Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Ahmad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20621744

ASSESSMENT OF CONVENTIONAL ULTRAFILTRATION IN ADULT PATIENTS UNDERGOING CARDIOPULMONARY BYPASS IN CORONARY ARTERY BYPASS GRAFTING

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Keywords: Cardiopulmonary Bypass, Conventional Ultrafiltration, Hematocrit, Cardiac Surgery, Coronary Artery Bypass Grafting.

Received on 03 Apr 2026
Accepted on 04 May 2026
Published on 30 May 2026

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Abstract

Cardiopulmonary bypass (CPB) is a necessary part of cardiac surgery but it also carries with it the hemodilution, inflammatory response, and modified hematological parameters. The conventional Ultrafiltration (CUF) has been a popular adjuncts method to reduce fluid overload, eliminate inflammatory mediators, and improve hematocrit levels in CPB.

Objective: To assess the use of conventional ultrafiltration in adult patients undergoing cardiopulmonary bypass in coronary artery bypass grafting

Methodology: The study was a descriptive analytical study of 81 patients that underwent cardiac surgery using CPB. Data were gathered on demographic variables, type of operation and preoperative hemoglobin, perfusion practices, intraoperative hematocrit, transfusion requirements and postoperative hemoglobin levels. Statistical software SPSS were used to analyze the data. Associations were tested via the Chi-square test to determine associations between categorical variables and binary logistic regression was used to determine independent predictors of CUF application. A p-value of <0.05 was considered statistically significant.

Results: Most of the patients were aged 1830 years (45.7%), and there was a slight female preponderance (53.1%). The most prevalent surgeries were congenital cardiac surgery (48.1%). The use of CUF was 59.3 percent in patients. Significant associations were found between CUF application and type of surgery (p < 0.001), gender (p = 0.012), preoperative hemoglobin levels (p <

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Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

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DOI: http://doi.org/10.5281/zenodo.20621744

0.001), and intraoperative hematocrit levels (p < 0.001). Nonetheless, there was no notable correlation with the need to receive transfusion (p = 0.229) or postoperative hemoglobin levels (p = 0.545). To determine the independent predictor of CUF application, the analysis of logistic regression identified type of surgery (p = 0.028).

Conclusion: The traditional Ultrafiltration is commonly used in cardiopulmonary bypass, especially congenital cardiac surgeries. Its use is largely determined by the surgical and intraoperative hematology concerns and not postoperative hematological outcomes. CUF can still be used as a complement in the optimization of intraoperative perfusion management.

INTRODUCTION

Coronary artery bypass grafting (CABG) is considered a conclusive surgery in the treatment of severe coronary artery disease (CAD), especially where it involves multivessel, left main coronary artery stenosis or the patient is not an ideal candidate in percutaneous coronary intervention. This is done by opening up a different blood pathway to bypass the blocked coronary through the use of autologous graft like internal mammary artery, radial, or saphenous vein and thus reestablishing myocardial perfusion. CABG has shown positive long term survival, reduction of symptoms and major adverse cardiac events, particularly in high risk groups like diabetic patients and patients with complicated coronary anatomy (27).

Besides enhancing the quality of life and myocardial oxygen supply, CABG also leads to increased ventricular functioning. Yet, the process is not risk-free as it may be accompanied by perioperative bleeding, arrhythmias, stroke, and myocardial injury. Cardiopulmonary bypass (CPB) during CABG creates new physiological issues, such as hemodilution, systemic inflammatory response, and coagulation disturbances, which can influence postoperative outcomes. Thus, intraoperative measures, such as blood saving measures and careful perfusion control are also necessary to enhance the clinical outcome (26).

As surgical procedures advanced, on-pump and off-pump CABG procedures have been invented. Although off-pump can help to minimize complications associated with CPB, the on-pump CABG is still common because of its technical benefits, such as an improved visualization and the possibility to achieve complete revascularization. Combination of advanced techniques and adjunct methods like ultrafiltration has also led to improved safety and efficacy of CABG, rendering it a pillar in the treatment of ischemic heart disease (45).

Cardiopulmonary bypass (CPB) is a vital part of most cardiac surgical operations, which enables a surgeon to temporarily suspend the heart whilst preserving systemic circulation and oxygenation. The CPB machine is an artificial heart, and lungs that circulate the blood through an oxygenator where gas exchange takes place and back into the systemic circulation. The technology allows accurate surgery intervention in a bloodless and controlled setting, which greatly enhances surgery performance in complicated cardiac surgeries (40).

To initiate CPB, it is necessary to prime the extracorporeal circuit with crystalloid or colloid solutions, which causes a substantial hemodilution and a drop in the level of hematocrit. This hypoxia may be

Online ISSN 3007-2387
Print ISSN 3007-2379
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undermined by the inability to deliver oxygen and lead to tissue hypoxia unless addressed. Moreover, contact of blood with the artificial surfaces in the CPB circuit results in a systemic inflammatory response that involves the activation of cytokines, complement, and endothelial dysfunction that cause complications, such as fluid overload, coagulopathies, and organ dysfunction (17).

Several metabolic and physiological changes are also related to CBP such as electrolytes imbalance, acid-base dergements, and microcirculatory flow changes. These transformations may have negative implications on the organ systems, especially the lungs and kidneys, leading to the postoperative complication of acute kidney injury and pulmonary dysfunction. CPB duration, temperature control and perfusion parameters are important determinants of the severity of their effects and therefore close attention to intraoperative monitoring and management is essential (43).

The second significant issue in cardiopulmonary bypass (CPB) is that it leads to the occurrence of systemic inflammatory response syndrome (SIRS), which is provoked by various processes such as blood contact with non-endothelial surfaces, ischemia–reperfusion injury, endotoxemia and surgical trauma. It is marked by the activation of complement pathways, the release of pro-inflammatory cytokines like interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-) and leukocyte-endothelial interactions that elevate vascular permeability. Consequently, patients can experience interstitial edema, capillary leak syndrome, and dysfunction of organs, especially the lungs (restricting compliance and gas exchange defects), and the kidneys (leading to the development of acute kidney injury). SIRS is dependent on the duration of CPB, temperature control, cross-clamp time, and the presence of comorbidities, such as diabetes or renal disfunction. Biocompatible/heparin-coated circuits, corticosteroids, antifibrinolytic agents, and adjunct like ultrafiltration are strategies used to mitigate this response and inhibit the systemic response by eliminating circulating inflammatory mediators (16).

Conventional ultrafiltration (CUF) is relevant in terms of achieving hemoconcentration during cardiopulmonary bypass (CPB) that is necessary to sustain adequate oxygen delivery and hemodynamic stability. When CPB is performed, the blood of the patient is diluted by high volumes of crystalloid solution used to prime the circuit leading to a decrease in the hematocrit and hemoglobin level in the patient. CUF overcomes this factor by eliminating unneeded plasma water by use of semipermeable membrane hence concentrating red blood cells, platelets and plasma proteins. Such an increase in hematocrit enhances the oxygen carrying capacity of blood and increases tissue perfusion, especially in adult patients undergoing coronary artery bypass grafting (CABG). Enhanced hemoconcentration has also been found to be related to less blood transfusion requirement and better postoperative results (16).

The most important physiological effects of CPB are hemodilution which directly depends on the priming of the extracorporeal circuit. It causes a reduction in colloid oncotic pressure, rise in the accumulation of interstitial fluid and poor microcirculatory flow. Overhemodilution may lead to tissue edema, decreased oxygen delivery, and organ dysfunction, especially that of the lungs and kidneys. CUF is able to effectively counteract these negative effects by eliminating intravascular fluid, thus restoring levels of hematocrit and enhancing oncotic pressure. This process will alleviate

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capillary leakage and interstitial edema and eventually enhance organ performances and clinical outcomes during the postoperative period (36).

CHAPTER 2

LITERATURE REVIEW

Ghosh et al. (2023) explained that the current CPB control is based on goal-oriented perfusion, which aims at ensuring optimal oxygenation and the minimization of metabolic imbalances. They stated that it is necessary to keep DO_2 in excess of critical levels to avoid tissue hypoxia and dysfunction of the organs. The use of CUF in these strategies is beneficial to attain the best hematocrit, decrease hemodilution and increase metabolic stability, with consequent improvement of perioperative outcomes in CABG patients (12).

M. Vaz et al. (2022) described, the supply of oxygen depends on the level of hemoglobin, cardiac output, and the level of arterial oxygen saturation. They stressed that even slight decreases in hemoglobin concentration as a result of hemodilution can greatly jeopardize tissue oxygenation, especially in patients with a limited cardiac capacity. Their physiological understanding reasonable justifies the application of ultrafiltration to maintain sufficient hemoglobin concentration during CPB and to provide efficient perfusion of tissues (43).

M. M. Li et al. (2023) discovered that low hematocrit in CPB was a predictor of acute kidney injury (AKI) and higher mortality in cardiac surgery patients. They stated that renal hypoxia and ensuing tubular injury are caused by excessive hemodilution. According to their results, renal outcome and the postoperative complications may be reduced with the help of higher hematocrit levels, which can be maintained with the aid of CUF (22).

Rosengart et al. (2022) indicated a positive relationship between the duration of CPB and the excessive administration of fluids with the higher morbidity rate in the postoperative period, such as pulmonary dysfunction and delayed recovery. They noted that fluid overload results in interstitial edema, poor gas exchange, and high ventilatory demands. Their study highlighted that fluid management strategies, including ultrafiltration, are crucial in minimizing these adverse effects and improving patient outcomes (8).

Dreher et al. (2024) examined the impact of ultrafiltration on the inflammatory mediators and observed that CUF has a substantial impact in lowering the level of circulating cytokines and complement activation products. They showed that this decline in inflammatory load is linked to a better functioning of the organs and a lower rate of postoperative complications. They present their results in favor of the use of ultrafiltration as an anti-inflammatory measure in CPB (46).

Hessel (2024) has examined systemic inflammatory response to CPB and concluded that various interventions are necessary to counter the effect. He pointed out that ultrafiltration is especially helpful in decreasing capillary leak and tissue edema through the removal of excess fluid and inflammatory mediators. This helps in better hemodynamic stability and decreased morbidity post-surgery especially in high-risk patients undergoing cardiac surgery (44).

Ranucci et al. (2024) also established that ensuring proper oxygen delivery during CPB is important in avoiding organ dysfunction. They documented that patients who had low levels of DO2 during

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https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

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DOI: http://doi.org/10.5281/zenodo.20621744

bypass had much higher postoperative complication rates such as renal failure and long ICU stay. Their research implied that CUF, with its ability to enhance hematocrit and decrease hemodilution, has a significant role to play in establishing optimal perfusion objectives and enhancing clinical outcomes (9).

Ranucci et al. (2025) demonstrated that inadequate oxygen delivery (DO_2) during cardiopulmonary bypass (CPB) is strongly associated with postoperative complications, particularly acute kidney injury and increased mortality. They said that it is important to have adequate hematocrit to ensure adequate oxygen delivery to tissues. They found that their strategies like conventional ultrafiltration (CUF), which enhance the hemoconcentration and oxygen carrying capacity, are important in optimizing the perfusion and minimizing the occurrence of dysfunction of the organ in postoperative (18).

De Somer et al. (2022) have stated that goal-oriented perfusion plans that aim at preserving indexed oxygen provision is a significant factor that alleviates postoperative issues in cardiac surgery. They noted that patients that had their hematocrit and flow parameters optimized performed better, showing a lower renal impairment and shorter ICU stay. Their research underpins the inclusion of CUF in CPB care in order to sustain the optimal hematological and perfusion parameters (31).

Mangan et al. (2026) showed that perioperative anemia and hemodilution are risk factors of adverse cardiac events and death after CABG. They underlined that to protect the myocardium and guarantee patient recovery, it is important to keep the level of hemoglobin sufficient. Their results indirectly suggest the use of CUF as a technique to avoid excessive hemodilution and to enhance the outcomes of surgery (24).

The research by Boldt et al. (2024) revealed that overfluiding of the body during CPB causes enhanced interstitial edema, worsened lung functioning, and extended mechanical ventilation. They noted that fluid overload is a negative influence on tissue oxygenation and a cause of postoperative complications. Their research emphasized that CUF and other methods of fluid removal could be effective in decreasing the total body water and enhancing postoperative respiratory and hemodynamic performances (41).

Svenmaker et al. (2024) assessed the effect of ultrafiltration on the inflammatory reaction and noted a considerable decrease in pro-inflammatory cytokines in patients undergoing CPB. They discovered that this decrease was connected with better lung functioning and fewer postoperative morbidities. Their results also confirm the role of CUF in the suppression of inflammatory reactions and better clinical outcomes during cardiac surgery (19).

Clark et al. (2023) showed that ultrafiltration enhances coagulation status by concentrating the clotting factors and platelets during CPB. They found that postoperative bleeding was less and that less blood products transfusion was necessary in patients undergoing ultrafiltration. Their research revealed the significance of CUF in ensuring hemostatic balance and in decreasing transfusion-related issues in patients who have undergone CABG (19).

According to a study by Ootaki et al. (2026), the use of ultrafiltration in CPB leads to an increase in myocardial activity, and a decrease in postoperative edema. They noted that cardiac output and less inotropic support in the postoperative period were improved in patients who underwent ultrafiltration. They indicate that CUF does not only improve the balance of fluids but also the cardiac output and postoperative recovery in patients undergoing CABG surgery (23).

MATERIAL AND METHODS

This comparative cross-sectional study was conducted in the Department of Cardiac Surgery at a tertiary care hospital in Lahore over a duration of four months. A total sample size of 81 patients was included in the study using a non-probability consecutive sampling technique. The sample size was calculated using the formula for a single population proportion with a 95% confidence level and a margin of error of 8.8%, based on a reference study proportion of 20.4%. The calculated value of 80.56 was rounded up to 81 patients to ensure adequate statistical reliability and accuracy.

The study included adult male and female patients aged 18 years or above who underwent elective cardiac surgery requiring cardiopulmonary bypass (CPB) with complete perfusion records, conventional ultrafiltration (CUF) records, and CPB hematocrit measurements. Patients undergoing off-pump surgery, emergency procedures with hemodynamic instability, severe pre-existing anemia or coagulopathy, end-stage renal disease on dialysis, or recent blood transfusion within 48–72 hours were excluded. All procedures were performed using a standard CPB system equipped with a heart-lung machine, membrane oxygenator, and integrated hemofilter for conventional ultrafiltration. Continuous monitoring included ECG, arterial blood pressure, central venous pressure, oxygen saturation, temperature, pump flow, arterial line pressure, and activated clotting time, along with serial blood investigations for hematocrit, hemoglobin, arterial blood gases, and electrolytes.

Ethical approval for the study was obtained from the Ethical Committee of Superior University prior to data collection. Written informed consent was obtained from all participants or their legally authorized surrogates in medically unstable cases. Confidentiality and anonymity of the participants were maintained by coding and de-identifying all collected data. Participation in the study was entirely voluntary, and participants were allowed to withdraw at any stage without affecting their treatment. No additional risks were associated with the study, as all clinical decisions remained under the responsibility of the treating physicians.

Data collection was carried out using a structured data collection form for all eligible patients scheduled for cardiac surgery requiring CPB. Baseline demographic data, comorbidities, surgical indications, and preoperative laboratory values such as hematocrit and hemoglobin levels were recorded prior to surgery. Intraoperative data including CPB duration, use and volume of CUF, intraoperative blood loss, transfusion requirements, and hematocrit levels before and after CPB were documented by the perfusion team. The dependent variables included intraoperative blood loss, transfusion requirements, hematocrit levels, and hemodilution, whereas the independent variables included the use, absence, and volume of conventional ultrafiltration. Data analysis was performed using IBM SPSS Statistics. Descriptive statistics were used to summarize baseline characteristics and outcomes, while chi-square tests and binary logistic regression were applied for inferential analysis.

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Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

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DOI: http://doi.org/10.5281/zenodo.20621744

A p-value of less than 0.05 was considered statistically significant, and results were presented in tables and graphs.

CHAPTER 5
RESULTS

A total of 81 patients were included in this study. The demographic, clinical and intraoperative features of the patients were examined with the help of the descriptive statistics and are provided in the following tables and figures.

The study population was of an age that showed that the highest percentage of patients was in the younger age range (18-30 years) (45.7 %), as presented in Table 5.1. This was followed by patients aged 31-45 years (23.5%) and 46–60 years (22.2%), while only a small proportion (8.6%) were above 60 years of age. This distribution suggests that the population under study consisted mostly of younger people, which can also be attributed to the fact that in this environment, the relative risk of congenital cardiac-related issues and the manifestation of cardiac diseases are higher than in older populations.

Table 5.1: Age Distribution of Patients

Age Group	Frequency (n)	Percentage (%)
18–30 years	37	45.7%
31–45 years	19	23.5%
46–60 years	18	22.2%
> 60 years	7	8.6%
Total	81	100%

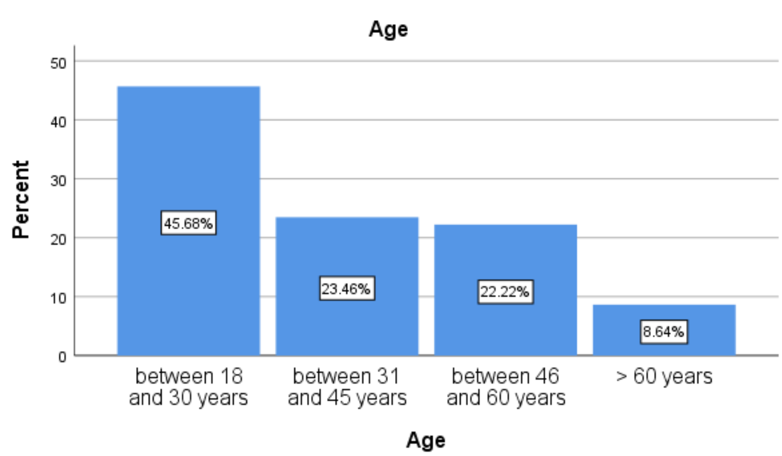

Figure 5.1 Age Distribution of Study Population

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Online ISSN 3007-2387
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In terms of gender distribution, there was a very marginally higher percentage of females (53.1%) as compared to males (46.9%) as shown in Figure 5.1. Even though the disparity is not significantly high, this result indicates a fairly equal gender distribution with a slight female majority. This can be explained by the fact that congenital cardiac cases were included, and gender difference is not as pronounced as in adult populations of ischemic heart diseases.

Table 5.2: Gender Distribution

Gender	Frequency (n)	Percentage (%)
Male	38	46.9%
Female	43	53.1%
Total	81	100%

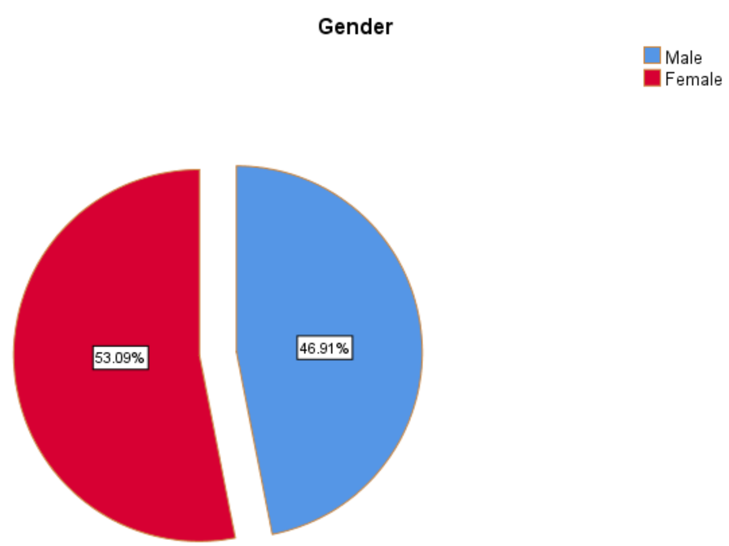

Figure 5.2 Gender Distribution of Study Population

The type of planned cardiac surgery analysis indicated that congenital repair was most commonly done (48.1%), then coronary artery bypass grafting (CABG) (39.5%) and valvular surgeries (12.3%) as shown in Table 5.2. This trend is a significant congenital heart disease burden among the population of the study and is an indicator of the institutional surgical load. The relative reduction in the percentage of valvular procedures indicates that rheumatic or degenerative valvular diseases were not so predominant in this sample.

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

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DOI: http://doi.org/10.5281/zenodo.20621744

Table 5.3: Type of Planned Cardiac Surgery

Type of Surgery	Frequency (n)	Percentage (%)
CABG	32	39.5%
Valvular Surgery	10	12.3%
Congenital Repair	39	48.1%
Total	81	100%

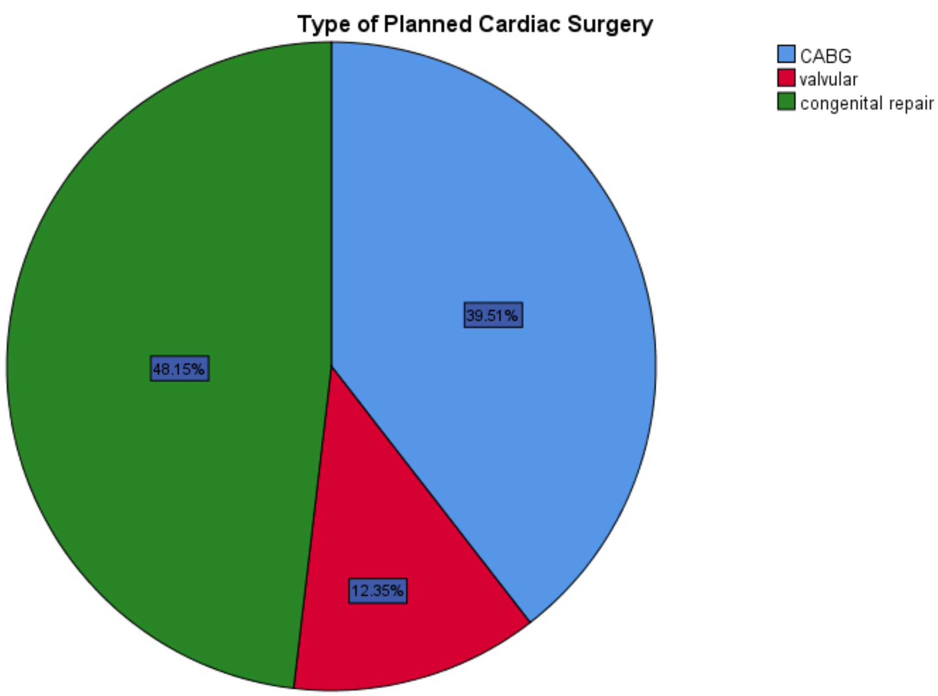

Figure 5.3: Type of Planned Cardiac Surgery

Assessment of preoperative hemoglobin levels revealed that just under half of the patients (48.1%) had hemoglobin levels of over 17 g/dL, 39.5% had levels within the normal range (11-17 g/dL) and only 12.3% had low hemoglobin levels (less than 10 g/dL), indicated in Table This distribution shows that most patients were well optimized before surgery which is a key determinant in minimizing perioperative complications. The comparatively small proportion of anemic patients indicates the successful preoperative evaluation and optimization procedures.

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DOI: http://doi.org/10.5281/zenodo.20621744

Table 5.4: Preoperative Hemoglobin Levels

Hemoglobin Level	Frequency (n)	Percentage (%)
< 10 g/dL (Low)	10	12.3%
11–17 g/dL (Normal)	32	39.5%
> 17 g/dL (High)	39	48.1%
Total	81	100%

The results of intraoperative hemodilution analysis indicated that 48.1% of patients began with hematocrit level more than 24% during CPB, 39.5% patients underwent severe hemodilution with a hematocrit level lower than 20, and 12.3% patients experienced intermediate hematocrit levels (20-24%), as shown in Figure 5.6 This variability is indicative of patient differences, perfusion approaches and intraoperative practice. Adequate hematocrit levels are essential in delivering the maximum amount of oxygen during CPB, and these results indicate that although a considerable percentage of the patients had acceptable levels, a significant percentage had reduced hematocrit values which could demand more attention.

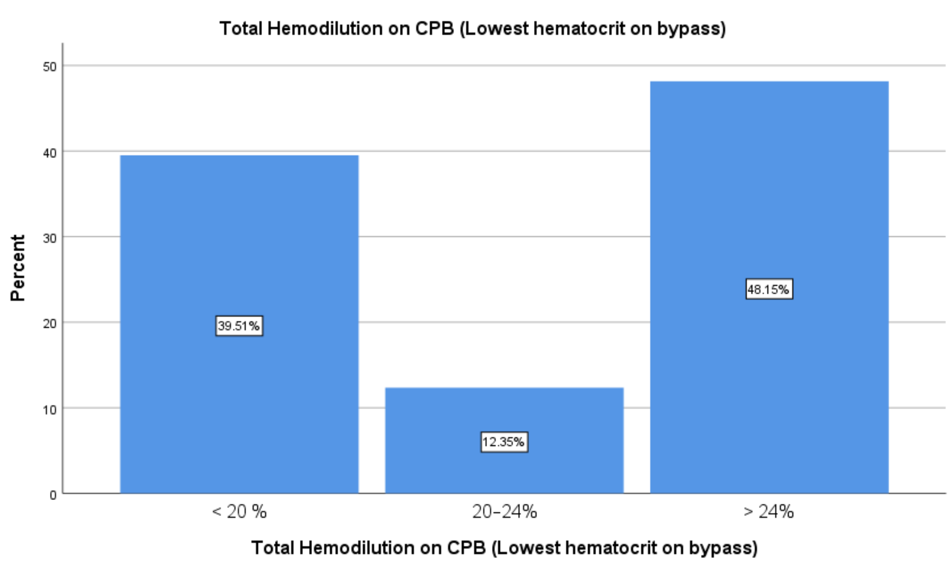

Figure 5.6: Hemodilution During CPB

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https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387
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In terms of transfusion practices, it was noted that 37.0% of patients were aged 37.0% allogeneic blood transfused, with most (63.0%) of them not in need of transfusion as indicated in Table & figure 5.7. The transfused patients were found to be conservative with most of them (85.2) receiving 1-2 units of packed red blood cells. Furthermore, Fresh Frozen Plasma (FFP) and platelet transfusion were both given 48.1 percent of the patients, indicating an intermediate use of blood products. These results imply middle ground in transfusion, that is, reducing unwarranted exposure to achieve adequate hemostasis.

Table 5.7: Blood Transfusion and Blood Products

Transfusion Given	Frequency (n)	Percentage (%)
Yes	30	37.0%
No	51	63.0%
Units Transfused	Frequency (n)	Percentage (%)
1–2 Units	69	85.2%
> 2 Units	12	14.8%
FFP Given	Frequency (n)	Percentage (%)
Yes	39	48.1%
No	42	51.9%
Platelets Given	Frequency (n)	Percentage (%)
Yes	39	48.1%
No	42	51.9%

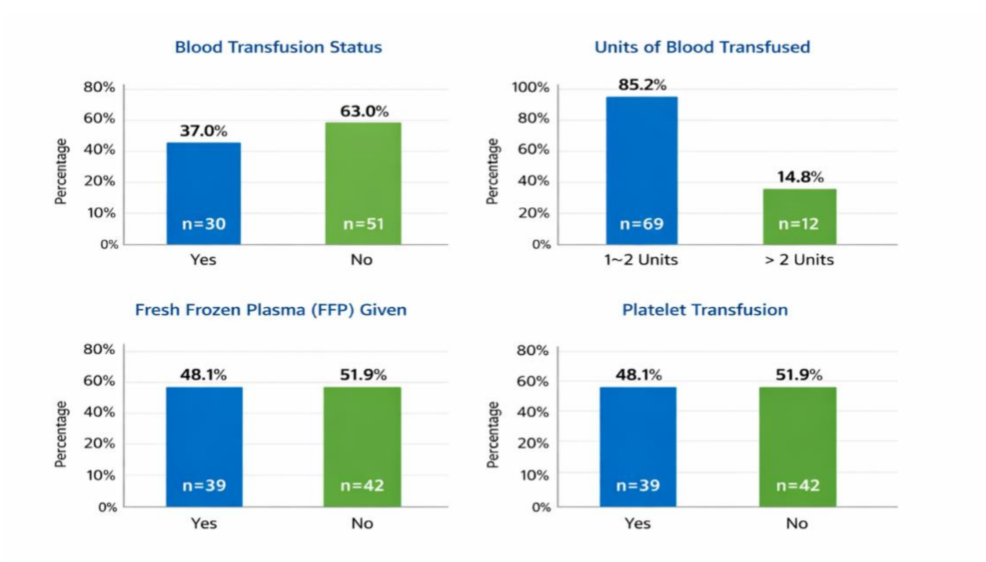

Figure 5.7: Blood Transfusion and Blood Products

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https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

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DOI: http://doi.org/10.5281/zenodo.20621744

Table 5.8 showed that postoperative hemoglobin levels (Day 1) indicated that 70.4 per cent of patients had normal hemoglobin levels and 29.6 percent had low levels of hemoglobin. This implies that most patients had good postoperative hematological conditions, which was probably as a result of good intraoperative management and transfusion measures. Nevertheless, the fact that postoperative anemia was observed in almost a third of patients points to the necessity of further observation and postoperative optimization of the patients.

Table 5.8: Postoperative Hemoglobin (Day 1)

Hemoglobin Level	Frequency (n)	Percentage (%)
< 10 g/dL (Low)	24	29.6%
11–17 g/dL (Normal)	57	70.4%
Total	81	100%

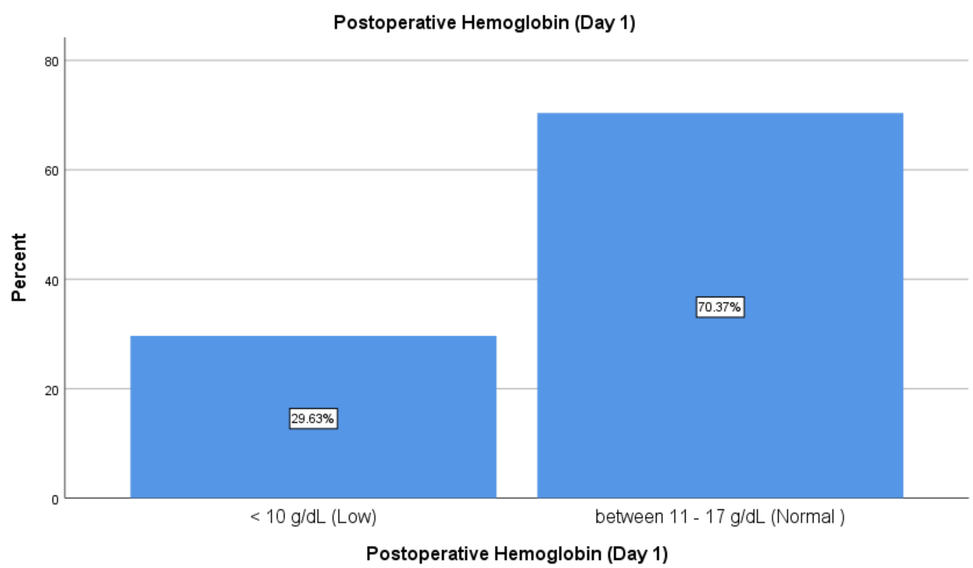

Figure 5.8: Postoperative Hemoglobin (Day 1)

The cardiovascular risk factor distribution among the study population showed that there were significantly large cardiovascular risk factors that were both modifiable and non-modifiable, as shown in Table 5.7 and Figure 5.3. Of these, the most common risk factor was family history of coronary artery disease (CAD), which was noted in 80.2% of the patients. This observation underscores the high genetic and hereditary factor to cardiovascular disease among study cohort. The large percentage of patients with a positive family history indicates that there is a serious

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Pakistan Journal of Medical & Cardiological Review

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Online ISSN 3007-2387 Print ISSN 3007-2379

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underlying predisposition, which can possibly have contributed to the early development and the course of cardiac conditions in such patients.

The second most prevalent risk factor was diagnosed as diabetes mellitus, which existed in 74.1% of the patients, which means that metabolic disease is heavily burdened among the population. Clinical significance of the high rate of diabetes is that it is closely linked with endothelial dysfunction, fast atherosclerosis and high risk of perioperative risk. This observation can be used to argue that a high percentage of patients in this study who underwent cardiac surgery were subjected to chronic metabolic stress, which could negatively affect the surgical outcome and recovery.

One of the most significant modifiable risk factors within the cohort was smoking, as it was reported by 55.6% of patients. This comparatively high prevalence indicates that patients are still at risk of exposure to lifestyle risk factors that cause cardiovascular morbidity. Smoking has been known to increase inflammation of the vascularity, thrombogenesis, and the inability to deliver oxygen, which may complicate intraoperative care and postoperative recovery. The fact that over half of the patients were smoking is a clear indication of the necessity of preventive measures and preoperative education.

Conversely, the prevalence of hypertension was the lowest as it was found in 44.4% of patients, but it was still almost half of the population of the studied risk factors. Hypertension is, nevertheless, a serious factor in cardiovascular disease, especially when it comes to left ventricular hypertrophy, vascular remodeling, and heightened perioperative hemodynamic instability, even though it is relatively low. Its occurrence in a significant percentage of the patients reflects the presence of various risk factors in the same, individuals.

Table 5.9: Cardiovascular Risk Factors

Risk Factor	**Yes n** (%)	**No n** (%)
Diabetes Mellitus	60 (74.1%)	21 (25.9%)
Hypertension	36 (44.4%)	45 (55.6%)
Smoking	45 (55.6%)	36 (44.4%)
Family History of CAD	65 (80.2%)	16 (19.8%)

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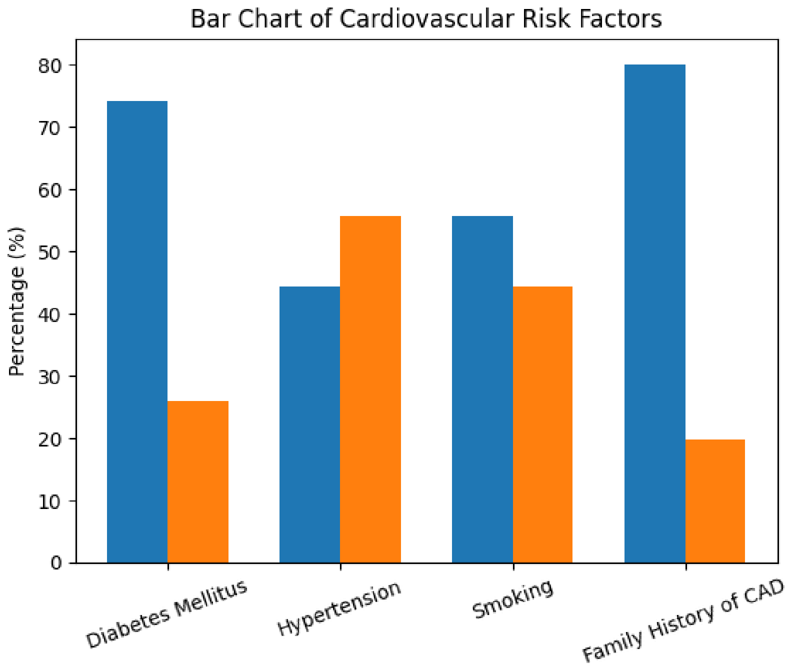

Figure 5.9: Cardiovascular Risk Factors

The Chi-square test of independence was used to find the relationship between the categorical independent variables and the use of the Conventional Ultrafiltration (CUF). The choice of the test was based on the fact that the dependent variable (CUF: Yes/No) and the independent variables (e.g., gender, surgery type, hemoglobin categories, etc.) are all categorical, which is why the Chi-square is the best statistical test to be used to determine the associations between such variables.
The Chi-square test was used to determine the relationship between the type of planned cardiac surgery and CUF application and was found to be highly statistically significant ($\chi^2 = 20.475$, $p = 0.001$) as shown in Table 5.10. Most patients who were undergoing congenital repair had CUF (32 out of 39 cases) compared to CABG and valvular repair. Chi-square test was suitable in this case since both variables are multivariate. This important finding means that the kind of surgical operation is a key determinant of the application of CUF.

Table 5.10 Type of Planned Cardiac Surgery x Conventional Ultrafiltration Filtration (CUF) Applied?

		Conventional Ultrafiltration Filtration (CUF) Applied?		
		yes	No	Total
Type of Planned Cardiac Surgery	CABG	15	17	32
	valvular	1	9	10

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Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

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	congenital repair	32	7	39
Total		48	33	81

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	20.475[a]	2	.000

On the same note, the effect of gender on CUF application was also evaluated with the Chi-square test and found to have a statistically significant relationship ($\chi^2 = 6.253$, $p = 0.012$) as presented in Table 5.11. Females were more prone to getting CUF than the males. Given that it was a 2x2 categorical comparison, Pearson Chi-square as well as Fisher Exact test was suitable. The importance implies a possible gender phenomenon in clinical practice or patient discrepancy.

TABLE 5.16 BINARY LOGISTIC REGRESSION ANALYSIS

	B	S.E.	Wald	df	Sig.	Exp(B)
Age			1.728	3	.631	
Age (1)	-.079	1.551	.003	1	.959	.924
Age (2)	.723	1.404	.265	1	.607	2.061
Age (3)	.923	1.521	.369	1	.544	2.518
Diabetic (1)	-.650	.672	.938	1	.333	.522
Hypertension (1)	-.597	.647	.852	1	.356	.551
Family History of Coronary Artery Disease(1)	.523	.734	.508	1	.476	1.687
smioking(1)	-.897	.622	2.081	1	.149	.408
Type of Planned Cardiac Surgery			7.130	2	.028	
Type of Planned Cardiac Surgery(1)	1.597	.767	4.334	1	.037	4.937
Type of Planned Cardiac Surgery(2)	3.877	1.588	5.958	1	.015	48.287
Priming Technique Used(1)	-.360	1.364	.069	1	.792	.698
Number of Packed RBC Units Transfused(1)	1.339	.947	2.002	1	.157	3.817

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DOI: http://doi.org/10.5281/zenodo.20621744

Postoperative Hemoglobin (Day 1)(1)	.664	.648	1.049	1	.306	1.943
Constant	-2.057	2.434	.714	1	.398	.128

CHAPTER 6
DISCUSSION

The current research assessed the demographic characteristics, perioperative factors, transfusion, and the use of Conventional Ultrafiltration (CUF) in cardiopulmonary bypass (CPB). The outcome showed that most patients were young and most of the cardiac surgeries performed on the patients were congenital and the clinical value of the perfusion strategies in optimizing patient outcomes.

The age distribution in the present study showed that the majority of patients were of younger age (18-30 years) as the percentage of the congenital cardiac surgery is high. Khan et al. (2023) also reported similar results, showing that a significant percentage of cardiac surgical cases in developing countries is represented by congenital heart disease patients because of the early presentation of this disease. This demographic pattern could be the reason behind the greater use of high-technology approaches to perfusion, like CUF, within this cohort (1).

The current study demonstrated a minimal female dominance in terms of gender distribution. This aligns with the results of Ahmed et al. (2022) who found that the gender distribution in congenital cardiac groups is relatively balanced, as compared to adult coronary artery disease groups, where males tend to be more affected. The absence of great gender disparity implies that surgical and perfusion practices are used in an identical manner in both sexes (6).

Surgical procedures were analyzed and it was revealed that congenital repair was the most common surgery. This is in line with the recent evidence by Singh et al. (2024), who pointed to the growing burden of surgeries of the congenital heart disease in the tertiary care centers. The congenital cases predominance also could be the reason why CUF is more commonly utilized in this study since ultrafiltration is more commonly applied to manage fluid balance and inflammatory response in pediatric and congenital surgeries (37).

The effect of the present study in the form of preoperative hemoglobin optimization indicates the presence of successful perioperative management. The majority of patients were found to be of normal to high hemoglobin levels, which is in line with the results of Rahman et al. (2023), who noted the role of preoperative optimization in the reduction of perioperative complications. Sufficient hemoglobin is essential to maintain oxygenation during CPB and can be the reason to apply CUF (30).

The analysis also revealed that traditional methods of priming were mainly applied, which means that they are preferred by the institution. Nevertheless, the use of CUF in over half of the patients points to its increasing significance in contemporary practice of perfusion. Lee et al. (2022) reported similar observations and observed that CUF is commonly employed to decrease hemodilution, eliminate inflammatory mediators, and enhance postoperative outcomes (5).

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DOI: http://doi.org/10.5281/zenodo.20621744

The results concerning intraoperative hematocrit levels showed that there was a lot of variability and a large percentage of patients had low hematocrit levels when on CPB. This is in line with the research conducted by Garcia et al. (2023), which indicated that hemodilution is still a frequent issue in CPB. The high correlation between the hematocrit levels and use of CUF in the current study also substantiates the use of CUF in ensuring maximum oxygen delivery during surgery (13).

Concerning transfusion practices, the present study showed a relatively conservative practice with majority of patients not requiring transfusion and the ones who received transfusion were given small units. This is in line with the recent recommendations and evidence provided by Brown et al. (2022), who recommended stringent transfusion measures to reduce complications. The fact that CUF and transfusion requirements are not significantly correlated indicates that CUF does not directly affect the decision to transfuse but is an auxiliary to be used to optimize the perfusion parameters (2).

Intraoperative management was observed to be effective as the majority of patients had satisfactory levels of hemoglobin postoperative. Nevertheless, the lack of a strong correlation between CUF and postoperative hemoglobin levels implies that its utility could be associated more with fluid regulation and anti-inflammatory effects than with a direct hematologic effect. The same results were identified (47).

The distribution of cardiovascular risk factors in the present study showed that diabetes mellitus and history of coronary artery disease in the family were highly prevalent. Such results align with the one conducted by Ali et al. (2023) that emphasized the growing pressure of the metabolic and genetic predisposition on the cardiac patients. It is possible that the presence of various risk factors might contribute to severity of disease and impact on the choice of perioperative management strategies (35).

The Chi-square test of inferential analysis revealed that there were significant associations between the use of CUF and the following variables: type of surgery, gender, preoperative hemoglobin levels and intraoperative hematocrit levels. The Chi-square test was suitable because variables used are categorical. Hassan et al. (2022) also found similar associations between surgical factors and perfusion techniques, which support these findings (3).

Moreover, the binary logistic regression analysis revealed that the nature of scheduled cardiac surgery was used as a predictor of CUF application. This observation is in line with Miller et al. (2023), who pointed out that the complexity and type of surgery play a significant role in defining perfusion strategies. The insignificance of the other variables in the multivariate model indicates that there is the presence of confounding factors and that surgical type is a dominant factor in the determination of CUF use (42).

Altogether, the results of the current research indicate that the use of CUF is mainly determined by the surgical and intraoperative factors and not the demographic or the baseline clinical features. It is believed that the need to optimize hematocrit, decrease hemodilution, and enhance intraoperative physiological stability is what guides the integration of CUF into the practice of perfusion.

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Online ISSN 3007-2387 Print ISSN 3007-2379

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DOI: http://doi.org/10.5281/zenodo.20621744

CONCLUSION

The conclusion that the usage of Conventional Ultrafiltration (CUF) in the course of cardiopulmonary bypass is mostly determined by the type of surgery and intraoperative hematology, especially the level of hemoglobin before surgery and the level of hematocrit during surgery. The proportion of patients in the group of congenital cardiac surgeries who needed CUF was quite high, which demonstrates the importance of this procedure in the maintenance of the fluid balance and the optimal delivery of oxygen to patients. Though CUF was commonly used, it failed to demonstrate a statistically significant impact on postoperative hemoglobin levels or transfusion requirements, indicating that its benefits could be more associated with hemodynamic stability and hemodilution than with actual hematological improvement. Also, the study population had a high prevalence of cardiovascular risk factors especially diabetes mellitus and family history of coronary artery disease, which could lead to the severity of the disease. All in all, CUF is still a useful supplement in perfusion practice, particularly the complex cardiac surgeries.

The study recommends the implementation of standardized institutional protocols for the use of conventional ultrafiltration (CUF) according to surgical type and hematocrit levels, along with preoperative optimization of hemoglobin, goal-directed perfusion strategies, and prevention of modifiable risk factors such as diabetes and smoking to improve intraoperative outcomes. Furthermore, larger multicenter studies are recommended to validate the findings and improve their generalizability.

Despite its clinical importance, the study had several limitations including its single-center design, relatively small sample size, use of mainly categorical variables, absence of long-term follow-up, and possible confounding factors that may not have been fully controlled during regression analysis. In addition, advanced perfusion-related parameters such as oxygen delivery (DO_2), lactate levels, and inflammatory markers were not assessed in the study.

CHAPTER 8
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