Malahayati International Journal of Nursing and Health Science, Volume 07, No.12, February 2025: 1442-1453

MINH
MALAHAYATI INTERNATIONAL JOURNAL OF NURSING AND HEALTH SCIENCE
ISSN 2620-9152 (Print)
ISSN 2621-4083 (Online)
DOI: 10.33024

Nomor: 79/E/KPT/2023

ARTICLE INFORMATION
Received: December, 30, 2024
Revised: February, 27, 2025
Available online: February, 28, 2025
at : https://e-jurnal.iphorr.com/index.php/minh

Effectiveness of warm blood reperfusion in reducing the incidence of reperfusion injury in cardiac surgery using the aortic cross clamp procedure: A systematic review

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

Abstract

Background: The management of cardiac surgery is not devoid of complications, which can result in disability or even mortality. Various interventions are implemented to mitigate the complications associated with cardiac surgery. Warm reperfusion is one of the easy, efficient and harmless intervention options for patients.
Purpose: To determine the effectiveness of warm blood reperfusion in reducing the incidence of reperfusion injury in cardiac surgery using the aortic cross clamp procedure.
Method: A literature search based on several online databases such as ProQuest, PubMed, Sage Journal, Scopus, SpringerLink, Oxford and Frontiers published from 2018-2024.
Results: The results of the study indicate that there are several interventions aimed at reducing the incidence of reperfusion injury. Several interventions can be carried out including: giving warm reperfusion, medication and choosing the type of cardioplegia. Reperfusion injury is measured by several variables such as increased cardiac troponin, arrhythmia, inotropic use and length of stay in the intensive care unit.
Conclusion: Warm reperfusion was more effective and efficient compared to several other interventions such as medication and cardioplegia selection.

Keywords: Cardiopulmonary Bypass; Reperfusion Injury; Warm Reperfusion.

INTRODUCTION

Surgical management of cardiovascular disease is currently on the rise. This increase in the number of surgeries is accompanied by a corresponding rise in the rates of complications and mortality (Matos, Silva, Jesus, Guimaraes, & Cordeiro, 2020). According to iData Research, the number of cardiac surgeries exceeds 900.000 procedures annually in the United States with projections that the number will reach 1.3 million by 2029. Data from the Harapan Kita National Heart Center Hospital (RSPJNHK) obtained the number of operations in 2022 for Coronary Artery Bypass Graft (CABG) surgery as many as 751 cases, surgery on congenital heart defects; 166 cases, valve repair and replacement operations as many as 420 cases, vascular surgery 69 cases, cardiac tumor surgery 16 cases and others 108 cases.

Heart surgery is a surgical procedure that requires the use of a heart lung machine (HLM). HLM is used for Cardiopulmonary Bypass (CPB) procedures, so that blood will continue to circulate throughout the body and oxygenation will be maintained even though during surgery the heart stops beating and the lungs stop expanding. This provides the benefit that surgical procedures can be easier because there is no interruption (Ali, Athar, & Ahmed, 2019).

Open heart surgery using CPB has the potential to increase inflammation, electrolytes imbalance, arrhythmia, myocardial dysfunction, heart failure, infection and endocrine response. Therefore, organ protection strategies play an important role in reducing the negative effects of cardiac surgical procedures. One important organ of protection is to

DOI: https://doi.org/10.33024/minh.v7i12.514

protect the heart itself (myocardial protection) from injury due to surgical procedures (Busro, Romolo, Sastroasmoro, Rachmat, Sadikin, Santoso, & Jusuf, 2018).

Myocardial protection is carried out in three ways: decreasing temperature (hypothermia), preventing cardiac distention (avoid distention) and administering cardioplegia fluid. The combination of these three methods will result in optimal myocardial protection. Myocardial protection is needed to avoid injury to the heart itself. Injury to the heart can occur due to physical injury due to surgical procedures, injury due to ischemia; at the time of cross clampp off (ischemia injury), during reperfusion; injury when the heart regains coronary flow (reperfusion injury) (Watanabe, Yashiki, Tomita, & Yamaguchi, 2011).

Reperfusion injury can be caused by a sudden rush of blood flow to the coronaries and a sudden change from acidosis to alkalosis in the heart cells (White, Avery, Müller, Li, Le, Thliveris, & Freed, 2016). Reperfusion injury can also be caused because hypothermic conditions can destabilize cell membranes, inhibit sodium pumps, calcium accumulation, cell edema and decrease sarcoplamic reticulum function (Irfan, Anjum, Althobaiti, Alotaibi, Siddiqui, & Ramzan, 2022). In this case, the occurrence of arrhythmia can be an early marker of reperfusion injury (Vaduganathan, Mensah, Turco, Fuster, & Roth, 2022).

In some heart surgery procedures, the aortic blood flow to the coronary arteries will be stopped by clamping the aorta. Furthermore, the coronary arteries will be given cardioplegia fluid so that within 1-2 minutes the heart will stop beating. The cardioplegia fluid contains a certain composition and is given in a cold temperature in the range of 4-10 degrees. During the surgical procedure the operator will also keep the heart from bloating or distension (Sadeghi, Austin, Totonchi, Bakhshandeh, Hadavand, & Ghavidel, 2018).

Metabolism of heart cells when the heart stops beating still occurs. This puts the cells at risk of damage when the coronary arteries return to blood flow. The heart can be injured in this condition, known as reperfusion injury. (Chai & Kussman, 2015). Reperfusion injury can be caused by a sudden rush of blood flow into the coronary arteries and a sudden change from acidosis to alkalosis in the heart cells (White et al., 2016). Reperfusion injury can be characterized by an increase in the markers Cardiac troponin-I (CTn-I) and Cardiac troponin T (Ctn-T). In simple clinical assessment post cross clamp off arrhythmia can indicate reperfusion injury (Ji, Liu, Lu, Liu, Wang, Feng, & Hu, 2019).

Several strategies are used to reduce reperfusion injury. One of them is by providing warm blood circulation (warm reperfusion) shortly before cross clamp off (Amatya, Sharma, Pokharel, & Shrestha, 2015). Warm reperfusion is a technique of providing blood circulation to the coronary arteries with a warm temperature (34-36 ^{0}C) (Peretto, Durante, Limite, & Cianflone, 2014). This strategy can normalize metabolic and enzyme functions. This strategy also aims to normalize electrolyte transfer. Normal electrolyte transfer will make the action potential of depolarization and repolarization physiological and will avoid arrhythmia (Yu, Cong, Yap, Hausenloy, & Ramachandra, 2023).

Based on the description above, the researcher considers it important to know and statistically prove the effectiveness of warm reperfusion in reducing the incidence of reperfusion injury. Prevention of reperfusion injury is expected to reduce patient morbidity and mortality rates. In the end, this will have an impact on improving patient life and the quality of hospital services (Rivinius, Heil, & Doesch, 2023).

RESEARCH METHOD

A systematic review used is based on the prism statement. Literature search from 7 databases, namely PUBMED, Sage Journal, Oxford, Scopus, Proquest, Springerlink and Frontiers. Using the PICO strategy in determining keywords when conducting literature searches. Search population: patients undergoing cardiopulmonary bypass surgery. Intervention: warm reperfusion. Comparison: warm reperfusion and no warm reperfusion. Results: The incidence of arrhythmias after crossclamp off. The inclusion criteria for this article are (1) Open access, full text, (2) Cardiac surgery, (3) RCT, (4) last 5 years, (5) suitability of the abstract to the research objectives. Exclusion criteria are (1) duplication, (1) not relevant to the research objectives.

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

RESEARCH RESULTS

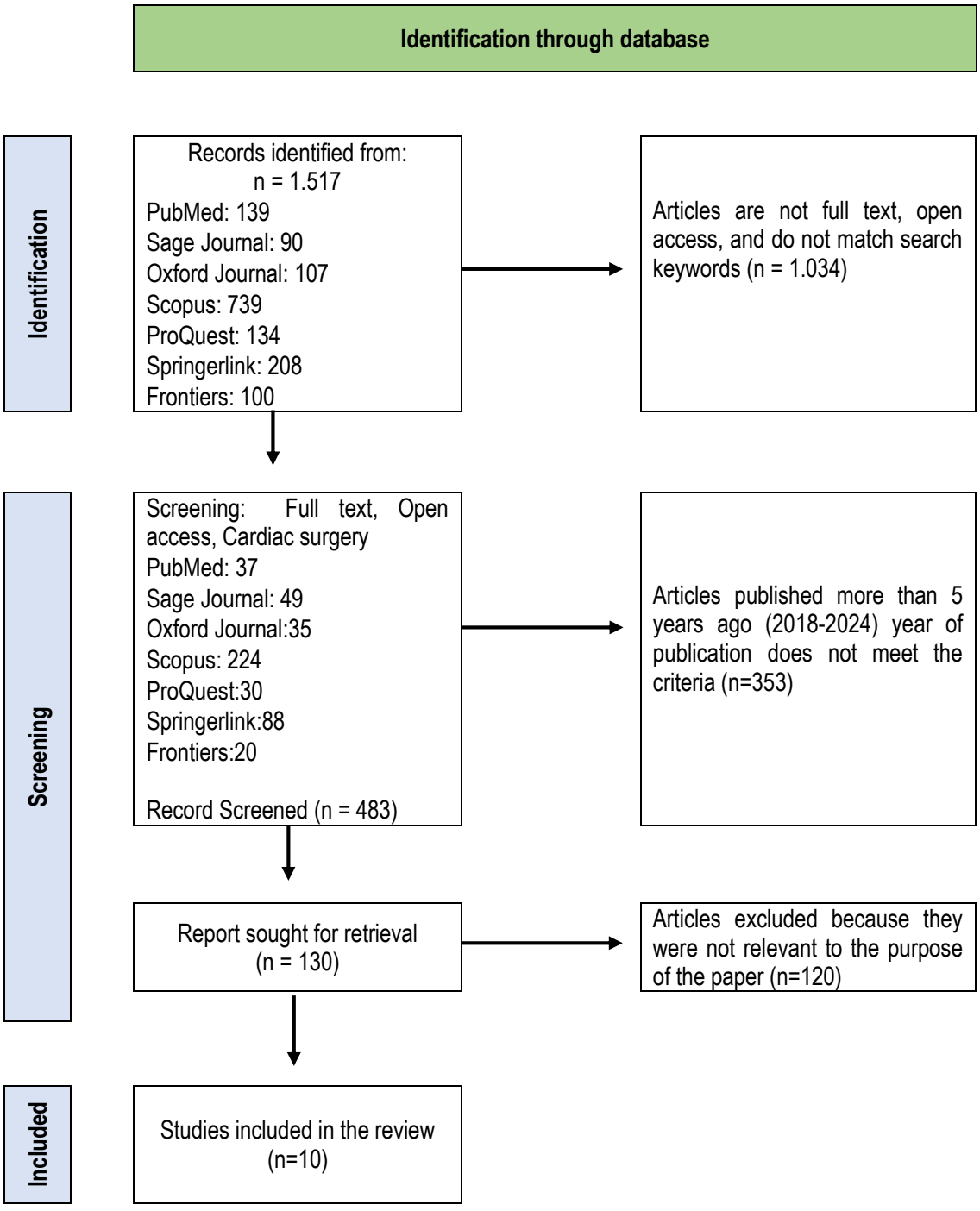


Figure: PRISMA Flow Diagram

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

Table. Summary of the Articles'Review

(Author, Year) (Country)	Purpose	Method	Results
(Ji et al., 2019) (China)	To investigates the effect of warm induced and reperfusion blood cardioplegia on the release of troponin-I during the CABG.	In our research, 24 three-vessel coronary artery disease (CAD) patients underwent CABG and were divided into two groups randomly: Group of warm induction and reperfusion blood cardioplegia (Group W N=12); Group of simple warm induction and no reperfusion (Group C N=12). The effect of myocardium protection of the two methods of myocardium protection were evaluated by clinical outcome, CTnI. Serial venous blood samples were obtained before and after surgery.	In both groups, there were no differences in operative parameters. The level of CTnI increased from postoperative 6 h ($P \ll 0.05$), reached peak in 24～72 h and recovered postoperatively on 6th day in both groups. Compared with group C, the plasma concentrations of CTnI in group W were significantly lower at 6 h, 24 h and 72 h ($P \ll 0.01$). The results suggest that the method of warm induction and reperfusion blood cardioplegia reduces the leakage of CTnI than group of simple warm blood cardioplegia in CABG patients.
(Elgariah et al., 2019) (Egypt)	To compare the effect of terminal hot shot cardioplegia, the effect of remote ischemic preconditioning and the effect of both techniques on myocardial recovery after adult cardiac surgery.	One hundred forty-five patients were divided into four groups comparing hot shot group, remote ischemic preconditioning group, combined hot shot and remote ischemic preconditioning group and the control group. The data collected included preoperative demographic and clinical characteristics, intraoperative data and postoperative short term outcome including inhospital mortality.	Patients of the combined group were found to have significantly better outcome including fewer ventricular arrhythmias, less intra-operative need of intra-aortic balloon pump, low cardiac output, and less length of ICU stay. The in-hospital mortality showed a significant difference between the 4 groups. Among patients without hot shot, the incidence of postoperative temporary epicardial pacing was higher and decreased in patients underwent hot shot and remote ischemic preconditioning but didn't reach a statistical significance.

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

(Author, Year) (Country)	Purpose	Method	Results
(Salameh et al., 2018) (Germany)	To evaluate drug administration in control treatment, without drug and without CPB.	The sample was divided into 6 groups: without drug and without CPB, control group with EGCG, control group with minocycline, CPB group without drug, CPB group with EGCG and CPB group with minocycline. After induced CPB group samples were subjected to arrest procedure for 90 minutes followed by reperfusion for 120 minutes, samples with drugs were given EGCG (10 mg/kg body weight) or minocycline (4 mg/kg body weight) 15 minutes before measurement. The second dose was administered 10 minutes after release from CPB (EGCG 10mg/kg body weight or minocycline (2 mg/kg body weight). Samples were assessed at baseline and 120 min later (lactate and cardiac creatine kinase, ejection fraction, MAP, ATP production).	Baseline parameters were not significantly different among the 6 experimental groups. At the beginning of the experiment and after reperfusion (at the end of the experiment) ejection fraction, cardiac output and blood pressure were not significantly different between the 6 experimental groups (Table 1). However, as the vital parameters of piglets were closely monitored, catecholamines had to be administered mainly during and after weaning from CPB in the three CPB groups to support the cardiovascular system. As a result, the total catecholamine requirement was significantly higher in CPB-fed piglets compared to the control group (Table 1). In addition, lactate which is an indicator of metabolic state and creatinine kinase indicator for muscle damage were significantly increased in the three CPB groups at the end of the reperfusion period (table 1). Only the CPB+EGCG group showed a mild but significant decrease in creatinine kinase compared to CPB alone.
(He et al., 2022) (China)	To evaluate the efficiency of amiodarone in preventing the occurrence of reperfusion ventricular fibrillation (RVF) after aortic cross-clamp (ACC) release in patients undergoing open-heart surgery.	Study: Meta-analysis Searches were conducted through several databases: Science, Cochrane Library, EMBASE, and PubMed since January 2021 for journals relevant to the study objectives.	Seven studies (856 enrolled patients; 311 in the amiodarone group, 268 in the lidocaine group, and 277 in the placebo group) were selected for the meta-analysis. The incidence of RVF was significantly decreased in the amiodarone group compared to the placebo group (RR = 0.69, 95%CI: 0.50–0.94, P = 0.02). However, amiodarone and lidocaine did not confer any

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

(Author, Year) (Country)	Purpose	Method	Results
			significant difference (RR = 0.98, 95%CI: 0.61–1.59, P = 0.94). The percentage of patients requiring electric defibrillation counter shocks (DCSs) did not confer any significant difference between patients administered amiodarone and lidocaine or placebo (RR = 1.58, 95%CI: 0.29–8.74, P = 0.60; RR = 0.55, 95%CI: 0.27–1.10, P = 0.09; respectively).
(Sadeghi et al., 2018) (Iran)	To compare the effects of the newly introduced procaine hydrochloride (PHC) containing cardioplegic solution (Shahid Ghazi Pharmaceutical Co. Tabriz, Iran) and lidocaine (L) in cardioplegic solution on post aortic clamp arrhythmia in coronary artery bypass graft surgery.	A randomized clinical trial that was performed in Rajaie cardiovascular, Medical and research center after obtaining permission from the ethics committee. A total of 100 patient candidates for coronary intervention from October 2016 to March 2017 were divided into two groups and randomly assigned one of the two cardioplegic solutions that were only different in the antiarrhythmic solution contents of procaine hydrochloride and lidocaine.	After aortic de-clamp, in the PHC group, the spontaneous return of heart rate was higher (P value = 0.02, 64% for PHC and 42% for L group). Furthermore, the required dosage for lidocaine and magnesium (P = 0.02) and inotrope (P = 0.04) were also relatively lower, but in general, the percentage of arrhythmia occurred requiring defibrillator and pacemaker after operation between the two groups did not show any significant differences. Clinically, the required cardioplegic solution volumes were slightly higher in PHC group.
(Tan et al., 2022) (China)	To compare the outcomes of four types of cardioplegia during cardiac surgery: del Nido (DN), blood cardioplegia (BC), histidine-tryptophan-	Randomized controlled trials (RCTs) and observational cohort studies from 2005 to 2021 were identified in PubMed, Embase, and Cochrane databases. Data were extracted for the primary endpoint of perioperative mortality as well as the	Data were extracted from 18 RCTs and 49 observational cohort studies involving 18,191 adult patients (55 studies) and 1,634 children (12 studies). Among adult patients, risk of mortality was significantly higher for HTK (1.89, 95% CI 1.10, 3.52) and BC (RR 1.73, 95%

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

(Author, Year) (Country)	Purpose	Method	Results
	ketoglutarate (HTK) and St. Thomas.	following secondary endpoints: atrial fibrillation, renal failure, stroke, use of an intra-aortic balloon pump, re-exploration, intensive care unit stay and hospital stay. A network meta-analysis comparing all four types of cardioplegia was performed, as well as direct meta-analysis comparing pairs of cardioplegia types.	CI 1.22, 2.79) than for DN. Risk of atrial fibrillation was significantly higher for BC (RR 1.41, 95% CI 1.09, 1.86) and DN (RR 1.51, 95% CI 1.15, 2.03) than for HTK. Among pediatric patients, no significant differences in endpoints were observed among the four types of cardioplegia.
(Busro et al., 2018) (Indonesia)	To determine the effect of the addition of terminal warm blood cardioplegia in postoperative complex congenital heart surgery patients.	A randomized controlled trial was conducted on 109 cyanotic patients aged, 1 to 5 years who underwent complex biventricular repair. They were divided into a control group of 55 patients who had histidine-tryptophan-ketoglutarate only and a treatment group of 54 who had histidine-tryptophan-ketoglutarate with terminal warm blood cardioplegia. Endpoints were clinical parameters, troponin I levels, and caspase-3 as an apoptosis marker.	The incidence of low cardiac output syndrome was 34%, with no significant difference between groups (35.2% vs. 33.3%, p = 0.84). The incidence of arrhythmias in our treatment group was lower compared to the control group (36% vs. 12%, p = 0.005). Troponin I and caspase-3 results did not show any significant differences between groups. For cases with Aristotle score ≥ 10, weak expression of caspase-3 in the treatment group post-cardiopulmonary bypass was lower compared to the control group.
(Arafat et al., 2021) (Egypt)	To assess the safety of Del Nido cardioplegia in adult patients with low EF compared to intermittent warm blood cardioplegia.	Meta analysis, 73 patients with ejection fraction ≤ 40% who underwent cardiac surgery using Del Nido cardioplegia since September 2018 through September 2019. These patients were compared with 81 patients who received intermittent warm blood cardioplegia who were operated on before	Peak troponin was significantly higher in the delnido group, however after multivariate regression CPB time showed the most influential factor on troponin values. level (coefficient 0.005 (95% CI: 0.003- 0.008); P < 0.001) ICU length of stay was significantly higher in the group Del Nido cardioplegia. After multivariable

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

(Author, Year) (Country)	Purpose	Method	Results
		September 2018	regression analysis, use of warm blood cardioplegia showed significantly shorter ICU length of stay (coefficient - 1.80 (95% CI - 3.06 - -0.55); P = 0.01).
(Turan et al., 2020) (USA)	To establish whether dexmedetomidine reduces the incidence of new-onset atrial fibrillation and the incidence of delirium.	RCT, the sample was divided into two groups, 400 patients in the intervention group and 398 in the placebo group. Patients who received dexmedetomidine will be given before incision as much as 0-1 µg/kg/hour then increased 0-2 µg/kg/hour at the end of CPB and at postop increased 0-4 µg/kg/hour for 24 hours. Then assessed the incidence of atrial fibrillation and delirium in patients.	The incidence of AF was 121 (30%) in 397 patients who received dexmedetomidine and 134 (34%) in 395 placebo patients, (97-8% CI 0-72, 1-15; p=0-34). The incidence of delirium also did not significantly increase from 12% of the placebo group to 17% dexmedetomidine group.
(Volpi et al., 2019) (United Kingdom)	To find out the use of 'hot-shot' (terminal warm blood cardioplegia) provides better outcomes after heart surgery in adults.	Systematic review, systemic journal search through MEDLINE from 1950 to April. 2018 using OVID with keywords: [thoracic surgery OR valve surgery OR heart surgery OR coronary artery bypass OR cardiac surgery] AND [terminal warm blood cardioplegia OR terminal hot-shot OR warm cardioplegia].	It seems that using hot-shot produces faster results biochemical, electrical and possibly functional myocardial recovery from cardiopulmonary bypass. However, no studies have been conducted was able to show that this leads to improved clinical outcomes in addition to a lower incidence of atrial fibrillation.

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

DISCUSSION

The systematic review carried out has the main objective of knowing the latest scientific research related to interventions provided in an effort to reduce reperfusion injury (Hasyim, Samodro, Sasongko, & Leksana, 2013). Reperfusion injury is a process, not the end of an event. The process of reperfusion ischemia is related to K+ ion release, membrane depolarization, anaerobic lactate production, decreased ATP, increased intracellular H+, Na and Ca loading, electrolyte imbalance, cell swelling, free radical and anti-oxidant production, mitochondrial pore opening, apoptosis and necrosis (Zilla, Yacoub, Zühlke, Beyersdorf, Sliwa, Khubulava, & Williams, 2018). Reperfusion ischemia is also responsible for endothelial activation which leads to microvascular dysfunction and coronary artery deterioration, vasoconstriction and spasm, myocardial contractile dysfunction, reperfusion arrhythmias, inflammatory activation and disruption of the coagulation cascade (Dobson, Faggian, Onorati, & Vinten, 2013).

Cardiac Troponin-I (CTn-I) is a specific and sensitive marker of myocardial injury. CTn-I is found exclusively in cardiac muscle and is clearly distinct from skeletal isoforms, thus making it a specific marker of myocardial damage (Toyoda, Yamaguchi, Yoshimura, Oka, & Okita, 2023). This specificity is particularly beneficial for patients undergoing cardiac surgery as the value of serum creatinine kinase and lactate dehydrogenase measurements is limited by the release of enzymes from non-cardiac tissues. CTn-I was elevated in all patients after cardiac surgery (Yuksel, Canbaz, & Ege, 2013). This fact indicates the inevitable myocardial damage due to cardiac arrest. CTn-I measurement can detect small differences in myocardial tissue damage (Durham, & Worthley, 2022).

Ischemia and decreased temperature show influence on ion movement and metabolic changes. Levels of high-energy metabolites such as adenosine triphosphate and phosphocreatine decrease within seconds when oxygen supply to the brain is interrupted (Tse, 2016). The breakdown of adenosine triphosphate and the switch of intracellular metabolism to anaerobic glycolysis leads to increased levels of inorganic phosphate, lactate and intracellular H^+ , resulting in intra- and extracellular acidosis and influx of calcium Ca^{2+} into the cells. The loss of adenosine triphosphate and acidosis also inhibits mechanisms that normally deal with excess intracellular Ca^{2+} by taking Ca^{2+} from the cell, further aggravating the excess intracellular Ca^{2+} (Zaman, Archbold, Helft, Paul, Curzen, & Mills, 2020).

These problems are exacerbated by failure of the adenosine triphosphate-dependent Na -K^{++} pump and K^+ , Na^+ and Ca^{2+} channels, leading to additional Ca^{2+} influx. Excess Ca^{2+} induces mitochondrial dysfunction (increasing intracellular calcium influx even further, in a vicious cycle) and activates many intracellular enzyme systems (kinases and proteases) (Coté, Lerman, & Anderson, 2024). In addition, early genes are immediately activated and depolarization of the nerve cell membrane occurs, with the release of large amounts of the excitatory neurotransmitter glutamate into the extracellular space. This leads to prolonged and excessive activation of membrane glutamate receptors, which further stimulates Ca^{2+} influx through activation of Ca^{2+} channels in another vicious cycle. this may be an important mediator of cell death and arrhythmic events (Polderman, 2019).

Warm reperfusion is the administration of warm blood flow with a blood temperature of 36-37 degrees Celsius to the coronary circulation (Wallace, & Baker, 2024). The blood flow given is 250-300 ml/min. Can be adjusted to the flow when cardioplegia is given (Elgariah, El Nasr, Fawzy, Wahby, & Taha, 2019). Warm reperfusion is given for 3-4 minutes. This time is considered sufficient and ideal to get the benefits of warm reperfusion. This procedure is performed before cross clamp off (Salameh, Dhein, Mewes, Sigusch, Kiefer, Vollroth, & Dähnert, 2020).

So providing warm circulation at the beginning of cardioplegia reduces damage by avoiding contractures due to cold temperatures (Al-Sarraf, Thalib, Hughes, Houlihan, Tolan, Young, & McGovern, 2011). Therefore, giving warm circulation (warm reperfusion) before Cross clamp off will be beneficial because it removes substances produced by anaerobic metabolism and by carrying free radicals produced during cardiac arrest (ischemia) (He, Zhang, & Xiong, 2022). Kawasuji's results show that terminal warm blood cardioplegia can also improve myocardial reoxygenation and optimize the balance of myocardial oxygen supply and demand during reperfusion (Turan, Duncan, Leung, Karimi, Fang,

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

Mao, & Raza, 2020). The 5 articles that provided warm reperfusion interventions showed statistically significant reductions in reperfusion injury. This is evidenced by the decrease in arrhythmia rate, decrease in troponin, speed of heart rhythm to spontaneous rhythm, lower ST-segment ECG changes, less inotropic needs, decreased use of arrhythmic drugs after cross clamp off (Arafat, Hassan, Alfonso, Alanazi, Alshammari, Mahmood, & Pragliola, 2021).

Of the 3 articles that provided medical interventions, the results showed significant results compared to placebo. This is shown by a decrease in creatininkinase, a decrease in the incidence of atrial and ventricular arrhythmias post cross clamp off (Tan, Bi, Li, Gu, Wang, Xiong, & Du, 2022). In interventions carried out with the selection of cardioplegia, the results show different benefits for each cardioplegia. Cardioplegia containing PHC is better at restoring spontaneous rhythm. Delnido has a low mortality rate. Meanwhile, HTK has a lower arrhythmia rate (Volpi, Ali, & De Silva, 2019).

CONCLUSION

From the results of the review that has been done, the author considers that warm reperfusion is one of the appropriate interventions to be carried out in cardiac surgery patients in an effort to reduce reprfusion injury. When compared to other interventions such as the administration of drugs, this intervention is more effective because it does not cause complications, and is more efficient because it does not require additional equipment. In addition, warm reperfusion is very easy to perform, does not require post-intervention monitoring and is proven to physiologically help restore the heart to normal conditions before the heart performs its function as a pump.

Warm reperfusion is performed by providing warm blood flow to the coronary ostium with a flow of 250-350 ml/min for 2-4 minutes. When warm reperfusion is given a perfusionist watches the warm reperfusion pressure and sees changes in heart rhythm that begin to occur. The rhythm that was originally asystole will show signs of depolarization and repolarization electrical activity.

REFERENCES

Ali, S., Athar, M., & Ahmed, S. M. (2019). Basics of CPB. *Indian J Anaesth*, *49*(4), 257-62.

Al-Sarraf, N., Thalib, L., Hughes, A., Houlihan, M., Tolan, M., Young, V., & McGovern, E. (2011). Cross-clamp time is an independent predictor of mortality and morbidity in low-and high-risk cardiac patients. *International Journal of Surgery*, *9*(1), 104-109.

Amatya, A., Sharma, A., Pokharel, J. N., & Shrestha, S. M. (2015). Ventricular Tachyarrhythmia after Aortic CrossClamp Release in Cardiac Surgeries.

Arafat, A. A., Hassan, E., Alfonso, J. J., Alanazi, E., Alshammari, A. S., Mahmood, A., & Pragliola, C. (2021). Del Nido versus warm blood cardioplegia in adult patients with a low ejection fraction. The Cardiothoracic Surgeon, 29, 1-5.

Busro, P. W., Romolo, H., Sastroasmoro, S., Rachmat, J., Sadikin, M., Santoso, A., & Jusuf, A. A. (2018). Role of terminal warm blood cardioplegia in complex congenital heart surgery. *Asian Cardiovascular and Thoracic Annals*, *26*(3), 196-202.

Coté, C. J., Lerman, J., & Anderson, B. (Eds.). (2024). A Practice of Anesthesia for Infants and Children, E-Book.

Dobson, G. P., Faggian, G., Onorati, F., & Vinten-Johansen, J. (2013). Hyperkalemic cardioplegia for adult and pediatric surgery: end of an era?. *Frontiers in physiology*, *4*, 228.

Durham, D., & Worthley, L. I. G. (2022). Cardiac arrhythmias: diagnosis and management. The tachycardias. *Critical Care and Resuscitation*, *4*(1), 35-53.

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

Elgariah, M., El Nasr, M. A., Fawzy, H., Wahby, E., & Taha, A. (2019). Effect of terminal warm reperfusion (hot shot) and remote ischemic preconditioning, either separately or combined, on myocardial recovery in adult cardiac surgery. *Journal of the Egyptian Society of Cardio-Thoracic Surgery*, *25*(3), 230-235.

Hasyim, D., Samodro, R., Sasongko, H., & Leksana, E. (2013). Perbedaan Pengaruh HES 6%(200) Dalam NaCl 0, 9% dan Dalam Larutan Berimbang pada Base Excess dan Strong Ion Difference Pasien Seksio Sesaria dengan Anestesi Spinal. *JAI (Jurnal Anestesiologi Indonesia)*, *5*(2), 83-91.

He, L. M., Zhang, A., & Xiong, B. (2022). Effectiveness of amiodarone in preventing the occurrence of reperfusion ventricular fibrillation after the release of aortic cross-clamp in open-heart surgery patients: A meta-analysis. *Frontiers in Cardiovascular Medicine*, *9*, 821938.

Irfan, S., Anjum, N., Althobaiti, T., Alotaibi, A. A., Siddiqui, A. B., & Ramzan, N. (2022). Heartbeat classification and arrhythmia detection using a multi-model deep-learning technique. *Sensors*, *22*(15), 5606.

Ji, B., Liu, M., Lu, F., Liu, J., Wang, G., Feng, Z., & Hu, Q. (2019). Warm induction cardioplegia and reperfusion dose influence the occurrence of the post CABG TnI level. *Interactive CardioVascular and Thoracic Surgery*, *5*(1), 67-70.

Matos, A. A., Silva, D. B., Jesus, M. L., Guimaraes, A. R., & Cordeiro, A. L. L. (2020). Incidence of complications after cardiac surgery. *Int Phys Med Rehab J*, *5*(1), 25-28.

Peretto, G., Durante, A., Limite, L. R., & Cianflone, D. (2014). Postoperative arrhythmias after cardiac surgery: incidence, risk factors, and therapeutic management. *Cardiology research and practice*, *2014*(1), 615987.

Polderman, K. H. (2019). Mechanisms of action, physiological effects, and complications of hypothermia. *Critical care medicine*, *37*(7), S186-S202.

Rivinius, R., Heil, K. M., & Doesch, A. O. (2023). Surgical ventricular reconstruction for the treatment of advanced heart failure—return of the surgeons?. *Journal of Thoracic Disease*, *15*(7), 3538.

Sadeghi, S., Austin, N., Totonchi, Z., Bakhshandeh, H., Hadavand, N., & Ghavidel, A. A. (2018). Impact of Procaine Hydrochloride Versus Lidocaine in Cardioplegic Solution, on Reperfusion Arrhythmia During Coronary Artery Bypass Graft Surgery. *Multidisciplinary Cardiovascular Annals*, *9*(2).

Salameh, A., Dhein, S., Mewes, M., Sigusch, S., Kiefer, P., Vollroth, M., & Dähnert, I. (2020). Anti-oxidative or anti-inflammatory additives reduce ischemia/reperfusions injury in an animal model of cardiopulmonary bypass. *Saudi Journal of Biological Sciences*, *27*(1), 18-29.

Tan, J., Bi, S., Li, J., Gu, J., Wang, Y., Xiong, J., & Du, L. (2022). Comparative effects of different types of cardioplegia in cardiac surgery: A network meta-analysis. *Frontiers in Cardiovascular Medicine*, *9*, 996744.

Toyoda, Y., Yamaguchi, M., Yoshimura, N., Oka, S., & Okita, Y. (2023). Cardioprotective effects and the mechanisms of terminal warm blood cardioplegia in pediatric cardiac surgery. *The Journal of Thoracic and Cardiovascular Surgery*, *125*(6), 1242-1249.

Tse, G. (2016). Mechanisms of cardiac arrhythmias. *Journal of arrhythmia*, *32*(2), 75-81.

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514

Turan, A., Duncan, A., Leung, S., Karimi, N., Fang, J., Mao, G., & Raza, S. (2020). Dexmedetomidine for reduction of atrial fibrillation and delirium after cardiac surgery (DECADE): a randomised placebo-controlled trial. *The Lancet*, *396*(10245), 177-185.

Vaduganathan, M., Mensah, G. A., Turco, J. V., Fuster, V., & Roth, G. A. (2022). The global burden of cardiovascular diseases and risk: a compass for future health. *Journal of the American College of Cardiology*, *80*(25), 2361-2371.

Volpi, S., Ali, J. M., & De Silva, R. (2019). Does the use of a hot-shot lead to improved outcomes following adult cardiac surgery?. *Interactive CardioVascular and Thoracic Surgery*, *28*(3), 473-477.

Wallace, S. R., & Baker, A. B. (2024). Incidence of ventricular fibrillation after aortic cross-clamp release using lignocaine cardioplegia. *Anaesthesia and intensive care*, *22*(4), 442-446.

Watanabe, G., Yashiki, N., Tomita, S., & Yamaguchi, S. (2021). Potassium-induced cardiac resetting technique for persistent ventricular tachycardia and fibrillation after aortic declamping. *The Annals of thoracic surgery*, *91*(2), 619-620.

White, C. W., Avery, E., Müller, A., Li, Y., Le, H., Thliveris, J., & Freed, D. H. (2016). Avoidance of profound hypothermia during initial reperfusion improves the functional recovery of hearts donated after circulatory death. *American Journal of Transplantation*, *16*(3), 773-782.

Yu, F., Cong, S., Yap, E. P., Hausenloy, D. J., & Ramachandra, C. J. (2023). Unravelling the Interplay between Cardiac Metabolism and Heart Regeneration. *International Journal of Molecular Sciences*, *24*(12), 10300.

Yuksel, V., Canbaz, S., & Ege, T. (2013). Comparison between normothermic and mild hypothermic cardiopulmonary bypass in myocardial revascularization of patients with left ventricular dysfunction. *Perfusion*, *28*(5), 419-423.

Zaman, A. G., Archbold, R. A., Helft, G., Paul, E. A., Curzen, N. P., & Mills, P. G. (2020). Atrial fibrillation after coronary artery bypass surgery: a model for preoperative risk stratification. *Circulation*, *101*(12), 1403-1408.

Zilla, P., Yacoub, M., Zühlke, L., Beyersdorf, F., Sliwa, K., Khubulava, G., & Williams, D. F. (2018). Global unmet needs in cardiac surgery. *Global heart*, *13*(4), 293-303.

Ibnu Sofa*, Tuti Herawati, Sri Yona, Muhammad Adam

Fakultas Ilmu Keperawatan, Universitas Indonesia
Corresponding author: *E-mail: ibnu.sofa8@gmail.com

DOI: https://doi.org/10.33024/minh.v7i12.514