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Comparison Of Pre-Operative And Post-Operative Liver Profile In Patients Undergoing Cardiopulmonary Bypass: Correlation With Post-Operative Recovery

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Abstract

Background: Cardiopulmonary bypass is a lifesaving technique during heart surgery, but it can disturb normal blood flow and provoke inflammation, which also affects the liver. Changes in liver function profiles can, in turn, impact the recovery period and complication rates. This study showed changes in liver profile before and after CPB and how these changes influenced postoperative recovery outcomes and complications.

Methodology: This was a cross-sectional observational study. Data was collected from 150 patients undergoing cardiopulmonary bypass preoperatively and postoperatively. A pre-structured questionnaire was used to collect data from two different cardiac centers, based on predefined inclusion criteria.

Results: After cardiopulmonary bypass, liver function tests showed clear changes. AST, ALT, bilirubin, and INR increased, while albumin decreased, showing temporary liver stress. Patients who developed liver dysfunction stayed longer in the ICU, needed ventilation for longer hours, and had longer hospital stays. Longer CPB time, cross-clamp time, and low blood pressure during surgery were linked with impair liver function.

Conclusion: Cardiopulmonary bypass can cause short-term liver injury that affects patient recovery. Early monitoring of liver tests and good

control of blood pressure and CPB time can help reduce complications and improve outcomes after cardiac surgery.

Introduction

Cardiopulmonary bypass (CPB) has revolutionized cardiac surgery since its introduction by John Gibbon in the 1950s, enabling complex intracardiac procedures by temporarily replacing the functions of the heart and lungs (1). Despite its indispensable role in modern cardiac surgery, CPB is associated with several physiological disturbances, including hemodynamic alterations, systemic inflammatory response, hemodilution, hypothermia, ischemia-reperfusion injury, and oxidative stress, all of which may adversely affect multiple organ systems (2). Among these organs, the liver is particularly vulnerable because of its unique dual blood supply through the hepatic artery and portal vein, making it highly susceptible to reductions in tissue perfusion during CPB (3).

Hepatic dysfunction following cardiopulmonary bypass is multifactorial. Non-pulsatile blood flow, reduced mean arterial pressure, splanchnic hypoperfusion, inflammatory mediator release, and oxidative stress collectively impair hepatic perfusion and cellular metabolism. Furthermore, ischemia followed by reperfusion promotes the generation of reactive oxygen species, mitochondrial dysfunction, and hepatocellular injury (4). These pathophysiological changes may manifest as transient or persistent abnormalities in liver function tests (LFTs), including elevated serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), bilirubin, prolonged international normalized ratio (INR), and reduced serum albumin concentrations (5).

Assessment of liver function before and after cardiac surgery is clinically important because postoperative hepatic dysfunction has been associated with prolonged mechanical ventilation, longer intensive care unit (ICU) and hospital stays, increased risk of infection, greater transfusion requirements, multiple organ dysfunction, and higher postoperative mortality (6). Previous studies have reported that postoperative liver dysfunction occurs in approximately 10–35% of patients undergoing cardiopulmonary bypass, with hyperbilirubinemia being the most frequently observed biochemical abnormality and an important predictor of adverse clinical outcomes. Even mild postoperative elevations in liver enzymes have been associated with delayed recovery and increased healthcare utilization (7).

Several preoperative and intraoperative factors influence the degree of hepatic injury during CPB. Pre-existing liver disease, renal dysfunction, diabetes mellitus, obesity, hypoalbuminemia, anemia, advanced age, prolonged cardiopulmonary bypass duration, extended aortic cross-clamp time, intraoperative hypotension, blood transfusion, and systemic inflammatory responses all contribute to impaired hepatic perfusion and postoperative liver dysfunction (8). Optimization of perfusion pressure, pump flow, temperature management, minimization of bypass duration, and reduction of unnecessary transfusions have been shown to decrease the risk of hepatic injury during cardiac surgery (9).

Although transient alterations in liver function tests are frequently observed following cardiopulmonary bypass, their relationship with postoperative recovery remains inadequately investigated, particularly in local populations (10). Understanding perioperative changes in liver function and their association with recovery indicators may facilitate early identification of high-risk patients and improve perioperative management (11). Therefore, the present study aimed to compare preoperative and postoperative liver function profiles in patients undergoing cardiopulmonary bypass and to determine their correlation with postoperative recovery outcomes, including duration of mechanical ventilation, intensive care unit stay, and total hospital stay.

Aim

To compare pre-operative and post-operative liver function profiles in patients undergoing cardiopulmonary bypass and evaluate their correlation with postoperative recovery.

Objectives

To compare pre-operative and post-operative liver function parameters (ALT, AST, ALP, total bilirubin, serum albumin, and INR) in patients undergoing cardiopulmonary bypass.

To determine the association between postoperative changes in liver function tests and postoperative recovery outcomes, including duration of mechanical ventilation, intensive care unit (ICU) stay, and total hospital stay.

MATERIALS AND METHODS

This observational cross-sectional study was conducted at the Chaudhary Pervaiz Elahi Institute of Cardiology and the Pakistan Institute of Medical Sciences over a five-month period from September 2024 to January 2025. Adult patients undergoing cardiac surgery with cardiopulmonary bypass (CPB) were consecutively enrolled using a convenience sampling technique. Patients with pre-existing liver disease (e.g., cirrhosis or viral hepatitis), known coagulopathy, severe renal disease, those undergoing off-pump or emergency cardiac surgery, patients receiving medications known to significantly affect liver function, and those with incomplete perioperative records were excluded. The sample size was calculated using Cochran's formula based on a reported prevalence of postoperative hyperbilirubinemia following CPB. A conservative prevalence of 10%, 95% confidence level, and 5% margin of error yielded a minimum sample size of 138; however, data from approximately 150 patients were collected to improve statistical precision. Data were obtained from patient medical records using a structured data collection form, including preoperative and postoperative liver function parameters, while intraoperative variables were retrieved from perfusion records. Liver function assessment included serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), total bilirubin, serum albumin, and international normalized ratio (INR). Postoperative recovery outcomes included duration of mechanical ventilation, intensive care unit (ICU) stay, and total hospital stay. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were presented as frequencies and percentages. Paired-sample *t*-tests were used to compare preoperative and postoperative liver function parameters, independent-samples *t*-tests were applied to compare recovery outcomes between patients with and without postoperative liver dysfunction, and chi-square tests were used to determine associations between categorical variables. A *p*-value of <0.05 was considered statistically significant. Ethical approval was obtained from the Institutional Review Board of Bashir Institute of Health Sciences before commencement of the study, and patient confidentiality was maintained throughout the study by using anonymized data solely for research purposes.

RESULTS

Frequency of Post-Operative Complications:

A total of 150 patients undergoing cardiac surgery with cardiopulmonary bypass were included in the study. Postoperative liver dysfunction occurred in 40 patients (26.7%), while 110 patients (73.3%) did not develop it. Jaundice was seen in 61 patients (40.7%). Other complications such as renal impairment in 12.0%, bleeding in 12.7%, low cardiac output syndrome in 9.3%, sepsis in 7.3%, arrhythmias in 3.3%, neurological dysfunction in 2.7%, and mortality in 5.3% of patients. Inotropic support was required in 60.7% of cases.

Table 4.1 Frequency of Post-Operative Complications

Complication	Absent (n)	Present (n)	Frequency	Percentage (%)
Hepatic Dysfunction	110	40	40	26.7
Jaundice	89	61	61	40.7
Renal Impairment	132	18	18	12
Sepsis	139	11	11	7.3
Bleeding	131	19	19	12.7
Low Cardiac Output Syndrome	136	14	14	9.3
Neurological Dysfunction	146	4	4	2.7
Arrhythmias	145	5	5	3.3
Mortality	142	8	8	5.3
Inotropic Support	59	91	91	60.7

Serial Changes in Liver Function Parameters Following CPB

Liver function markers showed a significant postoperative deterioration. Total bilirubin increased from 0.90 to 2.24 mg/dL, while AST and ALT levels increased nearly fivefold within 48 hours ($p < 0.001$).

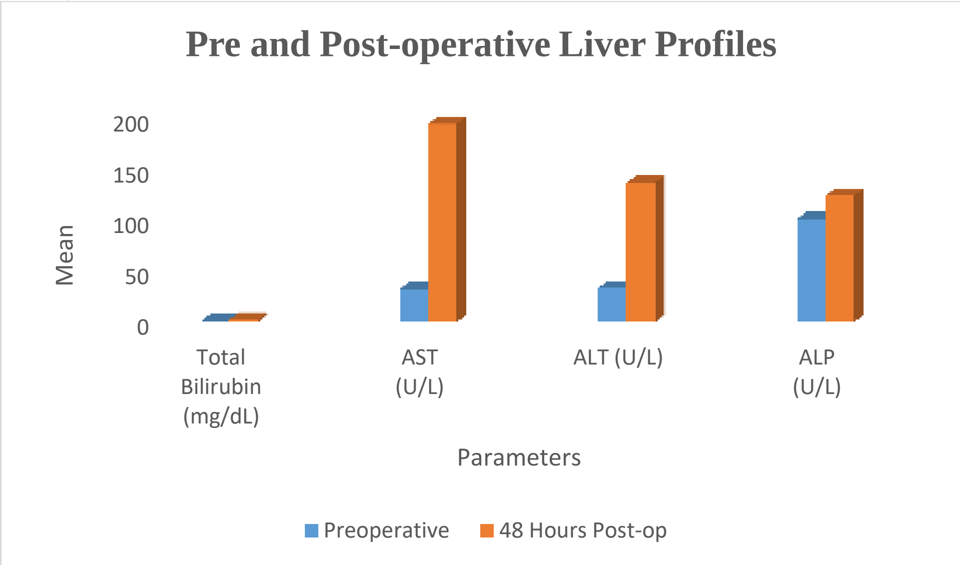

Figure 4.1 Changes in Pre and Post-Operative Liver Profiles

There was a significant difference seen between pre- and post-operative AST and ALT while comparing liver profiles preoperatively and at 48 hours postoperatively.

Impact of Hepatic Dysfunction on Clinical Outcomes

Patients who developed postoperative hepatic dysfunction experienced significantly worse recovery outcomes. The average stay in the ICU was 6.53 ± days in patients with hepatic dysfunction, as compared to 3.63 days in patients without hepatic dysfunction, estimated 80% longer stay in the ICU (mean difference = 2.90 days, 95% CI, $p < 0.001$). The duration of mechanical ventilation was also much longer significant in patients with hepatic dysfunction (24.60 hours vs 6.13 hours), showing a 302% increase (mean difference = 18.47 hours, 95% CI, $p < 0.001$). The total hospital stay days were increased from 8.15 days to 13.38 days in patients with hepatic dysfunction, 64% higher (mean difference = 5.23 days, 95% CI, $p < 0.001$).

The findings of our study show that liver dysfunction after surgery causes a significant delay in the postoperative recovery of patients.

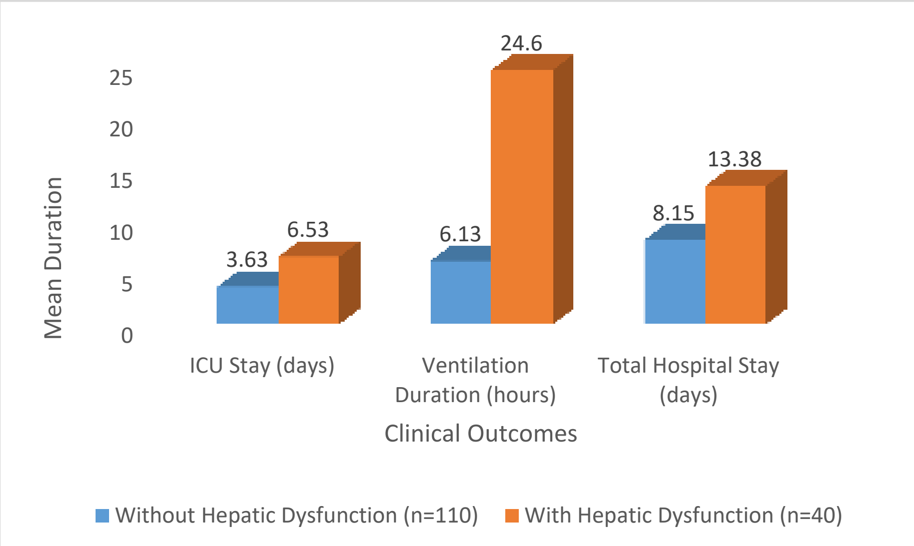

Figure 4.2 Postoperative liver dysfunctioneffects on recovery outcomes

Patients who developed postoperative hepatic dysfunction experienced significantly worse recovery outcomes.

Association of Risk Factors with Postoperative Jaundice

Among the 150 patients, jaundice was present in 61 (40.7%) cases

Patients with CPB duration ≥120 minutes showed a significantly higher rate of jaundice (77.0% vs 42.7%, $p < 0.001$). Cross-clamp time ≥60 minutes was also strongly associated with jaundice (91.8% vs 67.4%, $p < 0.001$). Hypotension presents a significant relationship with jaundice, with severe episodes occurring in 21.3% of jaundiced patients compared with 5.6% in non-jaundiced patients ($p < 0.001$).

Table 4.2 Risk factors associated with the post-operative jaundice.

Risk Factor	Category	Jaundice (n=61)	No Jaundice (n=89)		p-value
CPB Duration	<120 min	14 (23.0%)	51 (57.3%)		**<0.001**
	≥120 min	47 (77.0%)	38 (42.7%)		
Cross-clamp Time	<60 min ≥60 min	5 (8.2%) 56 (91.8%)	29 (32.6%) 60 (67.4%)		**<0.001**
Hypotension Episodes	No episodes	21 (34.4%)	65 (73.0%)		**<0.001**
	Moderate episode	27 (44.3%)	19 (21.3%)		
	Severe episodes	13 (21.3%)	5 (5.6%)		
Vasopressor Use	No	10 (16.4%)	19 (21.3%)		0.450
	Yes	51 (83.6%)	70 (78.7%)		

Patients who developed jaundice had significantly longer CPB and cross-clamp times and more frequent hypotension episodes compared with those without jaundice ($p < 0.001$).

Risk Factors Associated with Hepatic Dysfunctions

Hepatic dysfunction was present in 40 patients (26.7%). CPB time ≥120 minutes was also more common in patients with hepatic dysfunction (67.5% vs 52.7%), although this result does not reach statistical significance level ($p = 0.106$). Cross-clamp time ≥60 minutes was a significant marker of 90.0% vs 72.7% ($p = 0.025$). Hypotension was the most important parameter, with severe hypotension in 32.5% of patients with hepatic dysfunction compared to 4.5% without ($p < 0.001$). Vasopressor use was not significant ($p = 0.554$).

CPB is a severe cause of postoperative hepatic dysfunction, with bilirubin and coagulation factors peaking at 48 hours. Hepatic dysfunction is a significant predictor of increased ICU, ventilation, and hospital stays. Hypotension and ischemic time are the most important predictors of postoperative hepatic injury.

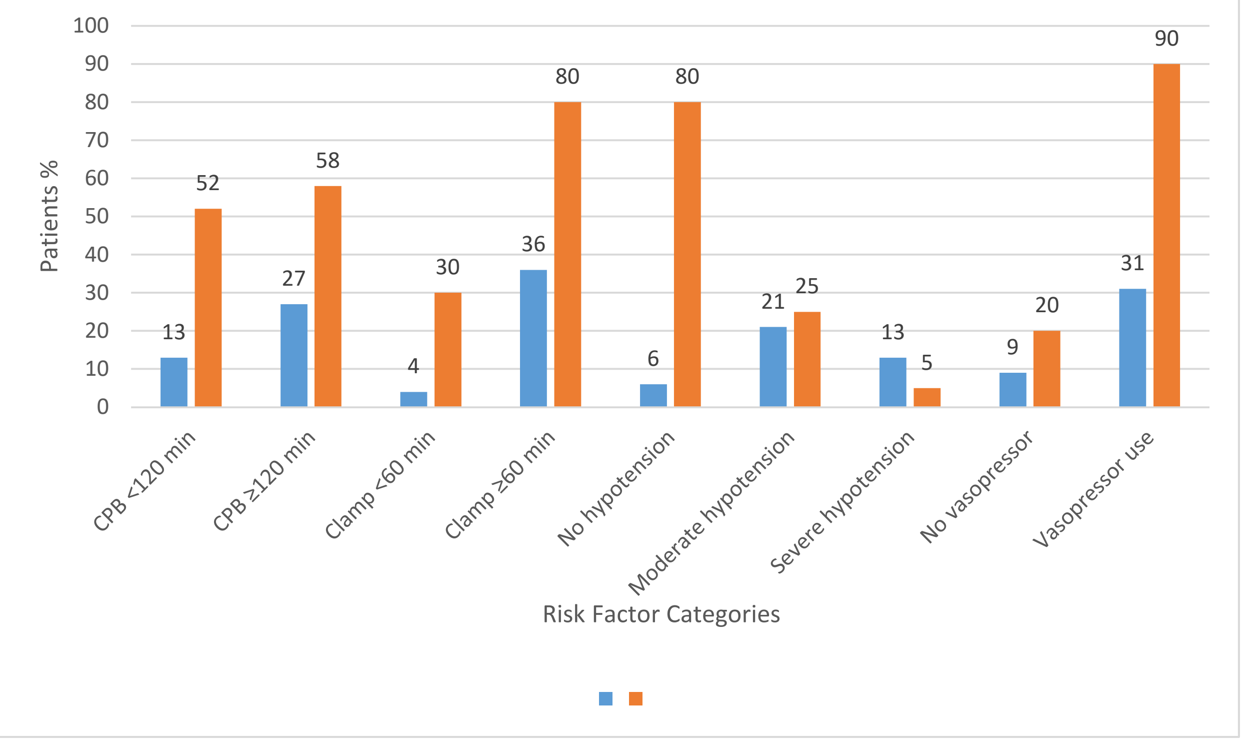

Figure 4.3 Hepatic dysfunction and intraoperative risk factors

DISCUSSION

CPB is anything but physiologically inert, and its effects are best seen in highly metabolically active organs such as the liver, which needs to be continuously oxygenated and perfused for its normal functioning [1].

Right after surgery, the postoperative liver function tests show important changes due to surgery. The total bilirubin level in the serum increased by almost 150% in the first 48 hours, while AST and ALT levels increased to five times the normal level, showing that the cells of the liver are prone to injury. The results are matched with previous studies done by [29] and [6] which shows that liver damage after cardiac surgery is a common and repeated pattern after surgery. Even the slightest high liver enzymes or bilirubin may also be considerable since they can affect the management during the surgery and postoperative recovery of patients.

The increase in bilirubin levels shows both liver cell injury and the temporary blockage of bile flow after cardiac surgery. This can be linked to different factors, including decreased blood flow and reperfusion injury to the liver, destruction of red blood cells in the bypass machine, and systemic inflammation caused by contact of blood with the artificial surfaces of the CPB circuit [22]. Some factors play a role in this problem, including ischemia–reperfusion injury, destruction of red blood cells caused by mechanical stress in the bypass machine, and inflammation in the body going on when blood comes into contact with artificial surfaces during CPB [18].

CPB starts the body's complement and clotting systems, which cause the release of inflammatory substances such as cytokines and free radicals. These things damage the lining of blood vessels, disturb liver vessels' blood flow, and make liver cells more prone to injury. In difficult situations, this response can progress to systemic inflammatory response syndrome (SIRS), which further increases stress on the liver [2],[3].

Ischemia–reperfusion injury is a key cause of liver dysfunction related to CPB. During bypass, blood flow to the liver decreased, and portal vein pressure is lowered, reducing oxygen delivery. This affected the centrilobular hepatocytes in zone 3 of the liver, which are already at risk because they receive less oxygen. When blood flow returns, large amounts of reactive oxygen species are produced, which cause cell damage from harmful oxygen molecules, disrupted the cell's energy system, damaged cell membranes, and lead to further injury by activated immune cells [30].

A patient shows signs of liver dysfunction if any one of the following parameters is: total bilirubin more than 2 mg/dL, AST or ALT raised to more than three times the normal upper limit, or an INR value greater than 1.5. These criteria were used to check liver injury after CPB. In our study, long aortic cross-clamp time was related to liver dysfunction after surgery, showing the important role of ischemic duration in determining the degree of liver injury.

Hemodynamic instability causes hepatic cells to be prone to damage. Severe hypotension episodes were seen in 32.5% of patients with hepatic dysfunction, which is compared to only 4.5% without it. Hypotension during CPB causes less blood flow towards the hepatic artery and splanchnic blood flow, resulting in oxygen deficiency and impaired metabolic function of the liver[18, 30].

Previous studies revealed that hepatic blood flow is highly reduced during CPB, and when combined with hypotension, the extent of liver injury rises sharply [25].

The relationship between CPB duration and postoperative jaundice was stronger than with overall hepatic dysfunction, showing that bilirubin may serve as a more sensitive marker and early warning of hepatic stress than AST and ALT. The use of bilirubin as an early indicator of hepatic injury after cardiac surgery gave us a clue for both monitoring and management strategies[14]. Clinically, postoperative hepatic dysfunction was strongly related to highly abnormal results. Patients who had liver impairment had longer ICU stays by 80%, increased mechanical ventilation by three times, and longer hospital stays by 64%. These findings were related to those given by [16, 28], who found that even slight disturbances in the liver can have profound effects on morbidity and mortality. Hyperbilirubinemia is more than just a laboratory finding; it gives a systemic warning sign that the liver is under stress.

Conclusion

After cardiac surgery using cardiopulmonary bypass, there were significant changes in the liver profile, which affected post-operative recovery. This cross-sectional study shows that patients after surgery showed a clear shift in the blood markers, described as a rise in bilirubin, enzymes like transaminases, alkaline phosphatase, and irregular coagulation profiles in the first 48 hours postoperatively. One in four patients has developed postoperative liver dysfunction, and two-fifths show clear signs of jaundice.

These liver changes were seen not only in the blood but also affected patient recovery. Those patients who developed impaired liver changes needed a longer time on the ventilator, stayed longer in the ICU, and had an increased stay in the hospital. Intraoperative parameters such as hypotension during bypass and longer cross-clamp time were the main causes of liver damage after the surgery. Such findings explain why healing takes longer following heart procedures.

Recommendation

In clinical practice, liver profile tests must be done in the early post-operative period after cardiac surgery routinely, especially in high-risk patients who are determined on the basis of longer cross-clamp time and longer bypass time. Intraoperatively, optimizing perfusion parameters such as sufficient oxygen delivery and minimizing hemodilution are the key factors to ensure enough hepatic blood flow. Since our study shows the liver changes till 48 hours, future studies may do larger cohorts or study long-term effects of CPB on liver profile to validate these findings.

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