Original Article

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During Extracorporeal Circulation (ECC): Metabolic Characteristics Management Reduce Post Operative Sepsis, Liver Dysfunction and Renal Dysfunction in Paediatric Patients

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Abstract

Aim: Aim of this study is to investigate the impact of perfusion flow, haematocrit level, lactate level and DO_2 (oxygen delivery) during extracorporeal circulation for paediatric patients post operative sepsis, liver and renal dysfunctions. *Introduction:* Organ dysfunction afterextracorporeal circulation (ECC) has been associated with oxygen delivery DO_2. For conventional extracorporeal circuit required crystalloid priming solution of 350-450 ml, resulting in hemodilution.The metabolic needs of paediatric patients during ECC is organ specific because of tissues oxygen consumption VO_2. If the ratio of VO_2/DO_2 is increase during ECC in paediatric patients which give unreliable value of VO_2/DO_2.This unreliable values give an anaerobic metabolism and lactic acidosis. Due to hemodilution and low delivery of oxygen, postoperative morbidity and mortality will increase. *Material and Methods:* In this prospective study we enrolled total of 180 consecutive paediatric and small children. Who underwent for cardiac surgery with extracorporeal circulation system. Patients were divided into two groups, based on patients haematocrit level ≤ 8.5% and >8.5% haematocrit level, oxygen delivery (DO_2) and extracorporeal circulation pump flow were recorded. For all paediatric operation with extracorporeal circulate system patients preoperative and post-operativetotal blood count, platelet count, blood urea, serum creatinine, electrolytes, SGPT, SGOT and total bilirubin(tb), serological viral test Hepatitis-B (HBsAg) and HIV test were performed. *Result:* In this prospective study we have investigated the lowest haematocrit, lowest oxygen delivery DO_2, and low perfusion flow rates may increase postoperative sepsis, liver dysfunction, renal dysfunction and overall ventilation hours / ICCU stay. *Conclusion:* The present study explored the specific haematocrit level, oxygen delivery DO_2 level, perfusion flow and lactate level during ECC in paediatric patients postoperative sepsis, liver dysfunction, renal dysfunction and overall ventilation hours / ICCU stay. The low haematocrit level and low perfusion flow during ECC in paediatric patients is a possible risk for post operative renal dysfunction. Adequate oxygen delivery and perfusionflow reduced risk of renal dysfunction and liver dysfunction.

Keywords: Extracorporeal; Haematocrit; Liver; Renal.

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Introduction

Extra corporeal circulation has been used since 1953 but we are still trying to determine for adequacy of extracorporeal circulation. Even though extra corporeal circulation systems, surgical techniques and anaesthesia techniques are improved, we have seen that post extra corporeal circulationthere is a significant morbidity and mortality found. So we

must re-evaluate our methods for extra corporeal circulation. We try to summarize the evidence base guidance to achieve optimal perfusion [1].

This is time to re-evaluate our perfusion techniques with the recent advance study.the adverse effect for paediatric patient's postoperative sepsis, liver dysfunction, renal dysfunction and ventilation hours / ICCU stay, is associated with the activation of inflammation, coagulation, and of the autonomic and endocrine systems, preservation of homeostasis and oncotic pressure. During extra corporeal circulation, we can control Hemostasis & Bleeding, CPB induced Systemic inflammation, Neurologic dysfunction, Renal dysfunction, Cardiac dysfunction and Pulmonary dysfunction. During extra corporeal circulation, all this issuecan control by arterial Flows rate, mean arterial pressures and haematocrit level.

The standards of perfusion were established in the 1980's. we select a flow rate by Calculating patient's body weight (kg) or by body surface area (m^2) [2]. At 37°C arterial flow rates 2.2 L/m^2 was recommended by Kirklin (Cardiac Surgery 1993, pg 80). For un anesthetized patients the CPB flow rates values is 2.4 – 3.2 L/m2/min. Under anesthetized CBP flow rates could be markedly reduced. During extracorporeal circulation Oxygen delivery and patient's oxygen consumption (VO_2) is depend on arterial flow rates. The organs i.e. heart, liver, kidney, brain required adequate blood pressure for optimal perfusion during extra corporeal circulation. We can measure the adequacy of arterial flow rates by Venous PvO_2 and SvO_2, Lactates, $DPCO_2$, or by arterial pressures. Since 1971 it has been suggested that measuring venous saturations (SvO_2) with a constant oxygen consumption(VO_2) can estimate the adequacy of CPB arterial flows (Q) [3]. However, PvO_2 or SvO_2 does not mean that cellular oxygenation is satisfactory. If distant capillaries are not equally perfused, tissues may not get blood flow and as a result the PvO_2 or SvO_2 may actually increase – mimicking a vascular shunt. Therefore PvO_2 or SvO_2 are useful and easy markers to measure but may not always related to adequate tissue perfusion [4].

In present era serum Lactate is a good marker of adequacy of perfusion [5]. Elevated blood lactate levels associated with metabolic acidosis are common among critically ill patients because of systemic hypo perfusion and tissue hypoxia. This situation represents lactic acidosis, resulting from an imbalance between tissue oxygen supply and demand. Lactate production results from cellular metabolism of pyruvate into lactate under anaerobic condition. Therefore, blood lactate level in blood is related to tissue hypo perfusion. A peak blood lactate level of >4.0 mmol/L during CPB was identified as a strong independent predictor of mortality and morbidity and suggests that occult tissue hypo perfusion occurred during extra corporeal circulation. PCO_2 gradient between arterial and venous blood gas samples ($DPCO_2$) is also another tool which represent adequacy of perfusion. A-V PCO_2Gradient ($DPCO_2$) = $PvCO_2$–$PaCO_2$This is well established experimental and clinical studies that critical oxygen delivery point is associated with an increase of blood lactate levels and a significant widening in $DPCO_2$. Since CO_2 is 20x more soluble in aqueous solutions than O_2, it is logical that $DPCO_2$ may serve as an excellent measurement of adequacy of perfusion.

Organ dysfunction after ECC has been associated with oxygen delivery DO_2. [6,7,8]. The level of hematocrit and arterial flow rate has been established to provide adequate DO2. The optimal hematocrit is 27% however with a lower hematocrit the flow rate must be increased to provide adequate DO_2. The patient's VO_2Oxygen content in the blood is mainly dependent upon the haematocrit level and the percentage of saturation of the hemoglobin. Once the haemoglobin is 100% saturated, PO_2 provides minimal increases in oxygen content of the blood. $PaCO_2$ have a markedly effect on the pH, HCO_3-, haemoglobin, saturation and most importantly cerebral circulation.

Material and Methods

For this prospective study we enrolled 180 consecutive paediatric and small children. Who underwent for cardiac surgery with extracorporeal circulation system. Patients were divided into two groups, based on patients haematocrit level ≤ 8.5% and >8.5% haematocrit level, oxygen delivery (DO_2) and extracorporeal circulation pump flow were recorded. The protocol was approved by the ethical clearance committee of our institute.

Surgery and Parameters Tested

For this prospective study all the patients gave written consent, anaesthesia was induced with Inj. Fentanyl (40-100µg/kg) and inj. Vecuronium (0.1-0.15 mg/kg). Extracorporeal circulation circuit were established with membrane oxygenator and moderate hypothermia (32±5*c) and roller pump. For all paediatric patients extracorporeal circulation flow was kept over 2.4 to 2.6 lpm. Mean arterial pressure was kept between 35-40mmHg with

Inj.Phyenylphrine and Inj. Sodium nitroprusside. Extracorporeal circulation circuit was prime with Inj. Ringer lactate 300-400ml. Inj. Heparin 5000IU/l and 100-150ml packed red blood cells. Before cannulation for extracorporeal circulation systemic Inj. Heparin was given through the internal jugular line by an anaesthesiologist.

Parameters Tested

Preoperative Test

For all paediatric operation with extracorporeal circulate system patients total blood count, platelet count, blood urea, serum creatinine, electrolytes, SGPT, SGOT and total bilirubin(tb), serological viral test Hepatitis-B (HBsAg) and HIV test were performed for all patients.

Perioperative Record

For every paediatric operation the redial arterial line pressure, the pulse oximeter, lead electrocardiogram, nasopharyngeal temperature, central venous pressure line, extracorporeal circulation time, aortic cross clamp time, mechanical ventilation time, urine output, intensive care unit stay time(days) and packed red blood cell volume during CPB were recorded.

Postoperative Test

On first and second postoperative days through central venous line or vein puncture blood sample were analysed for concentration of blood count, platelet count, blood urea, serum creatinine, electrolytes, SGPT, SGOT and total bilirubin (tb).

Statistics Analysis

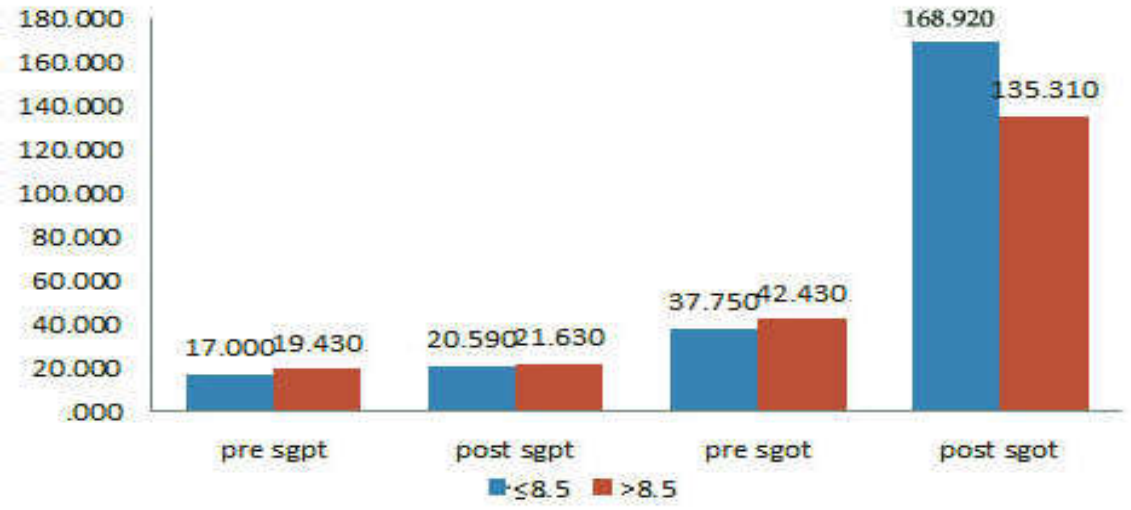
SPSS software version 10.0 (SPSS, USA) was used for analysis. Data were presented as mean ± Standard of deviation. The Chi-square test and student's t- test were used to compare categorical variables. Less than 0.05 P value were considered significant.

The limitation of this study is the relatively small study population. However, studies addressing outcomes after extracorporeal circulation. The metabolic characteristics management reduce sepsis, liver and renal dysfunction in paediatric patient.

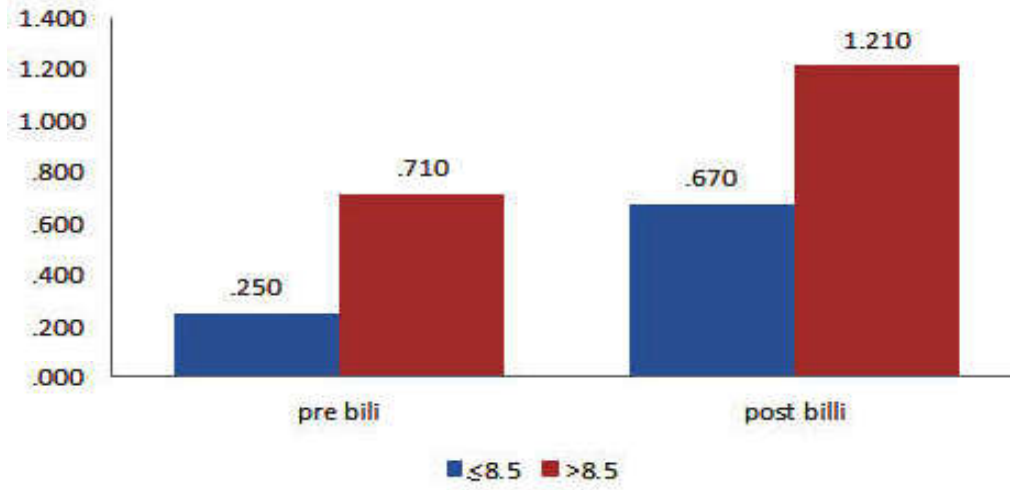
Result

For metabolic characteristic management arterial blood sample were collected in vivo for assessment of postoperative sepsis, liver function and renal dysfunction. For this study a total of 95 (52.77%) male and 85 (47.23%) female paediatric patients were included. Their age was (526.87±553.03) (Table 1)

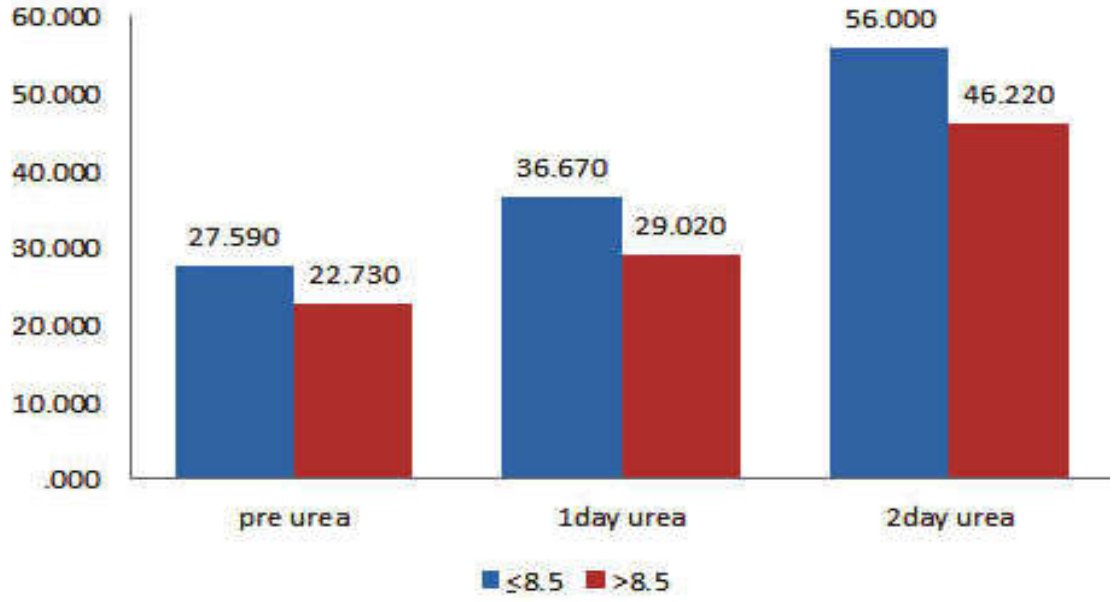
The perioperative liver functions are shown in Table 2 and Graph. 1, Graph. 2. SGPT, SGOT and serum bilirubin were analysed and compared with preoperative liver function. In ≤ 8.5 Group haematocrit level group patients preoperative SGPT was 17±6.128 and postoperative SGPT was 20.58±7.672 Preoperative SGOT was 37.75±7.133and postoperative SGOT was 168.92±110.495 Preoperative total bilirubin was 0.25±0.435 and postoperative total bilirubin was 0.67±0.474= In >8.5 Group haematocrit level group patients preoperative SGPT was 19.43±10.268 and postoperative SGPT was 21.63±8.183 Preoperative SGOT was 42.43±26.166



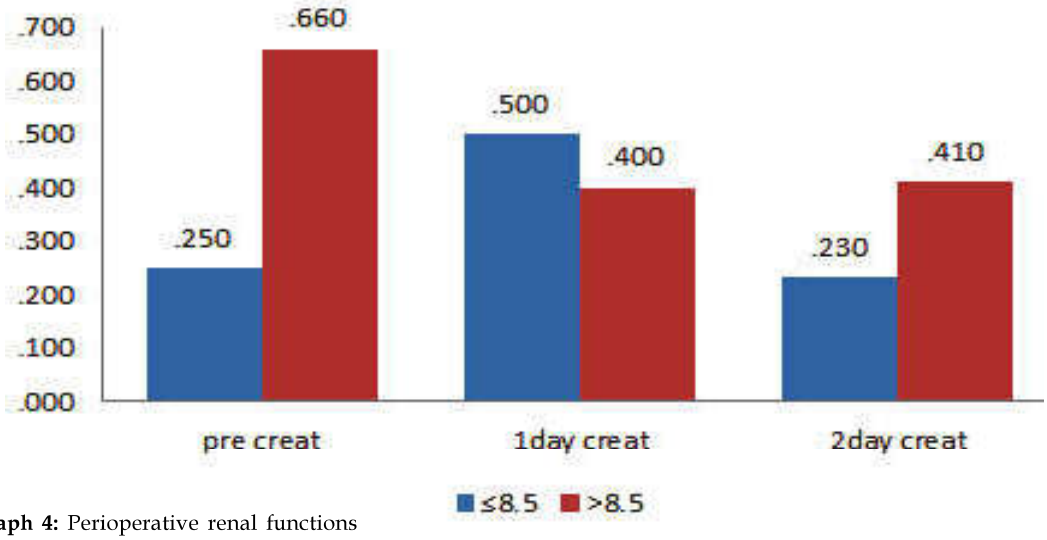
Graph 1: Perioperative liver functions



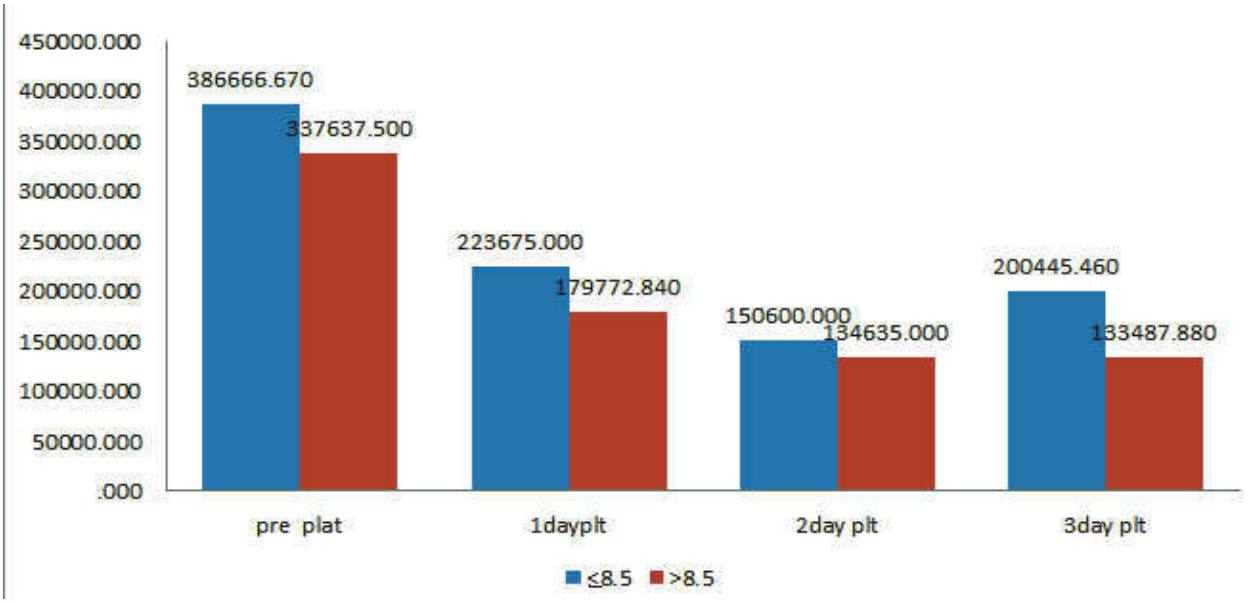
Graph 2: Perioperative liver functions



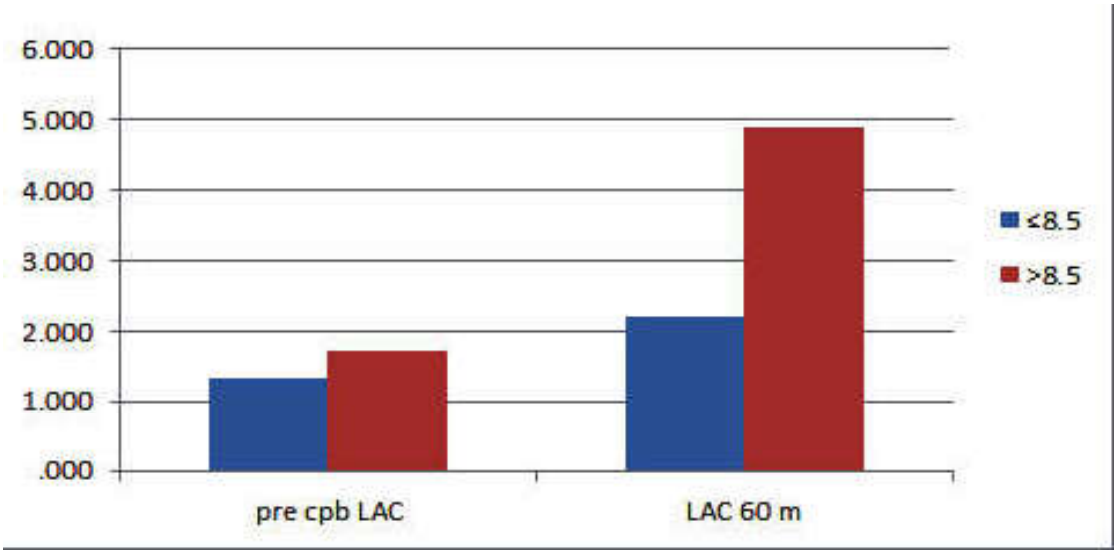
Graph 3: Perioperative renal functions



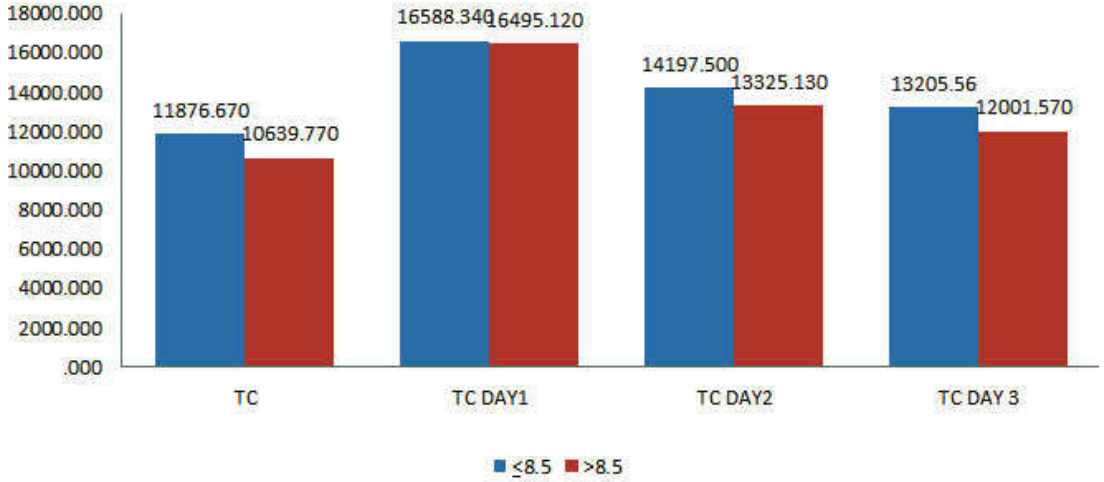
Graph 4: Perioperative renal functions



Graph 5: Perioperative infection functions



Graph 6: Perioperative infection functions



Graph 7: Perioperative infection functions

Table 1: Demographic data

Variable	Total number
sex	
Male	95
Female	85
AGE(day)	526.87±553.03
Height(cm)	71.34±16.12
weight (kg)	6.73±3.09
Body surface area	0.23±0.43
Flow rate	1.01±0.38
Cardio Pulmonary Bypass time	95.36±43.18
Cross clam time	63.32±34.02

Table 2: The perioperative liver functions

Variable	<8.5 Group	>8.5 Group	P-value
pre SGPT	17±6.13	19.43±10.27	0.06
post SGPT	20.59±7.68	21.63±8.19	0.39
pre SGOT	37.75±7.14	42.43±26.17	0.1
post SGOT	168.92±110.5	135.31±57.5	0.02
pre bilirubin	0.25±0.44	0.71±0.84	0.01
post bilirubin	0.67±0.48	1.21±0.82	0.01

Table 3: The perioperative renal functions

Variable	<8.5Group	>8.5Group	P-value
pre urea	27.59±11.1	22.73±10.26	0.01
Urea1day	36.67±11.05	29.02±12.68	0.01
Urea2day	56±29.52	46.22±26.37	0.32
pre creatinine	0.25±0.44	0.66±4.37	0.37
creatinine1day	0.5±0.51	0.4±0.5	0.16
creatinine2day	0.23±0.42	0.41±0.5	0.03

Table 4: The perioperative infection rate

Variable	<8.5Group	>8.5Group	P-value
pre platlet	386666.67±117255.88	337637.5±132609.09	0.02
platlet day 1	223675±96417.14	179772.84±83836.02	0.01
platlet day 2	150600±76220.51	134635±78563.94	0.18
platlet day 3	200445.46±132172.71	133487.88±91066.15	0.01
pre cpb Lactate	1.34±0.95	1.73±1.03	0.01
Lactate after 60 minite	2.2±1	4.89±2.93	0.01
Pre Total count	11876.67±2866.52	10639.77±3985.22	0.02
Total count day 1	16588.34±6310.31	16495.12±7024.95	0.93

and postoperative SGOT was 135.30±57.495 Preoperative total bilirubin was 0.7±0.833 and postoperative total bilirubin was 1.2±0.818

The perioperative renal functions were shown in Table 3 and Graph 3, Graph 4. Blood urea and serum creatinine test were analysed and compared with preoperative renal function.

In ≤ 8.5 Group haematocrit level group patients preoperative blood urea was 27.58±11.092 and postoperative blood urea was 36.67±11.045 Preoperative Serum creatinine was 0.25±0.435 and postoperative Serum creatinine was 0.5±0.503. In>8.5 Group haematocrit level group patients preoperative blood urea was 22.73±10.254 and postoperative blood urea was 29.01±12.675 Preoperative Serum creatinine was 0.65±0.436 and postoperative Serum creatinine was 0.39±0.491

The perioperative infection rate were shown in Table 4 and Graph 5 Graph 6, Graph 7. Perioperative white blood cell counts, platelet count, and serum lactate level were analysed. In ≤ 8.5 Group haematocrit level group patients preoperative WBC was 11876.67±2866.52 and postoperative WBC was 16588.34 ±6310.31. Preoperative Platelet count was 386666..67±117255.88 and post operativeplatelet count was 223675.00±96417.14. Preoperative Serum lactate level was 1.33±0.94 and postoperative Serum lactate level was 2.22±1.236. In >8.5 Group haematocrit level group patients preoperative WBC was 10639.22±3985.95 and postoperative WBC was

16495.12 ±7024.95. Preoperative platelet count was 337637.5 ±132609.09 and post operativeplatelet was 179772.84 ±83836.02. Preoperative Serum lactate level was 1.7310639±1.022 and postoperative Serum lactate level was 4.56±3.618

Discussion

In this prospective study we observe that during extracorporeal circulation for paediatric patients the relationship of extracorporeal circulation pump flow, haematocrit level and oxygen delivery (DO_2) management reduce postoperative sepsis, liver and renal dysfunction.

The possible risk factor for postoperative ischemia or inflammatory organ injury or both may reduce by increasing the oxygen delivery(DO_2) with adequate haematocrit and extracorporeal circulation pump flow [2,9,10]. In this prospective study we found the recent improvement in extracorporeal circulation techniques for paediatric patients reduce postoperative sepsis, liver and renal function. [6,7,11,12,10]. For adequacy of paediatric perfusion as per new monitoring techniques, optimal extracorporeal circulation flow rates improve patient metabolic need.

By monitoring of an average oxygen and mixed venous saturation of organs and tissues, metabolic needs of patients can judge.

During extracorporeal circulation metabolism shifts from aerobic to anaerobic due to critical DO_2 oxygen delivery. If DO_2 value is falls at certain level, oxygen consumption VO_2 cannot maintain the metabolism to shifts from aerobic to anaerobic.

In this situations lactate concentration rises and increased mortality and morbidity. During extra corporeal circulation the ratio of VO_2/DO_2 will increase in such as anemia and reduced of extracorporeal flow rate. So oxygen consumption VO_2 and oxygen delivery DO_2 ratio values are unreliable for identifying anaerobic metabolism and lactic acidosis [9,13,14,15].

Anaerobic metabolic measurement technology of lactate level monitoring is also another popular tool for paediatric extracorporeal circulation. But lactate level has limitation. Lactate confirms the accumulation of lactate but doesn't permit prophylactic interventions. The main factors leading to organ dysoxia are the hemodilution and low oxygen delivery DO_2 [1,10,12] of extracorporeal circulation

Conclusion

The possible risk factor for postoperative ischemia or inflammatory organ injury or both may reduce by increasing the oxygen delivery(DO2) with adequate haematocrit and extracorporeal circulation pump flow.

In this prospective study we also found that extracorporeal circulation time is independently associated factor for hyperlactemia. Due to hyperlactemia and hyperglycaemia the delivery of oxygen DO_2 value also found low.

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