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EVALUATION OF PERIOPERATIVE FLUID MANAGEMENT STRATEGIES IN CARDIAC PATIENTS IN PAKISTAN

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Abstract

Background: Perioperative fluid therapy plays a crucial role in maintaining hemodynamic stability in patients undergoing cardiac surgery. Proper fluid management ensures adequate organ perfusion, prevents hypovolemia, and reduces postoperative complications such as renal dysfunction and mortality. Both crystalloids and colloids are widely used for volume replacement; however, synthetic colloids have been associated with nephrotoxicity and coagulation disturbances, raising safety concerns. As a result, crystalloids are increasingly preferred in clinical practice. Despite international evidence comparing these fluids, limited local data are available in Pakistan to evaluate their safety and efficacy in cardiac surgery patients, highlighting the need for this study.

Objective: The primary objective of this study was to compare the outcomes of crystalloid versus colloid solutions for perioperative fluid management in cardiac surgery patients.

Methods: This was a descriptive, cross-sectional study conducted at Cardiac Surgery Department of Punjab Institute of Cardiology, Lahore from July 2025 to October 2025, including 400 patients (200 in each group) aged 30-70 years who were put under cardiac surgery under general anaesthesia. Patients were randomly divided into crystalloid (Ringer acetate 20 ml/kg) and colloid (Hydroxyethyl starch 10 ml/kg) groups. Mean arterial pressure (MAP), serum creatinine levels (preoperative condition, and 24 hours after surgery), and mortality were measured. The SPSS version 27 was used to analyse the data.

Results: Intraoperative MAP remained stable in both groups without significant difference. Postoperative serum creatinine levels were higher in the colloid group compared to the crystalloid group ($p \leq 0.05$). In-hospital mortality was low and comparable between both groups ($p > 0.05$).

Conclusion: Crystalloid was found to be more hemodynamically stable and safer to the kidneys compared with colloid hence will be well warranted to use crystalloid than colloid during surgery in treating perioperative fluid therapy in patients undergoing cardiac surgeries.

Keywords: Cardiac Surgery, Crystalloids, Colloids, Perioperative Fluid Management, Renal Function

INTRODUCTION

The high blood losses, cardiopulmonary bypass, anaesthesia and systemic inflammatory effects of cardiac surgery patients lead to major changes in hemodynamic. It is important to maintain an appropriate organ perfusion and intravascular volume perioperative conditions to avoid hypovolemia, tissue hypoperfusion, and postoperative outcomes like acute kidney injury (AKI), cardiovascular instability, and high mortality rates. Fluid therapy is another part of the perioperative management that is applied to maximize cardiac output, normalizes blood pressure, and ensures blood flow to the vital organs.

Crystalloids or colloids are normally used in the perioperative fluid management. Crystalloids include Ringer acetate and normal saline, these are cheap, readily available, and are mostly regarded to be safe. They diffuse quickly through the intravascular and interstitial areas and are commonly employed in supplanting the volume in

surgery.**Error! Reference source not found.** The larger molecules in colloids such as hydroxyethyl starch (HES) and albumin are held within the intravascular compartment longer theoretically offering a better plasma volume expansion**Error! Reference source not found.**. Their application has however been linked to unfavourable effects such as nephrotoxicity, coagulopathy and heightened risk of bleeding especially in patients who are in a critical condition, and during cardiac surgery **Error! Reference source not found.**. Such safety issues have caused various regulatory bodies in different countries including the European Medicines Agency to limit the use of the synthetic colloids where a move towards the use of crystalloid based fluid therapy is encouraged. **Error! Reference source not found.**

The conflicting findings of earlier studies on the comparative efficacy and safety of crystalloids and colloids are attributed to differences in their dosage and route of administration. There is some evidence that colloids could offer a better hemodynamic stability and lower total fluid needs, but some also indicate an increased case of postoperative renal dysfunction and coagulation abnormalities with colloid administration. Specifically, cardiac surgery patients are a particularly vulnerable group because of the risks of cardiopulmonary bypass, blood loss, and inflammatory stress, which is why the selection of fluid therapy is of particular importance to minimize the adverse effects of postoperative complications.

In Pakistan, there is a lack of regional data that assesses the results of crystalloid versus colloid perioperative fluid management by cardiac surgery patients. International evidence is at the basis of most clinical decisions and may not be able to capture the local population of patients, comorbidities as well as surgical practices. The presence of such common comorbidities as hypertension, diabetes, and dyslipidaemia in the local population can cause additional risk factors of postoperative renal dysfunction, which is why region-specific studies are necessary.

The rationale behind the study is to give some local evidence on comparison of crystalloid and colloid solution in the perioperative care of cardiac surgery patients. The study seeks to evaluate the stability of hemodynamic, the renal function at the postoperative period, and in-hospital mortality, thus informing clinical practice on the need to use safe and more effective fluid management techniques. Knowledge of the consequences of various fluid types will contribute to the increase of perioperative care, minimization of complications, and optimization of recovery among cardiac surgery patients in Pakistan.

Objective: To compare the effects of crystalloid and colloid solutions of administering perioperative fluids to patients in cardiac surgery.

METHODOLOGY

This was a randomized controlled trial study, which was conducted at Cardiac Surgery Department of Punjab Institute of Cardiology, Lahore from July 2025 to October 2025, after getting ethical approval. The WHO sample size calculator was used to calculate the total number of 400 patients to be used in the research. The sample size of each group was 200 patients, and it was determined that a 80 percent power was required, a 95 percent confidence level, and the expected mean postoperative creatinine level of 72umol/L in the crystalloid group and 76umol/L in the colloid group. Non-probability consecutive sampling technique was used to recruit patients who attended within the time of the study.

The sample selection criteria where the patients should be aged between 30-70 years, both males, with cardiac surgery under general anaesthesia and should be categorised as ASA I- II. The exclusion criteria were created to guarantee the homogenous population patients who had undergone cardiac surgeries or combined surgeries, excessive postoperative bleeding (>100 ml/h), intra/postoperative inotropic/vasoactive/diuretic support needs were excluded. In addition, the patients that had developed hypotension (blood pressure below 100/60 mmHg) because of arrhythmias were also disqualified. This prudent sample was used to have a clear cohort to make strict comparisons of the perioperative outcomes in the crystalloid and colloid groups.

The study included patients aged between 30 and 70 years of both genders who were due to undergo cardiac surgery under general anaesthesia and were categorised as ASA physical status I or II. Those patients who had earlier undergone cardiac surgery, those undergoing combined cardiac surgery, or those with excessive postoperative bleeding (more than 100 mL per hour) were excluded in the study. Moreover, patients that needed intraoperative or postoperative inotropic or vasoactive or diuretic maintenance, or who did not have intraoperative blood pressure of 100 or above and 60 or below were not included to minimize confounding variables.

Data Collection

A total of 400 patients who reported to the operation theatre were enrolled in the study after the ethical review committee gave consent. All the participants were provided with informed consent in writing. Baseline demographic and clinical information was taken, such as name, age, gender, type of operation, smoking history (>5 pack-years), alcohol consumption (>20 mL/day), hypertension (BP ≥140/90 mmHg), dyslipidaemia (total cholesterol >200 mg/dL), diabetes mellitus (BSR >200 mg/dL), and preoperative serum creatinine level.

The lottery approach was then used to randomly assign patients in two groups. Group A had a crystalloid solution (20 mL/kg Ringer acetate), whereas Group B had a colloid solution (10 mL/kg hydroxyethyl starch 130/0.62). Time taken to operate, the blood loss during the operation and the number of fluids administered were noted. The measured and recorded baseline mean arterial pressure were at 20, 40 and 60 minutes in the operating theatre.

Patients were taken to the postoperative. After a period of 24 hours, a blood sample was taken with the aim of measuring the level of serum creatinine. The researcher entered the postoperative values and any mortality during hospital stay on a structured proforma.

Statistical Analysis

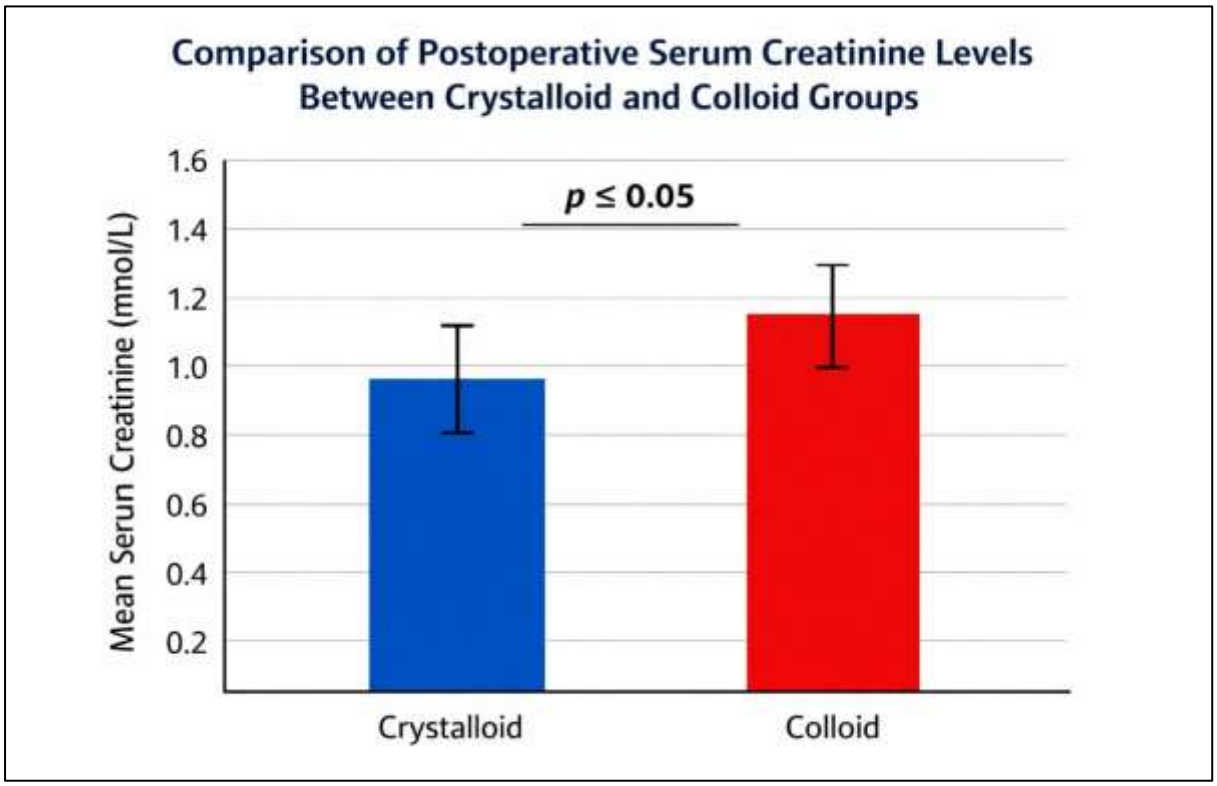
The SPSS version 27.0 was used to analyse all the data. The quantitative variables (age, duration of surgery, blood loss, total fluid volume, mean arterial pressure (MAP) and serum creatinine) were tested using Shapiro-Wilk test to test their normality. Quantitative variables were described using mean and SD and categorical variables were described using frequency and percentages e.g. gender, comorbidities, type of surgery and mortality. The independent sample t-tests were used to compare continuous variables of crystalloid and colloid group. Categorical results (mortality) were analysed by using chi-square test. The p-value of 0.05 was considered a significant value.

RESULTS

Four hundred patients were enrolled and 200 in each group. The crystalloid and colloid groups were similar in terms of baseline demographics, comorbidities, and type of surgery. The mean arterial pressure was also steady at the baseline, 20, 40, and 60 minutes in both groups with no significant differences ($p>0.05$). Colloid group showed significantly higher postoperative serum creatinine levels, which were higher than in the crystalloid group ($p=0.05$), and this suggests that colloid group is more affected by the kidneys. The mortality rate in the in-hospitals was low and similar in the two groups ($p>0.05$). There were no significant negative episodes of the perioperative period.

Table 1: Baseline Characteristics of Patients

Variable	Crystalloid Group (n=200)	Colloid Group (n=200)	P-value
Age (years), mean ± SD	55.2 ± 10.3	54.8 ± 9.9	0.62
Gender (Male/Female)	120/80	118/82	0.78
Hypertension, n (%)	80 (40%)	85 (42.5%)	0.65
Diabetes Mellitus, n (%)	65 (32.5%)	70 (35%)	0.58
Dyslipidaemia, n (%)	50 (25%)	55 (27.5%)	0.60
Smoking history, n (%)	70 (35%)	68 (34%)	0.84
Alcohol use, n (%)	10 (5%)	12 (6%)	0.65
Type of Surgery (CABG/Valve)	150/50	148/52	0.78
Preoperative Creatinine (mmol/L)	1.0 ± 0.2	1.0 ± 0.3	0.90

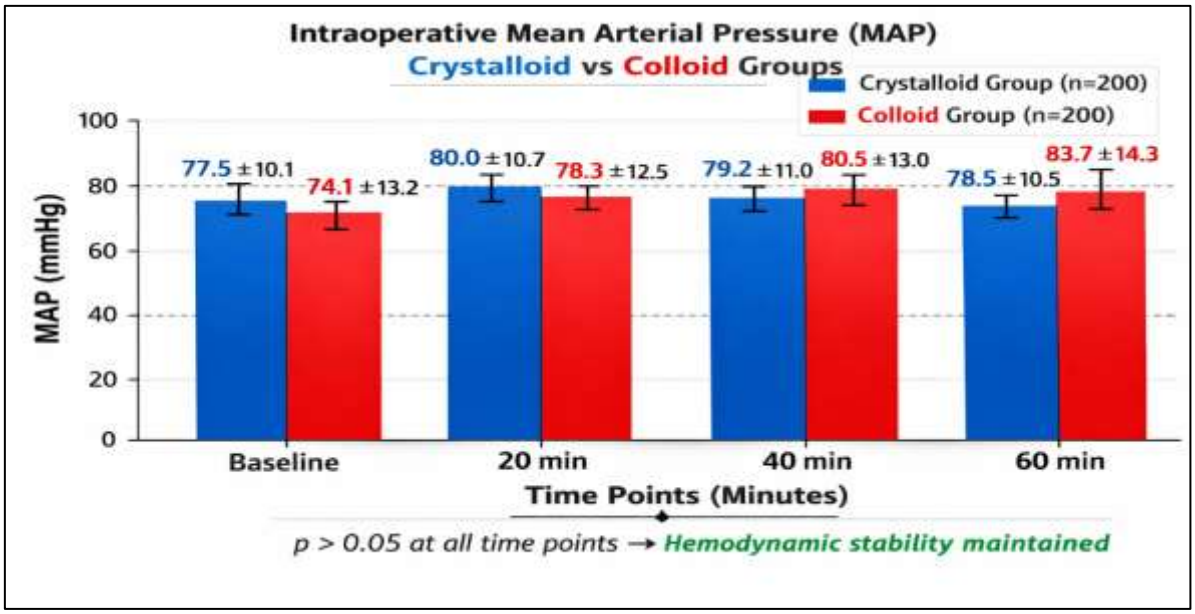


The Colloid group (~1.16 mmol/L) showed higher postoperative serum creatinine than the Crystalloid group (~0.97 mmol/L, $p \leq 0.05$), which means that the former had a higher renal stress. MAP was also stable in both groups, whereas colloids have the potential to damage renal perfusion. Better renal safety Crystalloids offer

sufficient volume. This recommends the use of crystalloids, instead of colloids, to minimize renal postoperative complications in patients under cardiac surgery.

Table 2: Intraoperative Mean Arterial Pressure (MAP) in Crystalloid vs Colloid Groups

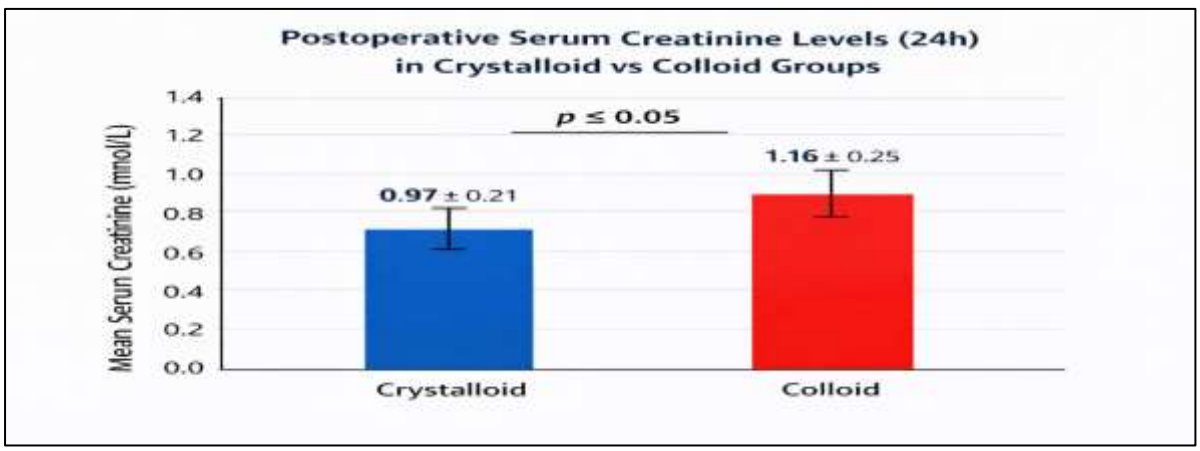
Time Point (minutes)	Crystalloid Group (mmHg), mean ± SD	Colloid Group (mmHg), mean ± SD	P-value
Baseline	77.5 ± 10.1	74.1 ± 13.2	0.12
20	80.0 ± 10.7	78.3 ± 12.5	0.28
40	79.2 ± 11.0	80.5 ± 13.0	0.45
60	78.5 ± 10.5	83.7 ± 14.3	0.08



MAP during and after the surgery was maintained constant at all time points in Crystalloid and Colloid groups and there were no significant differences ($p > 0.05$). This shows that both fluids are equally effective in keeping the hemodynamic norms throughout cardiac operating procedures, although they have varying renal outcomes. The postoperative renal function cannot be completely predicted by the hemodynamic parameters, and fluid choice is of significance in terms of renal safety.

Table 3: Postoperative Serum Creatinine Levels in Crystalloid vs Colloid Groups

Parameter	Crystalloid Group (n=200), mean ± SD	Colloid Group (n=200), mean ± SD	P-value
Preoperative Creatinine (mmol/L)	1.0 ± 0.2	1.0 ± 0.3	0.90
Postoperative Creatinine (24h) (mmol/L)	0.97 ± 0.21	1.16 ± 0.25	≤0.05



Colloid group showed more postoperative serum creatinine (1.16 + 0.25 mmol/L) compared to Crystalloid group (0.97 + 0.21 mmol/L, p 0.05). It means that colloids may act as renal stressors, whereas crystalloids are not harmful to the kidney since they are as stable intraoperative. The findings suggest the use of crystalloids as one of the

favored options of intravenous fluids to reduce the occurrence of renal complications during the postoperative phase in cardiac surgery patients.

Table 4: In-Hospital Mortality in Crystalloid vs Colloid Groups

Outcome	Crystalloid Group (n=200)	Colloid Group (n=200)	P-value
Mortality (n, %)	1 (0.5%)	2 (1.0%)	0.56
Survival (n, %)	199 (99.5%)	198 (99.0%)	0.56

The death rates were low in-hospitals with Crystalloid (0.5) and Colloid (1.0) showing no significant difference in the mortality rates (p=0.56). This implies that, the two kinds of fluids provide comparable total survival. Despite the variation in the renal outcomes, the mortality was also equal, and it proves that the effect of perioperative fluid decision on the renal performance is more significant, but not on immediate survival. These findings support the safe use of non-mortality-inducing crystalloids that enhance the hemodynamic condition and reduce the number of ng complications to the kidney.

Table 5: Postoperative Complications in Crystalloid vs Colloid Groups

Complication	Crystalloid Group (n=200), n (%)	Colloid Group (n=200), n (%)	P-value
Acute Kidney Injury (AKI)	5 (2.5%)	12 (6.0%)	0.04
Excessive Bleeding (>100 ml/h)	3 (1.5%)	4 (2.0%)	0.70
Need for Inotropic Support	4 (2.0%)	5 (2.5%)	0.73
Hypotension (BP <100/60 mmHg)	2 (1.0%)	3 (1.5%)	0.65
Arrhythmias	6 (3.0%)	7 (3.5%)	0.78

Compared to Crystalloid (2.5, p=0.04) acute kidney injury (AKI) was more prevalent in the Colloid group (6.0%). Other issues that were similar across groups included bleeding, inotropic support, hypotension and arrhythmias (p<|human|>Other complications were the same across groups which included bleeding, inotropic support, hypotension and arrhythmias (p>0.05). These findings suggest that both fluids equally can be used to achieve total hemodynamic stability, but crystalloids are safer in the kidneys hence it is better when used in perioperative care in cardiac surgery patients.

DISCUSSION

Perioperative fluids are critical in ensuring hemodynamic stability and maximization of outcome in the patients who are undergoing cardiac surgery. We have compared the influence of crystalloid solution and colloid solution on the hemodynamic, renal and postoperative complications in this study**Error! Reference source not found.**. We have found that the two fluids ensured the hemodynamic homeostasis of cardiac surgery by offering sufficient intraoperative mean arterial pressure (MAP) stability. Baseline, 20, 40, and 60 minutes showed that the MAP was similar in the two groups, and that both the crystalloids and colloids can effectively maintain blood pressure in the perioperative period. This observation agrees with other studies that have reported the same levels of hemodynamic stability using both types of fluids implying that when administered properly fluid choice does not have a major impact on instantaneous blood pressure control.

Although there was a similarity in the MAP readings, the readings showed some significant differences in the postoperative renal outcome. At 24 hours of post-operative, the serum creatinine level was greater in colloid group than in crystalloid group (1.16 ± 0.25 mmol/L vs. 0.97 ± 0.21 mmol/L, $p \leq 0.05$). This is a pointer of increased renal stress or premature renal impairment in the case of colloid use. The incidence of the acute kidney injury (AKI) was also higher in the colloid group (6.0) than in the crystalloid group (2.5, p=0.04). The findings align with those of the previous reports that have reported nephrotoxicity because of synthetic colloids especially hydroxyethyl starch (HES). Colloids spend more time in the intravascular compartment, but their large molecular weight and the possibility of causing tubular deposition can limit renal perfusion and glomerular filtration particularly in patients who are already vulnerable to stress, hypoperfusion, or inflammation of cardiac surgery. On the contrary, the crystalloids are more evenly spread throughout the intravascular space, interstitial space and seem to be able to offer adequate plasma volume without causing harm to renal function.

The low in-hospital mortality in the study was similar in those two groups (Crystalloid 0.5% vs. Colloid 1.0 and p=0.56) meaning that both types of fluids are safe about immediate survival outcomes. There were also intraoperative complications such as excessive bleeding, inotropic support requirement, hypotension, and arrhythmias, which were also common between groups. This implies that colloids have the potential to increase renal risk, however, in the short time the use of colloids has no significant outcome on other perioperative outcomes**Error! Reference source not found.**. The difference between the outcomes, renal and other hemodynamic or other clinical parameters is an important clinical observation: hemodynamic stability is not enough to assess the safety of fluid therapy and renal functioning, which needs to be closely observed, especially when colloids are used.

The implications of the study findings on clinical practice in the context of the perioperative management of cardiac surgery patients are significant. Since the use of crystalloids has been shown to be renal safe and with similar efficacy compared to that of crystalloids in maintaining MAP, crystalloids are to be considered as the first-line fluid of choice. Though colloids theoretically could be a better choice of intravascular volume expansion, the risk of renal impairment, as in our case, is more significant than the possible hemodynamic benefits. Use of synthetic colloids could be avoided in environments with limited renal functionality or those patients with high risks of developing AKI, which could assist in the reduction of postoperative morbidity and recovery **Error! Reference source not found.**.

There is also a considerable gap in local data that is covered in our study. Even though international recommendations suggest that perioperative fluids are to be chosen carefully, Pakistani populations had not been studied extensively. Risk factors at the local level, such as the high incidence of comorbidities and dyslipidaemia (high blood pressure, diabetes, etc.) can increase the risk of postoperative renal complications**Error! Reference source not found.**. The current study, by providing evidence on a high number of patients (400) supports a rationality behind the use of crystalloids in cardiac surgery patients in Pakistan, providing safe and effective perioperative care that is specific to the local population**Error! Reference source not found.**.

There are certain limitations that are to be considered. The researchers evaluated only short-term results, including serum creatinine 24 hours and in-hospital mortality in 5-7 days. No evaluation was carried out on long-term renal performance, readmission, and other postoperative complications. There was also less bias with randomization, but this was a one-centre study, and the results might not be applicable to other institutions or other patient groups with varying surgical practices. Multicentre studies with longitudinal follow-up will be encouraged in the future to further confirm those results and evaluate the effects of fluid option on long-term renal outcome and recovery in general**Error! Reference source not found.**.

This research shows that both the crystalloids and the colloids make the intraoperative hemodynamic stable in cardiac surgery patients. Nonetheless, crystalloids are linked with improved renal outcomes, such as fewer postoperative serum creatinine, less AKI, and does not raise mortality or other complications These findings confirm that crystalloids should preferentially be used in managing perioperative fluids during cardiac surgery especially in patients who are at risk of having renal impairment. Optimizing fluid therapy will help clinicians to provide greater patient safety, minimise postoperative renal complications, and increase overall surgical outcomes. **Error! Reference source not found.Error! Reference source not found.**

CONCLUSION

As seen in this paper crystalloid and colloid perioperative fluid administration show comparable hemodynamic stability in cardiac surgical patients. The mean arterial pressure of the two samples was not at a lower rate than the starting value and was maintained throughout the intraoperative period and this indicated that the two types of fluids are able to manage satisfactory blood pressure during surgery. However, significant variations were observed in result of the renal outcomes. The cases of acute kidney injury and the postoperative serum creatinine level were more in patients who received colloids as opposed to those who did not and this suggests that there was increased stress in the renal process with the use of hydroxyethyl starch. The groups had low and other post appetencies of bleeding, hypotension, arrhythmias and inotropic support need. These reasons attract attention to the fact that colloids are hemodynamically stable, but they can damage renal activity. Less dangerous are crystalloids, they are also an effective volume support, but they do not increase the risk of the kidneys. Therefore, the preferred choice of fluids to treat perioperative should be the crystal.

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