanger should be used from the start of the procedure. If warming device not available then tubing can be placed under forced-air warming blankets or alternatively pre-warmed fluids may be given [17]. Forced air blankets, circulating water garments and warming blankets may be used to actively keep patients warm during surgery by applying them over non surgical surfaces. Hot packs and warm blankets in addition to above may be used in the post operative period to re-warm the patient [15, 17].

5. Limitations

The major limitation of our study is the small numbers included. However, these were consecutive and non selected patients observed by our perfusion students. Our study is observational and can only demonstrate associations and not causations. And longer the term post discharge outcomes were not included. In-spite of these, our study points to similar outcomes of previous studies. There is a paucity of hypothermia related outcomes of cardiac surgery in the Indian adult population and we intend to add to the literature in this regard. Our findings suggest that further studies, including randomized controlled trials, may be useful to determine the true magnitude of adverse effects and if correcting hypothermia improves clinical outcomes. This was an exploratory and hypothesis generating pilot study. We are in the process of a larger in depth study.

6. Conclusion

The study concludes that peri-operative hypothermia is a prevalent and concerning issue in cardiac surgeries in India, leading to increased risks of bleeding and blood transfusion. Maintaining normothermia might be useful in peri-operative management of patients undergoing cardiac surgery, especially OPCABG, by reducing bleeding and need for blood transfusion. The findings advocate for more stringent temperature management protocols during such surgeries to improve patient outcomes.

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