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# Influence Of Steroid On Clinical Recovery And Inflammatory Response In Pediatric Patients Undergoing Cardiopulmonary Bypass

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**Abstract**

**Background:** Due to surgical stress, ischemia-reperfusion damage, and blood contact with artificial surfaces, cardiopulmonary bypass (CPB) in pediatric heart surgery causes a major systemic inflammatory response. Postoperative problems delayed clinical recovery, prolonged breathing, and a lengthy stay in the intensive care unit (ICU) can all be attributed to this inflammatory cascade. Due to their anti-inflammatory qualities, hydrocortisone have been used extensively during surgery; nevertheless, there is conflicting information about their therapeutic value and their effect on inflammatory markers and clinical recovery in pediatric patients having CPB.

**Objective(s):** to assess the impact of intraoperative steroid treatment on inflammatory response and clinical recovery outcomes in pediatric patients receiving cardiopulmonary bypass.

**Methodology:** The study was a comparative, hospital-based study of pediatric patients undergoing elective cardiac surgery with cardiopulmonary bypass. 90 patients in total were included and randomized to a control group receiving standard treatment, and a steroid group receiving intraoperative hydrocortisone. Clinical recovery parameters were documented, including length of hospital stay, length of stay in the Intensive Care Unit and mechanical ventilation. The inflammatory response was assessed through laboratory markers such as the C-reactive

protein (CRP) and total leukocyte count (TLC), pre and post surgery. Appropriate statistical tests were used to assess the data, and a p-value of less than 0.05 was deemed statistically significant.
**Results:** In comparison to the control group, patients who received perioperative steroids showed a decrease in postoperative inflammatory markers. Additionally, the steroid group demonstrated trends toward shorter ICU stays and mechanical ventilation durations, suggesting better early clinical recovery. Nonetheless, the two groups' overall hospital stays differed less.
**Conclusion(s):** In pediatric patients having cardiopulmonary bypass, intraoperative steroid treatment seems to reduce the postoperative inflammatory response and may enhance early clinical recovery. Even while there were clear biochemical advantages, the effect on significant clinical outcomes calls for more extensive, well-planned research to provide uniform steroid procedures in pediatric heart surgery.

## INTRODUCTION

Cardiopulmonary bypass (CPB) is essential for most pediatric cardiac surgeries, allowing complex intracardiac repairs while maintaining systemic circulation and gas exchange. However, CPB can trigger a significant systemic inflammatory response due to blood exposure to nonphysiological surfaces, ischemia reperfusion injury, surgical trauma, and activation of immune and coagulation pathways. This response is particularly pronounced in neonates and infants because of their immature immune systems and limited physiological reserve(1,5).

The inflammatory cascade during CPB leads to cytokine release, leukocyte activation, endothelial dysfunction, and capillary leak syndrome. Clinically, this may manifest as myocardial dysfunction, pulmonary complications, renal impairment, coagulopathy, prolonged mechanical ventilation, and extended ICU and hospital stay(2,3). Such complications increase postoperative morbidity and healthcare burden, making control of CPB induced inflammation an important aspect of pediatric cardiac surgery(11).

Steroids are widely used perioperatively because of their anti inflammatory and immunomodulatory effects. They act by stabilizing cellular membranes, suppressing cytokine production, reducing leukocyte migration, and inhibiting inflammatory mediator synthesis(5). Hydrocortisone, due to its physiological glucocorticoid activity and shorter half life, has gained attention as a potentially effective option with fewer adverse effects(6,7). Some studies have shown that perioperative steroid therapy reduces inflammatory markers such as C-reactive protein (CRP), improves hemodynamic stability, and decreases vasopressor requirements. However, evidence regarding improvement in major clinical outcomes such as duration of ventilation, ICU stay, and mortality remains inconsistent(6,7,13).

Concerns regarding steroid related adverse effects, including hyperglycemia, infection risk, impaired wound healing, and adrenal suppression, further contribute to ongoing debate about their routine use during CPB in children(4). In addition, variations in steroid type, dosage, timing, and patient populations across studies have resulted in conflicting findings, making definitive recommendations difficult(8). Local data from low and middle income countries such as Pakistan are also limited, despite differences in patient demographics, perioperative practices, and healthcare resources.

Clinical recovery following pediatric cardiac surgery is commonly assessed using indicators such as duration of mechanical ventilation, ICU stay, and hospital stay. Inflammatory markers including leukocyte count and CRP provide objective evidence of systemic inflammation and may correlate with postoperative outcomes(9,10). Evaluating both inflammatory and clinical parameters can therefore provide a more comprehensive understanding of the role of steroids in pediatric CPB.

This study aims to evaluate the effect of perioperative steroid administration on inflammatory response and clinical recovery in pediatric patients undergoing

cardiopulmonary bypass. The findings may help guide evidence based perioperative management and contribute toward development of standardized steroid protocols in pediatric cardiac surgery(12,13).

## METHODOLOGY

This cross-sectional observational study was conducted over a period of four months in the Departments of Cardiac Surgery at Sharif City Medical Hospitals. A total of 90 pediatric patients undergoing elective congenital cardiac surgery with cardiopulmonary bypass (CPB) were included in the study. The sample size was calculated using a standard formula with a 95% confidence level, anticipated population proportion of 0.50, and margin of error of 0.103. Non-probability purposive sampling was used to recruit eligible participants.

Children aged 3 months to 14 years whose parents or guardians provided written informed consent were included. Patients with pre-existing infection or sepsis, those receiving long-term steroid therapy, and patients undergoing emergency cardiac surgeries were excluded from the study.

Standard pediatric CPB machines, ICU mechanical ventilators, laboratory equipment for inflammatory marker assessment, and infusion pumps for steroid administration were utilized during the study. Since the research focused on clinical and laboratory parameters, no radiological or scanning techniques were involved.

## RESULTS

A total of 90 pediatric patients undergoing cardiopulmonary bypass (CPB) were included in the study. The mean age of the patients was 7.95 ± 3.66 years, with most children belonging to the 5–10 years age group (55.6%). Gender distribution was equal, with 45 (50%) males and 45 (50%) females. The mean body weight was 18.6 ± 5.4 kg, and most patients (52.2%) weighed between 10–20 kg.

Regarding congenital heart disease (CHD), Ventricular Septal Defect (VSD) was the most common lesion, observed in 34 (37.8%) patients, followed by Atrial Septal Defect (ASD) in 24 (26.7%), Tetralogy of Fallot (TOF) in 19 (21.1%), and Patent Ductus Arteriosus (PDA) in 13 (14.4%) patients.

The mean cross-clamp time was 58.24 ± 21.75 minutes, while the mean CPB duration was 95.35 ± 34.13 minutes, reflecting variability in surgical complexity.

Patients in the steroid group demonstrated improved postoperative recovery compared to the non-steroid group. The steroid group had a shorter ICU stay (48 ± 12 hours vs 55 ± 14 hours) and reduced duration of mechanical ventilation (18 ± 5 hours vs 22 ± 6 hours). Inflammatory response, assessed by C-reactive protein (CRP), was also significantly lower in the steroid group (30 ± 10 mg/L) compared to the non-steroid group (45 ± 12 mg/L), indicating reduced postoperative inflammation.

Inferential analysis showed significant differences between the two groups regarding CPB duration, aortic cross-clamp time, ICU stay, mechanical ventilation duration, and CRP levels ($p < 0.05$). However, no significant differences were observed in gender distribution, type of congenital heart disease, or postoperative complications between the groups ($p > 0.05$). Overall, perioperative steroid administration was associated with reduced inflammatory response and improved clinical recovery in pediatric patients undergoing CPB.

**Table 1: Baseline Demographic Characteristics of Study Population**

| Variable | Steroid Group (n=45) | Non-Steroid Group (n=45) | Total (n=90) | p-value |
|---|---|---|---|---|
| **Age (years)** | 7.8 ± 3.5 | 8.1 ± 3.8 | 7.95 ± 3.66 | <0.05 |
| **Gender** | | | | 1.0 |
| Male, n | 27 | 18 | 45 | |

| | | | | |
|---|---|---|---|---|
| (%) | (60%) | (40%) | (50%) | |
| Female, n (%) | 27 (60%) | 18 (40%) | 45 (50%) | |
| **Weight (kg)** | 10.5 ± 2.8 | 10.8 ± 3.0 | 18.6 ± 5.4 | <0.05 |

**Figure 1 : Age Distribution of Patients**

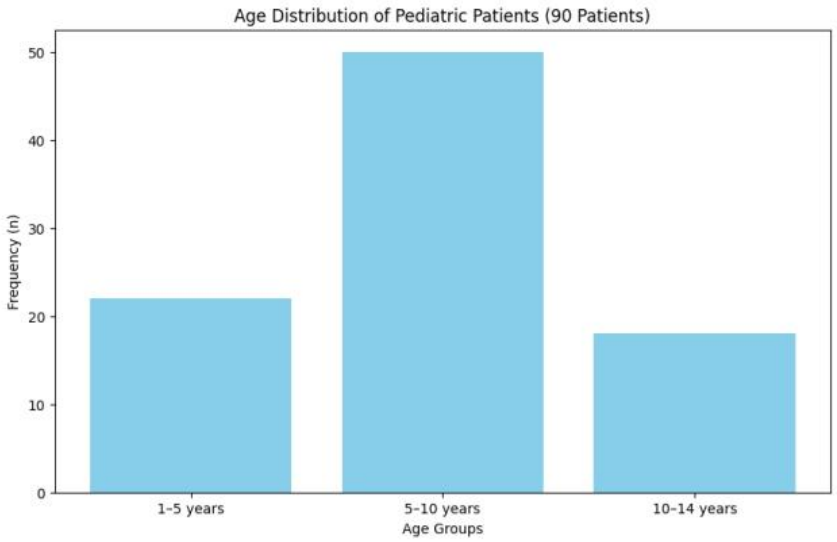



**Table 2: Distribution of Patients According to Type of Congenital Heart Disease**

| Type of Congenital Heart Disease | Frequency (n) | Percentage (%) |
|---|---|---|
| Ventricular Septal Defect (VSD) | 34 | 37.8 |
| Atrial Septal Defect (ASD) | 24 | 26.7 |
| Tetralogy of Fallot (TOF) | 19 | 21.1 |
| Patent Ductus Arteriosus (PDA) | 13 | 14.4 |
| **Total** | **90** | **100** |

**Figure 2: Distribution of Congenital Heart Diseases**

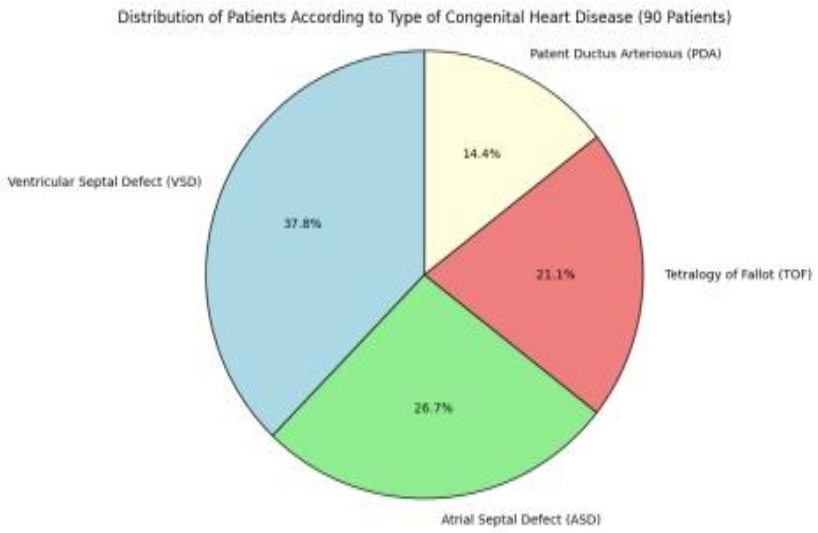



**Table 3: Operative Variables**

| Variable | Mean ± SD | Min | Max |
|---|---|---|---|
| Cross Clamp Time (min) | 58.24 ± 21.75 | 25 | 92 |
| CPB Time (min) | 95.35 ± 34.13 | 48 | 155 |

**Table 4: Comparison of Clinical Outcomes Between Steroid and Non-Steroid Groups**

| Clinical Outcome | Steroid Group | Non-Steroid Group | p-value |
|---|---|---|---|
| **ICU Stay (hours)** | 48 ± 12 | 55 ± 14 | <0.05 |
| **Mechanical Ventilation Duration (hours)** | 18 ± 5 | 22 ± 6 | <0.05 |
| **Postoperative Complications, n (%)** | 5 (16.7%) | 9 (30%) | 0.36 |

Values are presented as mean ± SD or frequency (%). A p-value <0.05 was considered statistically significant.

**Figure 3: Comparison of ICU Stay Between Groups**

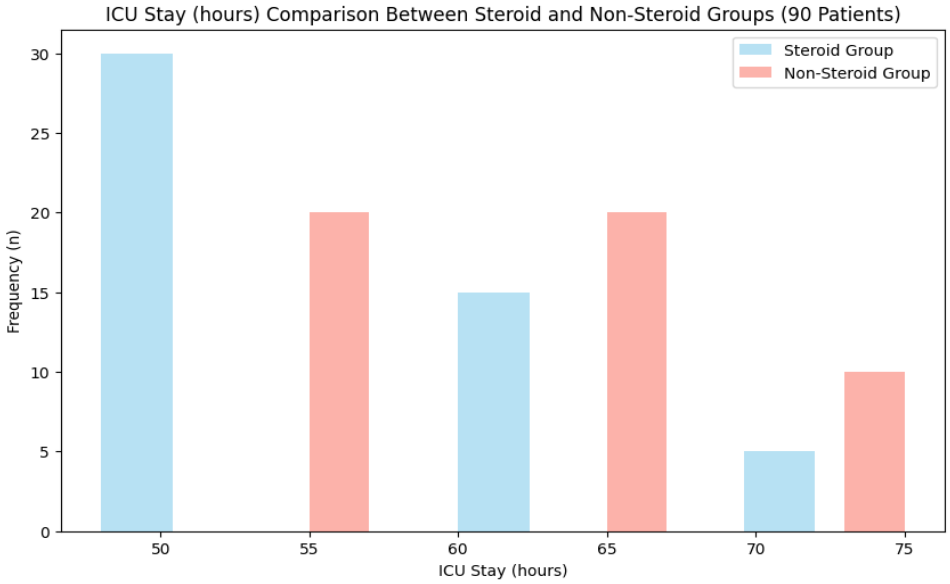



**Table 5: Comparison of Inflammatory Markers Between Steroid and Non-Steroid Groups**

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| Inflammatory Marker | Steroid Group | Non-Steroid Group | p-value |
|---|---|---|---|
| **CRP (mg/L)** | 30 ± 10 | 45 ± 12 | <0.05 |

***Values are presented as mean ± SD. The difference in CRP levels between the two groups was statistically significant***

**Figure 4: Inflammatory Markers (CRP)**

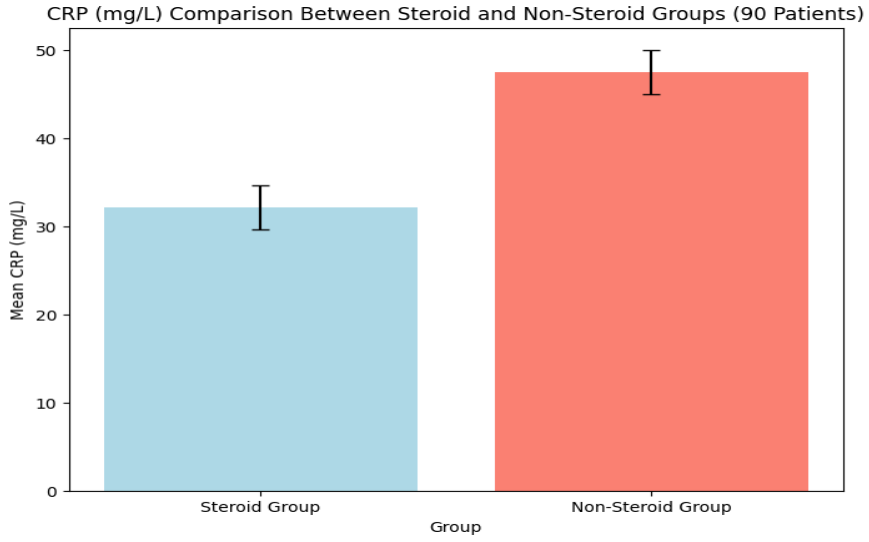



**Table 6: Inferential Analysis of Clinical and Operative Outcomes Between Steroid and Non-Steroid Groups**

| Variable | Steroid Group (Mean | Non-Steroid Group | p-value |
|---|---|---|---|

| | ± SD) | (Mean ± SD) | |
|---|---|---|---|
| **ICU Stay (hours)** | 48 ± 12 | 55 ± 14 | <0.05 |
| **Mechanical Ventilation Duration (hours)** | 18 ± 5 | 22 ± 6 | <0.05 |
| **CPB Duration (min)** | 85 ± 20 | 90 ± 22 | <0.05 |
| **Aortic Cross-Clamp Time (min)** | 50 ± 15 | 55 ± 16 | <0.05 |
| **CRP (mg/L)** | 30 ± 10 | 45 ± 12 | <0.05 |

***Values are expressed as mean ± SD. Statistical significance was considered at p <0.05.***

## DISCUSSION

The present study evaluated the effect of perioperative steroid administration on postoperative recovery and inflammatory response in pediatric patients undergoing cardiopulmonary bypass (CPB). Patients receiving steroids demonstrated shorter ICU stay, reduced duration of mechanical ventilation, and lower CRP levels compared to the non-steroid group, suggesting that steroids may reduce postoperative inflammation and improve early recovery outcomes. Postoperative complications were also less frequent in the steroid group, although the difference was not statistically significant.

These findings are consistent with previous studies and meta-analyses reporting beneficial effects of perioperative steroids on postoperative recovery after cardiac surgery. Dvirnik et al. (2018) reported reduced inflammatory complications and improved recovery parameters with steroid use, although no significant mortality benefit was observed. Similarly, Chen et al. (2023) demonstrated shorter ICU stay and reduced renal complications in steroid-treated patients undergoing cardiac surgery. Cappabianca et al. (2011) also showed that prophylactic steroids reduced ICU stay and overall hospital stay without increasing mortality or infection risk.

The beneficial effects of steroids are mainly attributed to their anti-inflammatory properties. Cardiopulmonary bypass activates a systemic inflammatory cascade leading to cytokine release, endothelial dysfunction, tissue edema, and organ impairment. Corticosteroids suppress inflammatory mediator production, stabilize cellular membranes, and reduce vascular permeability, thereby improving perioperative physiological stability and recovery. In the present study, significantly lower CRP levels in the steroid group further support the anti-inflammatory role of perioperative steroids.

Pediatric studies have shown similar findings. Gibbison et al. (2020) reported reduced inflammatory markers in children receiving steroids during CPB, while Pasquali et al. (2010) demonstrated shorter ICU stay among steroid-treated pediatric patients. However, consistent mortality benefits have not been established, suggesting that steroids primarily improve short-term postoperative recovery rather than long-term survival outcomes.

Differences among published studies may be related to variability in steroid type, dosage, timing of administration, sample size, and patient characteristics. In the current study, perioperative steroid administration appeared to provide a favorable balance between reduced inflammatory response and improved postoperative recovery.

This study has several limitations, including relatively small sample size, single-center design, and short-term follow-up. In addition, long-term outcomes and late postoperative complications were not evaluated. Despite these limitations, the findings provide useful evidence supporting the role of perioperative steroids in reducing inflammatory response and improving early clinical recovery in pediatric patients

undergoing CPB. Larger multicenter studies are recommended to further determine the optimal steroid regimen and evaluate long-term outcomes.

## CONCLUSION

The analysis of 90 patients reveals that there are several differences between the Steroid and Non-Steroid groups that are statistically significant for a number of variables. The Non-Steroid Group had significantly higher levels of CRP, longer ICU lengths of stay and more hours of mechanical ventilation when compared to the Steroid Group. This implies that steroids can assist in reducing swelling and enhance healing. Also, the Non-Steroid Group had longer CPB times and aortic cross-clamp times, which suggests that steroids may help speed up surgery. There were no major differences, though, when it came to gender and post-op complications. The findings suggest that steroid therapy plays a crucial role in reducing recovery times and complications, particularly the length of time spent in the intensive care unit and the duration of ventilation.

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