

Effectiveness of Peritoneal Dialysis in Management of Acute Hyperthermia after On-Pump Heart Surgery in Infants

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Abstract Introduction: Acute hyperthermia is a common complication in the first 24 hours after open heart surgery with the incidence of 12% to 73%. The aim of this study was to evaluate the efficiency of postoperative peritoneal dialysis for controlling acute hyperthermia in pediatrics undergoing on-pump heart surgery.

Methods: We reviewed clinical outcomes of 40 infants who underwent congenital surgery from August 2016 to August 2017. Patients were divided into two groups in terms of peritoneal dialysis requirement as group A and B. Demographic data, intraoperative and postoperative variables were compared between the patients.

Results: Among the 40 high risk infants who underwent cardiac surgery, 20 patients were treated with peritoneal dialysis (group A). Mean rectal temperature and incidence of acute hyperthermia in 24h after surgery were higher in group A compared to group B ($p < 0.05$). Infants in group A were younger, lighter and showed lower BSA compare to group B ($p < 0.05$). Also, higher concentration of serum potassium and lower urinary output were seen in group A compared to group B ($p = 0.05$). The incidence of neurological events was significantly higher in patients of group A ($p < 0.05$). Intubation time and intensive care unit stay was significantly more prolonged in the group A with peritoneal dialysis ($p < 0.05$).

Conclusion: Peritoneal dialysis performance was effective in treatment of induced hyperthermia in the first 24 h after operation. Indeed, younger age and lighter weight children are more prone to postoperative complication related to cardiopulmonary bypass surgery.

Keywords: Congenital heart disease, Peritoneal dialysis, Cardiopulmonary Bypass, Hyperthermia

1.Introduction

In spite of advance in cardiac surgery techniques and postoperative care of patients, children with congenital heart disease (CHD) are encountered increasing risk of sever complication included acute renal failure (ARF), inflammatory response to cardiopulmonary bypass (CPB), hemodynamic instability and sepsis [1]. Hyperthermia is a common complication in the first 24 hours after CPB surgery with the incidence of 12% to 73% in studies of adults and children. This type of hyperthermia in pediatric is commonly related with the use of CPB, post-perfusion syndrome, infections, blood transfusions, dehydration and atelectasis [2,3] Peritoneal dialysis (PD) has been used for rewarming the body core in children suffering from hypothermia and renal failure, but the potential use of PD in treating hyperthermia is less indicated. The aim of the present study was to describe our experience of PD performance for treatment of acute hyperthermia after on-pump cardiac surgery in infants.

2. Material and Methods

2.1. Patients population

This study was carried out between August 2016 and August 2017 on infants with CHD who underwent on-pump surgery. In this period, a number of 60 infants with complex congenital heart defects, aged 18 months or younger, underwent open heart surgery. All patients gave written informed consents and were classified into two groups. Main indication for PD application were persistent hyperthermia (core temperature more than 39 °C that did not respond to routine strategies after 4h), oliguria (urine output < 0.5 ml /kg/h for more than 4 h) and generalized edema. Infants who were selected for PD were classified in Group A and infants who did not required PD were classified in group B. Demographic data, medical records, cardiac diagnosis, surgical procedures, intraoperative variables and CPB time and postoperative complications were reviewed, retrospectively, and compared between group A and group B.

2.2. PD administration

During the first 24 postoperative hours in the PICU, rectal temperature was measured and recorded in 4h intervals. Standard dose of Paracetamol (CobelDarou pharmaceutical company, Tehran, Iran) was administrated (15 mg/kg) in infants to reduce postoperative pain and fever. In patients with a high possibility of postoperative complications including hyperthermia, hyperkalemia and oliguria, a double-cuffed peritoneal Tenckhoff catheter was implanted in the deep pelvis through an infraumbilical approach intraoperatively. Standard commercially available dialysis solution with dextrose concentrations of 1.5%, 2.5%, and 4.25% was used (Samen pharmaceutical company, Mashdad, Iran). In addition, Heparin (500 U/L of dialysis solution) and antibiotics were added, if there was evidence of clinical sepsis or peritonitis. Cold peritoneal dialysis, PD solution temperature at 25 °C was initiated during the time of persistent hyperthermia (rectal temperature more than 39 °C). In the other cases with moderate hyperthermia, normothermic peritoneal dialysis was performed using PD solution temperature at 35-37 °C. PD continued until temperature stabilized below 37.5 °C in patients.

2.3. Analysis

Data were collected and analyzed using SPSS software (version 22; SPSS Inc, Chicago, IL, USA). Continuous variables of the study are presented as mean ± standard deviation. Independent student's t test and Chi-square analysis was performed to compare demographic data, intraoperative and postoperative variables among the patients. p value less than 0.05 was considered as significant level for all tests.

3. Results

Among 60 infants with CHD who underwent open heart surgery on cardiopulmonary bypass, 40 high risk infants with postoperative complications were enrolled in our study and were divided into group A (n=20) and B (n=20) based on PD requirement in PICU. The cardiac diagnosis was transposition of great arteries (TGA) in 10 cases, tetralogy of Fallot (TOF) in 29, complete atrioventricular canal (CAVC) in 12, total anomalous pulmonary venous return (TAPVR) in 5, and other complex pathology in 4 cases (Table 1).

Table 1. Congenital Heart Defects and Operations in 60 infants

Cardiac diagnosis	Surgical procedure	No	Percent
Tetralogy of Fallot (TOF)	Total repair TOF	29	48%
Complete atrioventricular canal (CAVC)	Repair	12	20%
Total anomalous pulmonary venous return (TAPVC)	Repair	5	8%
Atrioventricular septal defect	Repair	2	4%
Coarctation of aorta (CoA)	Repair	2	4%

Data are presented as number and percentage.

Basic demographics (age, sex, weight) and intraoperative variables (CPB and crossed-clamp time) are shown in Table 2. As Table 2 shows, infants in group A were younger ($p = 0.001$), lighter ($p = 0.001$) and showed lower BSA ($p = 0.001$) compared to group B. The incidence of neurological events due to acute hyperthermia in patients of group A was significantly higher than other group B ($p = 0.044$). These patients were gradually improved and discharged from PICU in desired condition. Based our data, infants in group A had higher concentration of serum potassium ($p = 0.001$) and lower urinary output ($p = 0.001$) compared to infants in group B. Likewise, intubation time ($p = 0.001$) and PICU stay time ($p = 0.001$) were significantly more prolonged in the patients of group A in comparison with group B.

Table2. Comparison of demographic characteristics of infant

Variables	Group A (n=20)	Group B (n=20)	p Value
Age (month)	4.6±1.8	12.65±4.6	0.001 **
Sex (male: female)	20 (10:10)	20 (9:11)	0.664
Weight (kg)	4.3±1.3	8.5±1.8	0.001 **
BSA (m ²)	0.27 ±0.04	0.42±0.6	0.001 **
Potassium (mmol/L)	5.1 ±0.79	3.9 ±0.55	0.001 **
Urinary output (mL/kg/weight/hour)	3.99 ±0.89	10.07 ±2.58	0.001 **
CPB time (min)	125.3 ±53.3	106 ±27.9	0.161
Cross-clamp time (min)	80.2 ±36	74.6 ±24.8	0.570
Neurological events	6 (20%)	1 (3.3%)	0.044*
Mechanical ventilation (h)	22.9 ±3.9	7.55 ±1.3	0.001 **
ICU stay (Days)	3.7 ±58	1.9 ±21	0.001 **

CPB: cardiopulmonary bypass, ICU: intensive care unit Continuous data are presented as mean ± standard deviation and analyzed using students t test. p value < 0.05 indicates statistical significance. * $p < 0.05$, ** $p < 0.005$

Postoperative 24-hour temperature pattern in both groups is shown in Figure 1. The PICU admission temperature was 37.1 ± 0.2 °C in group B versus 37.8 ± 0.06 °C in group A ($p = 0.009$). The incidence of acute hyperthermia during the 24h after operation was higher in patients of group A compared to patients of group B and the most increase of temperature was seen during 4-8 hours after surgery in group A ($p = 0.001$).

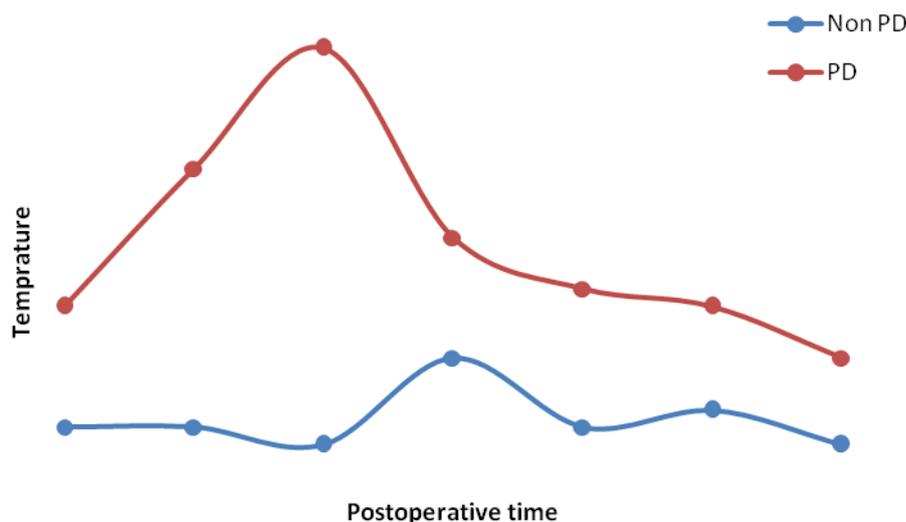


Figure 1. Comparison of postoperative mean rectal temperature during first 24h between group A and group B.

3. Discussion

Nowadays, surgical intervention in complex congenital heart disease is often performed in the neonatal and infant period. In spite of improvement in surgical procedures, CPB systems, preoperative and postoperative patient care, morbidity and mortality rates remain high (4). Postoperative hyperthermia is a usual complication after surgery which is recognized with over production of CO₂, muscular rigidity, respiratory and metabolic acidosis, hyperkalemia and terminal hemodynamic collapse. This serious condition induces increased brain oxygen demand and increased myocardial oxygen consumption [5,6]. The etiology of hyperthermia after surgery is considered to be related to the metabolic response to trauma, timing of surgery, the accumulation of blood in closed spaces, presence of drainage tubes, preoperative drugs administration, and infection. From pathophysiological point of view, hyperthermia is a well recognized complication after cardiac surgery due to inflammatory response to CPB, also called “post pump perfusion syndrome”, is specified by increased capillary permeability, peripheral vasoconstriction, myocardial edema, diffuse cerebral edema, diffuse bleeding diathesis and hyperthermia [7,8]. This condition may accentuate the ischemia-related injury cycle and exacerbates the effects of cerebral ischemia included the histopathologic consequences, delays neuronal metabolic recovery and increases excitotoxic neurotransmitter release, oxygen free-radical production, intracellular acidosis, and blood brain barrier permeability which alters function of the thermoregulatory center in hypothalamus [9,10].

This study was carried out on infants who underwent cardiac surgery on cardiopulmonary bypass and were treated for management of persistent fever in PICU. Our comparative data analysis supports this claim that children with younger age and lighter weight were more likely to develop persistent hyperthermia in the first 24 postoperative hours. Moreover, these patients are more vulnerable to inflammatory reaction and postoperative renal dysfunction due to more aggressive response to CPB. In the PICU of our center, PD has been the modality used for the treatment of persistent hyperthermia because of its simplicity, safety and, fewer complications in patients who does not respond to routine management of hyperthermia. Peritoneal dialysis has been indicated for rewarming the body core in patients suffering from hypothermia while the potential use of this method in treating violent hyperthermia is less well recognized. Accordingly, rectal temperature has been found to be an accurate estimate of core temperature in children, and exceeding 39 °C is generally considered to be clinically significant. PD can be considered in cases of hyperthermia refractory to treatment with routine methods which leads to rapid decrease of core temperature [11,12]. The probable cause of the postoperative hyperthermia is a number of sequential processes including presence of endotoxemia, blood contact with foreign surface of the CPB flow and development of ischemia reperfusion injury secondary to aortic cross-clamping. Similarly, inflammatory response syndrome can lead to pulmonary edema, impaired pulmonary gas exchange, alternating hemostasis, decreased ventricular filling, and delayed cerebral metabolic return [13,14].

The main limitation of this study was temperature monitoring that terminated on discharge from the PICU, with contribution of 60 patients by 48 hours. Also, no data were gathered regarding cerebral events after discharge, whereas neurological events may be had late consequences in patients.

4. Conclusions

Based our findings, peritoneal dialysis performance was effective in treatment of induced hyperthermia in the first 24 h after operation. Also, this study supports this claim that younger and lighter children are more prone to postoperative complication related to cardiopulmonary bypass surgery and need more postoperative care.

5. Acknowledgements

The authors have no additional acknowledgements.

6. Conflict of Interests

The authors declare that they have no conflict of interests.

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