

RESEARCH ARTICLE

COMPARISON STUDY: INTERMITTENT ANTIGRADE WARM CARDIOPLEGIA VERSUS ANTIGRADE COLD INTERMITTENT BLOOD CARDIOPLEGIA FOR MYOCARDIAL PROTECTION DURING ELECTIVE ON PUMP CORONARY ARTERY BYPASS GRAFTING IN EARLY POST-OPERATIVE PERIOD

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Abstract

..... Background: Defending the heart against potential damage during cross-clamping is the most important and vital step to ensuring a successful surgical outcome(1). The creation of cardioplegia solutions was one of the major advances in cardiac surgery that allowed surgeons to conduct complicated surgical procedures to avoid myocardial injury (14). Treating cardioplegia at a cool temperature would be a significant factor in lowering myocardial metabolism. However, the reduction in myocardial metabolism due to hypothermia, compared with that achieved by diastolic arrest, is usually very negligible. Since Normothermia's enzymatic and cellular processes work better (7). Owing to the propensity of the heart to resume electrical operation during normothermia, however, this must be administered consistently or only with short interruptions (4). Terminal warm blood cardioplegia ('hot shot') is normally done just before the elimination of the aortic cross-clamp since it has been demonstrated that myocardial metabolism is increasing (23).

Methods: A prospective controlled randomised study (200 hundred patients aged 40 to 65 years of both sexes underwent elective CABG pump surgery) will be included.

They will be divided into three groups of patients:

Group I:includes 100 Patients who received intermittent cold blood cardioplegia.

Group II: includes 100 Patients who received intermittent warm blood cardioplegia with controlled reperfusion for 3 minutes before aortic unclamping. Study made from January, 2019 to August, 2020, at National Heart Institute.All patients were thoroughly evaluated preoperatively, intraoperatively, and postoperatively.

Results: We hypothesized that in our patient cohort, warm blood cardioplegia could be as successful as or even better than the conventional antegrade cold blood cardioplegia. Patients were randomised into two similar blocks, each of which consisted of 100 patients, each of whom obtained one of the two cardioplegic solutions. Our analysis did not indicate a statistically important difference in the post-operative release of myocardial biomarkers (Troponin I) & CK in both classes. This finding did not significantly reflect the clinical outcome of our patient, which may indicate similar myocardial

protection in primary low-risk CABG patients for both cold and warm blood cardioplegia.

Conclusion: During the time of cardiac arrest, both methods tend to enable an equal and adequate approach for myocardial defence. To attain improved myocardial defence, warm blood cardioplegia needs a shorter administration interval. Therefore, the choice between one type of cardioplegia and the other remains at the discretion of the surgeon. The statistically minor variation found in the release of myocardial enzymes did not translate into distinct clinical results.

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Introduction:-

Cardioplegia is the most effective technique for maintaining myocardial activity during cardiac surgery and for acquiring a bloodless operating area. Cardioplegia is the agent that causes hyperkaliemic hypothermic arrest. Blood was also considered to be a key vehicle for potassium cardioplegia delivery (14).

The advantage of cold blood cardioplegia associated with mild to moderate hypothermia is that it reduces oxygen consumption and provides some degree of protection during low flow or low perfusion pressure periods. In comparison, when doing distal coronary artery anastomosis, cold blood cardioplegia offers a clearer vision (1).

As a healthy and effective procedure for myocardial safety, warm blood cardioplegia has been suggested based on the rationale that blood would theoretically enhance postoperative cardiac outcomes as opposed to crystalloid solution, since it approximates natural physiology more precisely, i.e. transporting oxygen to the myocardium or maintaining less hemodilution (7). In addition, to ensure shorter cycles, it is safer for enzymatic and cellular functioning (23). consequently, during cardiac surgical operations, there is also a controversy over improved cardioplegia for myocardial safety.

Aim of the work:

The objective of this study is to evaluate the short-term results of intermittent antegrade warm cardioplegia versus antegrade cold intermittent blood cardioplegia during elective pump coronary artery bypass grafting (CABG) during the early post-operative period for myocardial protection.

Patients and Methods:-

200 adult patients who underwent elective on-pump coronary artery bypass grafting (CABG) procedures were included in a randomised prospective trial. At the National Heart Institute, participants were recruited between January 2019 and August 2020. In our study, the enrolled patients were divided into two equivalent classes according to the form of myocardial defence chosen. Preoperatively, intraoperatively, and postoperatively, both patients were adequately examined.

Patients:

They will be divided into three groups of patients:

Group I:

Includes 100 patients who received intermittent cold blood cardioplegia.

Group II:

100 patients undergoing periodic warm blood cardioplegia with controlled reperfusion for 3 minutes prior to aortic unclamping were included.

- 1. Study made from January, 2019 to August, 2020, at National Heart Institute.
- 2. Preoperatively, intraoperatively, and postoperatively, both patients were carefully examined.

The research procedure was accepted by the Institution's Ethics Committee / Institutional Review Board and informed consent was received from each patient.

Inclusion criteria:

- 1. A form of informed written consent will be signed by the patients participating in the study.
- 2. Include coronary artery disease patients who have endured traditional elective on-pump coronary artery bypass grafting and who have received occasional warm or cold blood cardioplegia.
- 3. 1^{st} do patients.
- 4. Elective cases of CABG.
- 5. Patients with ejection fraction above 35%.
- 6. Patients with one to four grafts.
- 7. Sinus isolated ischemic heart disease without other cardiac disease (rheumatic, congenital, etc).

Exclusion criteria:

- 1. CABG associated with significant ischemic mitral regurgitation which necessitates mitral valve surgery.
- 2. Other methods of myocardial protection (off-pump CABG, or on-pump beating CABG.
- 3. Redo patients.
- 4. Emergency cases of CABG.
- 5. Patients with ejection fraction less than 35%.
- 6. Patients with recent infarction within the last month.
- 7. Other comorbidities as : kidney, liver and respiratory failure
- 8. Ischemic heart disease with other cardiac disease (rheumatic, congenital, etc).
- 9. Combined with valvularlesion which requirevalvular surgery.

Pre-operatively:

- 1. Cardiac enzyme and Troponin I (ctn 1).
- 2. Biochemical Marker Evaluation Blood tests for serum creatine kinase (CK) levels were taken at the time of entry into the intensive care unit and troponin-I levels were taken at 6, 12, 24 and 48 hours after aortic unclamping. Serum cardiac troponin-I (normal range, 0 to $0.02 \mu g/L$) concentration.
- 3. Electrocardiographic tracings were obtained the day before operation and immediately after arrival in the intensive care unit.
- 4. The following data have been obtained from each patient Preoperative criteria which include history taking, informed consent, clinical evaluation, full laboratory investigations, plain chest X-ray 12- lead ECG, echocardiography, coronary angiography, carotid duplex and preoperative counselling and consenting. Intraoperative data have been collected and include total cardiopulmonary bypass time, cross clamp time, warm or cold cardioplegia, the performed procedure and weaning off cardiopulmonary bypass.

Intra-operatively:

Intraoperative data have been collected and include total cardiopulmonary bypass time, cross clamp time, warm or cold cardioplegia, the performed procedure and weaning off cardiopulmonary bypass.

Post-operatively:

- 1. ICU stay and ventilation.
- 2. Using inotropic agents when indicated.
- 3. Spontaneous developing of sinus rhythm after release of aortic clamp.
- 4. Usage of intra-aortic Balloon Pump (IABP) support noted.
- 5. Blood transfusion.
- 6. Assessment of biochemical marker blood samples for the identification of serum cardiac enzyme levels, removal of creatine kinase (CK) at arrival in the intensive care unit and removal of troponin-1 levels at 6,12,24 and 48 hours after aortic de-clamping. (normal range of serum cardiac troponin-1 concentration. 0 to 0.02 μ g / L)
- 7. Post-operative ECG & echocardiography.
- 8. Ward stay and in-hospital morbidity and mortality.
- 9. Prophylactic antibiotics for 5 days.
- 10. Drains removed when drainage stops.

All the patients have been followed up at our outpatient clinic for 2 months clinically, ECG tracing and by echocardiographic data.

Preoperative preparation:

The morning dose of cardiac medicine was given to all patients.

After arrival in the preparation room, local anaesthesia was used to insert a 14 gauge peripheral intravenous cannula.

Using 0.03-0.07 mg / kg midazolam, sedation was optimised. Local anaesthesia was used to implant a 20 gauge nondominant radial artery cannula.

Two blood samples, 1st for preoperative baseline activated clotting time (ACT) and 2nd for baseline arterial blood gas (ABG) analysis, were removed from the arterial line.

Preoperative monitoring began with the use of five ECG leads, direct arterial blood pressure and pulse oximetry.

Steps of surgery:

Preoperative preparation and anesthesia.

Left internal mammary artery (LIMA) & saphenous vein graft (SVG) for complete median sternotomy& harvesting.

Aorto-cavalcannulation, then starting cardiopulmonary bypass.

Cross clamping of ascending aorta & administrating cardioplegia (anti-grade warm or cold intermittent cold cardioplegia).

Applying the distal & proximal anastomosis.

Finally, weaning from cardiopulmonary bypass & applying drains and closure in layers after hemostasis.

Patients in the hypothermic population were cooled to body temperatures of 31-32 ° C (nasopharynx) following activation of CPB. Re-warming started 10-15 minutes prior to the activation of the aortic cross-clamp.

Cardioplegia Techniques Myocardial protection was conducted according to group allocation through antegrade cold blood cardioplegia or warm antegrade blood cardioplegia. With a pressure of 80-90 mmHg, cardioplegia was injected into the ascending aorta.

Patients randomised to receive sporadic cold blood cardioplegia were spontaneously drifted to cool down to 30 $^{\circ}$ C to 32 $^{\circ}$ C after the development of cardiopulmonary bypass, while those randomised to receive warm blood cardioplegia were kept warmer than 35 $^{\circ}$ C during interval or continuous re-warming treatment.

With a nasopharyngeal probe, the body temperature was monitored continuously. The blood cardioplegia potassium concentration for both patients was 20-30 mmol / L. On both patients, the initial level of induced blood cardioplegia was 15-20 mL / kg. On both patients, the volume of resulting intermittent blood cardioplegia was 8 mL / kg.Throughout the procedures to ensure reduction of oxygen intake and ATP use, the mixture of asystole and decompression of the heart by venting was continuously determined. The aortic root is de-aired before each maintenance dose of antegradecardioplegia to prevent air from penetrating the coronary arteries.

Per 1000mL contains: 6.43 g of sodium chloride, 1.19 g of potassium chloride, 3.25 g of magnesium chloride, 175 mg of calcium chloride, 1.1 mmol / L of procaine hydrochloride, and 5 g / L of mannitol. The mixture contains 1000mL of the following ions: 110 mmol of sodium, 30 mmol of potassium, 16 mmol of magnesium, 1.2 mmol of calcium, 160 -mmol chloride, and 30-mmol mannitol. For 10 mL of 8.4 percent (840 mg) sodium bicarbonate injection combined for every 1000 mL of cardioplegic solution, the pH is balanced to around 7.8. In addition, sodium bicarbonate has been used to buffer acidosis during arrest.For oxygen radical scavenging and osmotic properties, inert sugar mannitol was used to improve osmolarity, sodium bicarbonate to buffer acidosis during arrest, and procaine hydrochloride to regulate the capacity of the membrane and to suppress arrhythmias.

Magnesium chloride may help stabilise the myocardial membrane by inhibiting the post-ischemic activity of myosin phosphorylase, which protects adenosine triphosphate (ATP) reserves. Intermittent Cold Blood Cardioplegia After cardio-pulmonary bypass, both patients were cooled to 30 ° to 32 ° C.

Once the aorta has been cross-clamped, the aortic root is infused with 1 L of chilled cold (4-6 $^{\circ}$ C) blood cardioplegia. Approximate composition of the applied blood cardioplegia was four parts blood to one part Ringers' crystalloid solution. The blood cardioplegia potassium concentration was 20-30 mmol / L for all patients in the cold group. On both patients, the volume of induced blood cardioplegia was 15-20 mL / kg. For all patients, the amount of subsequent intermittent cold blood cardioplegia was 8 mL / kg. After each distal anastomosis, both the aortic root and the completed venous grafts were infused with 300 to 600 ml of cold blood cardioplegia. If after any cardioplegia infusion, myocardial electrical activity was identified, an additional 300 to 600 mL of cardioplegia was infused until the cardiac activity stopped.

Proximal anastomoses were performed during a partial occluding clamp after crossclamp removal. When myocardial activity persists or recurs, cardioplegia solution may be reinfused at a rate of 300 mL/m2/minute for a period of two minutes. Reinfusion of the solution may be repeated every 30 -35 minutes or sooner if the myocardial temperature rises or returning cardiac activity is observed.

To help ensure the cooling of the myocardium, cardioplegia solutions have often been supplemented with topical cold saline or slush. To maintain sufficient hypothermia, the regional hypothermia solution around the heart can also be replenished continuously or regularly. To extract warmed infusates, suction was used.

To administer a small amount of a prepared arresting solution via a pump-driven syringe to the unmodified blood originating from the CPB circuit, Intermittent Warm Blood Cardioplegia was used. A roller pump was used to reinfuse blood removed directly from the pump oxygenator at 34-37 °C into the aortic root. The volume and rate of distribution of the potassium solution for concentrated cardioplegia was steadily lowered to the lowest level possible to preserve cardiac quiescence.

The first dosage lasts for 2-3 minutes at a flow rate of 300 ml / min (900 ml overall). For a cardioplegic arrest, the duration is registered. The syringe pump delivered 2 ml of the solution in about 20 s and then the flow rate was reduced to 150 ml / min, producing a final potassium chloride concentration of 20-30 mmol / L.

After each distal anastomosis (or after 10-15 minutes of ischaemia), a second dose of cardioplegia is administered at a flow rate of 200 ml/min (blood) containing potassium chloride and magnesium solutions for a further 2 min. After completing the last distal anastomoses (LIMA to LAD) and before releasing the cross-clamp, we applied controlled reperfusion —hot-shotl for 3 minutes with magnesium and procaine hydrochloride, but no further potassium chloride. This 3 minutes period of hot-shot delivery was used to remove the effect of cardioplegia.

The continuous blood infusion through the aortic root was administered until the heart regains its contractility, then the aortic root vent is used to de-air the heart and the cross clamp is then removed.

During CPB, hematocrite was maintained at around 28%. Myocardial defence was conducted according to party allocation by antegrade warm blood cardioplegia or antegrade cold blood cardioplegia.

Statistical Analysis:

Statistical Analysis methods include Values that were presented as means + SD or as numbers and proportions, as appropriate. The relations between qualitative variables were evaluated by Chi-square test or Fisher's exact test, as indicated. Means were compared with Student's test. Variables with P values < 0.05.

Results:-

This work was conducted on 200 consecutive patients who underwent isolated elective first time coronary artery bypass grafting (CABG) in National Heart Institute from 2019 to2020.

Preoperative data:

In group I, there were 56 males and 44 females, along with 59 males and 41 females in group II. The mean age was 55.67 ± 5.3 years for group I and 53.86 ± 5.3 for group II. As shown in table (1), there was no statistical difference between the two groups as to their age and gender distribution.

Both patients with a history of angina and chest pain in both types. Twelve patients in group (I) had NYHA Class I, 13 patients had NYHA Class II, 74 had NYHA Class III, and 1 patient had NYHA Class IV, while 26 patients in group (II) had NYHA Class I dyspnea, 10 patients had NYHA Class II, 62 had NYHA Class III, and 2 patients with NYHA Class IV dyspnea, mean ($2.64\pm0.7 \text{ vs } 2.4\pm0.89$) for group I and II (p=0.074) respectively (Table 1). In both groups, IHD preoperative risk factors and demographic data, including hypertension, diabetes and smoking, were comparable. In contrast, in both classes, preoperative laboratory trials were within the standard spectrum (with no major difference). The level of preoperative troponin was also ($0.03657\pm.02957$) in the cold group (I) and (0.0416 ± 0.03102) in the warm group (II). Table (1).

Intraoperative data:

In terms of bypass and cross clamp times, Table 2 shows that there was no statistically significant difference between the two groups. However, as regards random defibrillation, there is a statistically important difference between the two groups (55 patients in group I versus 93 patients in group ??). It should be noted that there were no significant differences between the two groups with regard to the inotropic support or IABP required to achieve weaning (Table 2). In addition, no statistically meaningful difference was observed between postoperative CK and troponin levels after 6, 12, 24, and 48 hours. In addition, there were no statistically significant differences in postoperative reopening, injury, ventilation time, infection, mortality and stroke.

Postoperative and discharge data:

In terms of postoperative complications, there was no statistically significant difference between the two groups. The postoperative problems in the two classes are seen in Table (2).

Both the patients had echocardiography at the time of discharge. In terms of the LV function, there was no statistically meaningful difference between the two classes. For research patients, clinical examination and followup echocardiography was conducted one and two months after surgery and no statistically significant discrepancy was observed between the two classes. Comparable postoperative echocardiographic results with a statistically nonsignificant discrepancy and retained myocardial performance were recorded by the two groups at two month intervals for both patient groups (Table 3).

| Items | | | | | | |
|--|--------|--------------------|----------------|--------|------|---------|
| | | Group I (N=100) | | Group | II | |
| | | | | (N=10 | 0) | |
| | | Ν | % | Ν | % | P-value |
| Gender | Female | 44 | 44.0 | 41 | 41.0 | 0.885 |
| | Male | 56 | 56.0 | 59 | 59.0 | |
| Mean age | | 55.67±5.3 | | 53.86± | 5.3 | 0.920 |
| Hypertension | | 43 | 43.0 | 47 | 47.0 | 0.851 |
| Diabetes mellitus | | 58 | 58.0 | 61 | 61.0 | 0.950 |
| Smoking | | 57 | 57.0 | 58 | 58.0 | 0.838 |
| Hyperlipidemia | | 35 | 35.0 | 41 | 41.0 | 0.471 |
| Family history of CAD | | 39 | 39.0 | 35 | 35.0 | 0.347 |
| Mortality | | 1 | 1.0 | 1 | 1.0 | 1 |
| Inotrop during first 24 hr after surgery | | 71 | 71.0 | 57 | 57.0 | 0.066 |
| Ventilation time> 24 hr | | 4 | 4.0 | 5 | 5.0 | 0.261 |
| Average NYHA class | | 2.64± | 2.64 ± 0.7 | | .89 | 0.074 |
| AF | | 23 | 23.0 | 18 | 18.0 | 0.484 |
| Mean LV ejection fraction % | | 53.3±4 | 53.3±4.9 | | .4 | 0.925 |
| Mean diameter of left atrium (cm) | | 3.8±0. | 3.8±0.9 | | 2 | 0.412 |
| Mean LV end-systolic diameter (cm) | | 3.8±0.1 | 3.8±0.3 | | 9 | 0.171 |

| Mean LV end-diastolic diameter(cm) | 5.4±0.5 | 5.6±0.6 | 0.915 |
|-------------------------------------|----------------|----------------|-------|
| Mean NO. of grafted vessels | 2.7±0.6 | 2.8±0.5 | 0.506 |
| Mean aortic cross-clamp time(min) | 55.4±7.6 | 53.0±6.6 | 0.055 |
| Mean pump perfusion time (min) | 94.2±10.2 | 93.8±7.2 | 0.214 |
| mean intensive care unit stay (day) | 2.6±1.1 | 2.4±0.5 | 0.216 |
| Preopcariac troponin I cTnI (µ/ML) | 0.03657±.02957 | 0.0416±0.03102 | 0.235 |
| S. creatinine (mg %) | 0.91±0.2694 | 0.84±0.2329 | 0.054 |
| SGPT (IU/dl) | 13.21±3.397 | 13.42±3.235 | 0.655 |

Non sig. >0.05 Sig. <0.05* High sig. <0.001*

 Table 2:- Hospital outcome.

| Items | | | | | _ |
|-----------------------------|-------------|------|-----------------|------|----------|
| | Group I | | Group II | | |
| | (N=100) | | (N=100) | | |
| | Ν | % | Ν | % | P-value |
| Use of IABP | 9 | 9.0 | 6 | 6.0 | 0.593 |
| Wound infection | 1 | 1.0 | 4 | 4.0 | 0.059 |
| Reopening | 2 | 2.0 | 1 | 1.0 | 0.497 |
| Stroke | 1 | 1.0 | 1 | 1.0 | 1 |
| Spontaneous defibrillation | 55 | 55.0 | 93 | 93.0 | 0.0001 * |
| Postoperative CK level (IU) | 30.3±16.10 | | 29.5±20.02 | | 0.084 |
| Troponin 6 hrs. (µg/mL) | 0.0919±0.06 | | 0.1076±0.08 | | 0.142 |
| Troponin 12 hrs. (µg/mL) | 0.198±0.102 | | 0.22±0.107 | | 0.098 |
| Troponin 24 hrs. (µg/mL) | 0.199±0.129 | | 0.23±0.1279 | | 0.096 |
| Troponin 48 hrs. (µg/mL) | 0.093±0.036 | | 0.106±0.081 | | 0.133 |
| S. creatinine | 1.30±.308 | | $1.41 \pm .464$ | | 0.506 |
| Hb (gm %) | 11.63±1.971 | | 11.76±1.785 | | 0.623 |
| SGPT | 30.38±21.20 | | 28.79±25.19 | | 0.63 |
| Mortality | 1 | | 1 | | 1 |

Non sig. >0.05 Sig. <0.05* High sig. <0.001*

 Table 3:- Hospital outcome.

| Items | Group I (N=100) | | Group II (N=100) | | | |
|-----------------|--------------------|---|---------------------|---|---------|--|
| | Ν | % | Ν | % | P-value | |
| One month data | | | | | | |
| LVEDD | 5.6 ± 0.2 | | 5.5 ± 0.2 | | 0.07 | |
| LVESD | 3.9 ± 0.2 | | 4.1 ± 0.2 | | 0.06 | |
| LA | 3.9 ± 0.1 | | 3.9 ± 0.1 | | 1.00 | |
| EF% | 58.5 ± 2.4 | | 57.5 ± 1.9 | | 0.06 | |
| Two months data | | | | | | |
| LVEDD | 5.15±0.56 | | 5.31±0.75 | | 0.0841 | |
| LVESD | 4.04±0.57 | | 3.8±0.57 | | 0.054 | |
| EF (%) | 58.48±3.08 | | 59.39±3.53 | | 0.053 | |
| LA | 4 ± 0.1 | | 4± 0.1 | | 1.00 | |

Non sig. >0.05 Sig. <0.05* High sig. <0.001*

Discussion:-

With the already available hyperkalaemiccardioplegic solutions, myocardial cell damage following cardiac surgery is inevitable. To decrease this cellular damage, multiple changes were made to the cardioplegic solutions (1). The concept of warm blood cardioplegia was introduced in 1983, based on a study that found that the normo-thermal arrested heart requires 80-90 percent less oxygen than the normal working heart and reports that 'Hot Shot' has a

significant positive effect on myocardial recovery (23). In a retrospective analysis, the intentional use of sporadic antegrade warm blood cardioplegia was first recorded by Calafiore (7).

One of the biomarkers used for risk assessment of several cardiac diseases and post-cardiac surgery (1) is cardiac troponin I (cTn I). Cardiac troponin I (cTn I) is one of the biomarkers used for risk assessment of several heart diseases and post-cardiac surgery. It is released whenever myocardial injury occurs, regardless of the injury mechanism and its release. It has been observed that its release after cardiac surgery is associated with increased morbidity and mortality (26). High sensitivity cardiac cTn I is therefore a predictor of myocardial damage and, in many cardiac pathologies and after heart surgery, has a prognostic function (14). We speculated that cardioplegia in warm blood was as successful or equivalent to cardioplegia in cold blood.

Baig MA (3) completed a study on 215 CABG patients. 94(44 percent) of the surveyed patients were in the sporadic antegrade warm blood cardioplegia group with a mean age of 54.61 ± 7.85 years and 121(56 percent) in the cold blood group with a mean age of 53.85 ± 9.32 years. The average surgical time was 119.26 ± 22.24 minutes in the cold blood category, in the warm blood cardioplegia group (p > 0.0001), equivalent to 105.73 ± 31.34 minutes. Random sinus rhythm resumption and peri-operative myocardial infarction were statistically marginal (p > 0.05). Within the sporadic antegrade community of cold blood cardioplegia, in the sporadic antegrade warm blood cardioplegia group (p=0.10), 21(17.4 percent) patients had perioperative myocardial infarction, compared with 9(9.6 percent). The two groups were close in terms of their demographic characteristics, with the mean age of the warm blood cardioplegia group (3).

In our analysis, the mean bypass time and cross-clamp time were minutes $(94.2\pm10.2 \text{ and } 55.4\pm7.6)$ and minutes $(93.8\pm7.2 \text{ and } 53.0\pm6.6)$ for Groups I and II, respectively. Our findings are close to those of Martin et al. (22), who recorded a mean bypass time of 86.4 ± 29.6 to 83.5 ± 29.7 minutes and an average cross clamp time of 48.9 ± 20.5 to 50 ± 23.4 minutes for an average of three distal anastomoses. Calaffore et al (7) reported a mean bypass time of 67.2 ± 21.3 to 76.3 + 27.5 minutes and an average cross clamp time of 45.2 ± 16.3 to 44.8 ± 15.2 minutes. Our findings also match that of Zeriouh et al.(30), who reported an average bypass time of 77.96 ± 25.20 to 82.93 ± 32.25 minutes for elective CABG, and an average cross clamp time of 39.92 ± 12.65 to 43.96 ± 15.85 minutes.

In our research, the parameters used to assess the two myocardial preservation methods were CKMB and cTnI for the calculation of ischaemic myocardial injury, inotropic assistance, and use of IABP, retention of ICU, mechanical ventilation, and mortality rates to represent the clinical outcome of myocardial survival.

As an indicator of myocardial healing after a time of cross-clamping, spontaneous defibrillation has been used by many surgeons and could reflect the condition of effective myocardial response (5). The level in our study of random defibrillation was 71 percent. In 93 warm blood group II patients, there was a statistically relevant discrepancy in the level of spontaneous resumption of sinus rhythm between the two classes compared to 55 cold group I patients (p 0.0001). From Jacquet et al. (17) in the cold population, intermittent warm blood cardioplegia spontaneous defibrillation was reported at 96.2 percent versus 83.6 percent. Elwatidy et al. (10) registered 95.7 percent spontaneous defibrillation in the warm blood population, compared to 2.5 percent in the cold population. In the article from Christakis et al (8), the rate of spontaneous defibrillation during cross-clamp removal was higher in patients with Normothermia (64%) than in patients with hypothermia (33%) (p<0.01). In our study, in warm blood group II patients, the incidence of spontaneous defibrillation could be attributed to the application of a hot shot of warm blood before de-clamping. The hot shot offers energy replenishment and regeneration from aerobic metabolism, Spontaneous heart defibrillation is intuitively known as a "good thing" by surgeons after eliminating cross-clamps, resulting in more physiological healing and higher rate of coronary blood pressure with marginally better control (23). There may be less depletion of high-energy phosphate or less heart distention due to the lack of fibrillation. It is well known that hypothermia alone can induce heart fibrillation (21).

The aortic cross clamp time in the cold blood cardioplegia group was 65.71 ± 13.58 minutes vs 62.52 ± 13.38 minutes in the warm blood group (p=0.08) in the Baig and coworkers analysis (3). Weaning doses of epinephrine were slightly low in the community of cold blood cardioplegia (p=0.006). In Category II, the frequency of IABP usage and postoperative peak levels of CK-MB were substantially high (p<0.05). In 14(12.6%) patients in the cold blood cardioplegia group, IABP was inserted, compared to only 4(4.3%) in the warm blood group (p=0.03). Max post-operative CK-MB values in the cold blood community were 106.19±94.28 IU / L and 70.50±38.03 in warm blood group (p > 0.0001).

In our study there was no difference in the incidence of post-operative atrial fibrillation between the two groups (23 vs. 18) in warm blood group and cold blood group respectively, (p value 0.3). Our data also confirm those by Fan et al. (11) who conducted a meta-analysis of warm versus cold cardioplegia identifying 41 randomized controlled trials with 5,879 patients. The in-hospital mortality, length of stay, incidence of stroke, and atrial fibrillation and use of balloon pumps did not differ between groups.

However, warm cardioplegia was associated with significantly better postoperative cardiac index (P< 0.00001), lower troponin concentrations on day 0 (P = 0.006), and significantly lower peak CKMB concentrations (P = 0.002). Fan et al (11) reported that the concentrations of both cTn and CK-MB were significantly reduced in warm group after surgery, as compared with the cold group. Their results demonstrated that warm cardioplegia was associated with lower postoperative enzyme release, which might indicate less cardiocyte injury (11). Mallidi et al (20) performed a prospective single center cohort study comparing patients receiving cold or tepid/warm cardioplegia during isolated CABG on early and late outcomes and found superior outcomes in the warm cardioplegia arm: perioperative death (1.6 versus 2.5%, P 0.027) and myocardial infarction (2.4 versus 5.4%, P<0.0001). The intermittent cold blood cardioplegia technique is probably associated with a higher incidence of fibrillation because the cold heart is exposed to cold blood when the cross-clamp is removed (23).

In our study, 71 patients in group I, compared to 57 patients in group II, experienced a need for inotropic support during the first 24 hours, which was statistically insignificant (p 0.66). The use of IABP was equal between the two categories: 9 patients versus 6 patients in categories I and II (P 0.593) respectively. Elwatidy et al (10) recorded an overall low cardiac output (LCO) of 9.5% relative to the tepid blood group, with a higher percentage among the cold group. In the cold community, they also reported more use of IABP than tepid bloodgroup (10).

Jacque et al (17) reported an incidence of 50 % use of inotropic support and 3.5% incidence of IABP use. The percentage was higher in cold group but this difference did not reach a statistical significance. Zeriouh and co-workers reported 11% incidence use of inotropic support in patients who underwent elective CABG with higher percentage in cold group but without a statistical significance (30).

However, Calafiore et al (7) reported statistically substantial higher low cardiac performance (CO) in patients having warm blood cardioplegia relative to cold blood cardioplegia, while in patients undergoing warm heart surgery, Christakis and associates reported a threefold higher occurrence of intraoperative vasopressor help (8).

In our study, 2 patients (1.5 percent) had postoperative cerebrovascular accidents; 1 patient in the normothermic group had left hemiplegia and aphasia with major permanent neurological deficits, and 1 patient in the hypothermic group had transient postoperative deficits without residual impairment. None of these distinctions were significant between groups. Whereas, in the warm group, Mauney and Kron reported a greater incidence of total neurologic events and perioperative stroke. Hyperglycemiasis ss a possible explanation for the higher stroke rate (19), loss of neuro-protective effects of moderate hypothermia and embolic phenomena were offered. Martin and colleagues, who suggested that normothermia increased the neurological risk of warm heart surgery in their prospective randomised trial, found the same fact in a study (22). In contrast to the Toronto prospective randomised trial, lower randomised trial, lower end that the incidence of both transient and persistent neurologic deficits doubled with warm versus cold perfusion, which showed no difference in the incidence of neurological complication between the two groups (16).

In our study, the periods of mechanical ventilation more than 24 hours, were alomost similar in both groups with insignificant statistically difference value (4 cases in group I, 5 cases in group II) (p 0.26). Whereas, Calafiore and his co-workers, demonstrated in their study significantly longer periods of mechanical ventilation as well as longer ICU stay in patients received cold cardioplegia than those received warm cardioplegia (7). The study of Loop and his co-workers demonstrated that the median length of stay in the intensive care unit, was one day in the normothermic group and two days in the hypothermic group, and the length of time spend in the intensive care unit correlates closely with morbidity and hospital stay (18).

During warm heart operations, the central nervous system is especially vulnerable to injury. Hot brains are more vulnerable to ischemic disruption or micro-emobilisation. This is why modern warm cardioplegia protocols have emerged that allow systemic temperatures to passively drift to $32 \degree C$ to provide the brain with more protection (14).

In our study there were no statistically difference value between the two groups. Whereas, Sirvinskas et al 2005 reported an incidence of 2.5% of perioperative MI with slightly higher statistically insignificant number in cold group (27).Elwatidy (10) reported 1.6% incidence of peri-operative MI in 2 patients who had both endarterectomy for RCA, and both had inferior MI that could related to the endarterectomy procedure. Franke et al (12). reported 2.5% incidence of perioperative MI in their study group and cold blood group. While, Zeriouh et al. (30) reported 12% incidence of perioperative MI in their study with higher statistically insignificant number among warm blood group. This relatively high percentage of perioperative MI may be related to the higher number of the patients in the study (n: 2292), or it could be related to inclusion of many patients with comorbidities, and emergent surgeries.

Bleeding after cardiac operations is an important cause of morbidity and mortality. In our study no difference of statistical significant was observed in the amount of chest tubes drainage in the first 24 hour after surgery in both warm and cold groups. Bleeding profile was normal before surgery as well as platelet count in both groups. Similarly, in a study performed by Calafiore, blood loss was similar in both normothermic and hypothermic group, with an average amount of 400cc in the first 12 hour. Also, the number of patients given blood transfusions were similar (7).

Boldt observed in his analysis that postoperative blood loss and the need for homologous blood in the hypothermic community were greater than in the normothermic community. During and after cardiopulmonary bypass, the fibrinogen level and platelet count were slightly lower in hypothermic patients than in normothermic patients. Boldt also noted that about 10 percent to 20 percent of hypothermic perfusion patients, Yau and his associates found that blood loss was significantly greater in patients with hypothermic bypass compared to patients who underwent normothermic bypass. Yau and his associates found that blood loss was significantly higher in patients with hypothermic bypass (29). Vaughn and coworker also found the same results, reporting a 20 percent decrease in daily blood loss in patients using normothermic bypass compared with those using hypothermic cardiopulmonary bypass (28).

In 2018, in Germany, Boening and associates examined variations between hot and cold sporadic cardioplegia and the effect on cardiac activity, metabolism, haemodynamic recovery, systemic recovery and infarction size of two blood cardioplegia solutions in healthy and infarcted rat cores. They came to the conclusion that the two blood cardioplegia solutions give similarly good myocardial protection using electron mcroscopic analysis and infarct scale planimetry. No substantial variation between the groups was found in haemodynamic recovery (4).

Onorati et al compared warm with cold blood cardioplegia and found that in patients with warm blood cardioplegia, postoperative cardiac function was improved, the need for transfusions was reduced and the postoperative hospital stay was shorter (24). Hayashida et al described the beneficial myocardial protective effects' of a warm solution that corresponded to better LV function, lower creatine kinase-MB levels, and less catecholamine support compared with patients receiving cold solution (15).

In our study, serum total CK and cTnI were measured serially immediately after surgery, 6, 12, 24 and 48 hours after arrival at the ICU, without any statistical difference between the two groups. In comparison, Elwatidy et al. (10) recorded slightly lower CK and CKMB releases relative to the cold group in the tepid blood group. Franke and others (12). In the warm blood group, the study showed a significant lower release of CKMB and cTn. In our sample, the complete serum CK and cTnI were assessed serially immediately after surgery at 6, 12, 24 and 48 hours after arrival at the ICU, with no statistical discrepancy between the two groups. In comparison, Elwatidy et al. (10) recorded slightly lower CK and CKMB releases relative to the cold group in the tepid blood group. Franke and others (12). The study showed a significant lower release of CKMB and cTn in the hot blood group. A meta-analysis of 34 randomised clinical trials was conducted by Guru and coworkers (13) and recorded a substantial improvement in CK-MB release from cold cardioplegia. A meta-analysis of 41 randomised clinical trials comparing cold and warm cardioplegia for myocardial safety in patients undergoing heart surgery was conducted by Fan and coworkers in 2010. THey reported that in the warm group after surgery, the concentrations of both cTn and CK-MB were significantly reduced as compared to the cold group. Their results showed that warm cardioplegia was associated with lower release of postoperative enzymes, which could indicate less injury to the cardiocytes (11). In 2014, Bruyn and colleagues showed no significant difference in the level of CKMB and cTn between hot and cold groups in patients undergoing either CABG or valve surgery (5). A warm heart requires 10-20 percent more oxygen than a cold heart, despite the proposed advantages of warm blood cardioplegia (14).

In the warm population, a prospective randomised study of Pelletier and associates compared intermittent antegrade warm blood cardioplegia with cold cardioplegia showed less release of CK-MB and troponin-T (25). Yau and his colleague's study found that within 48 hours of the operation, the full release of CK-MB, During warm blood cardioplegia, it was lower than cold blood cardioplegia, and after warm cardioplegia, the peak postoperative CK-MB levels tended to be lower, but no statistical meaningful difference was detected. (29) However, Ascione et al. (2) found a significant decrease in cardiac troponin I release at 1, 24, and 48 h postoperatively in favour of cold blood cardioplegia relative to warm blood card release.

In both the warm and cold groups, but without any statistical significance, postoperative echocardiography performed prior to discharge from the hospital shows preserved myocardial ejection fraction. For further evaluation, however, long-term follow-up is required.

Conclusion:-

We found that the use of two distinct forms of antegrade transient cardioplegia widely used in clinical practise to achieve cardiac arrest during on-pump CABG did not affect in-hospital outcomes in the presence of a complete revascularization of the coronary territories. There was no statistically important variation in the 30-day mortality risk of hot and cold blood cardioplegia, Implantation of postoperative IABP, acute neurological deficit, stroke, kidney dysfunction and atrial fibrillation. We observed that the therapeutic effects of warm or cold blood cardioplegia did not vary. During the time of cardiac arrest, both methods tend to enable an equal and adequate approach for myocardial defence. To attain improved myocardial defence, warm blood cardioplegia needs a shorter administration interval. Therefore, the choice between one type of cardioplegia and the other remains at the discretion of the surgeon.

In this study, the two distinct cardio-protective approaches were compared in low-risk and homogenous patients. In all classes of patients with cold and warm blood cardioplegia, the overall myocardial security found in the present study was adequate. In several dimensions, including operative and postoperative values in both categories, there were no statistically relevant variations. However, the incidence of spontaneous defibrillation was significantly higher in the cardioplegic warm blood group than in the postoperative cold blood group.

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