



Correlation Between Pediatric Open Heart Surgery Outcomes and Arterial-mixed Venous Oxygen Saturation Differences

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ARTICLE INFO

Article Type:

Research Article

Article History:

Received: 18 June 2012

Accepted: 19 Aug 2012

ePublished: 8 Sep 2012

Keywords:

Arterial-venous Oxygen Difference

Cardiac Surgery

Children

ABSTRACT

Introduction: Low Cardiac Output Syndrome (LCOS) contributes to postoperative morbidity and mortality. This article tries to find a predictive factor to interpret outcome after cardiac operation. **Methods:** In a cross-sectional study, 100 children with congenital heart disease undergoing cardiovascular surgery with cardiopulmonary bypass (CPB) without significant left-to-right shunt were selected. Arterial and central venous oxygen saturation values were measured via blood samples simultaneously

obtained in 6-hr intervals for a total of 24-hr during postoperative period at hours 0, 6, 12, 18, and 24. Postoperative ventilation support (intubation period) and cardiovascular support were also obtained from the hospital records. Statistical analysis was later performed comparing the arterial-mixed venous oxygen saturation differences and durations of required ventilatory and cardiovascular support, both for the complicated and non-complicated patient groups. The data was processed with correlation Pearson and Mann-Whitney U tests in SPSS 15 software, P less than 0.05 was significant.

Results: Mortality following cardiac operation is 6% and complications may happen in 45% of the cases. The highest Arterial-mixed venous oxygen saturation difference occurred immediately post operation (up to 57%). These measures were high up to 18 hours in complicated and non-complicated groups (36% vs. 31% ; $P < 0.05$). This factor cannot predict prolongation of intubation period in patients ($P > 0.05$). **Conclusion:** Arterial-mixed venous oxygen saturation difference may be high as much as 57% or as low as 23%. These different measures, being higher up to 18 hours in complicated to non-complicated groups after 18 hours, can be related to tissue ischemia during surgery and cannot be discriminative.

Introduction

Within the last three decades, reducing short and long term morbidity has become a great management concern.¹ LCOS (Low Cardiac Output Syndrome), usually occurring during the 6-18 hours postoperative period, still is common despite considerable advances in various aspects of perioperative and postoperative care of CHD (Congenital Heart Disease) patients.¹⁻³ It is associated with significant rise in both peripheral and pulmonary vascular resistance, as high as 25% and 40% above baseline values, respectively.¹ These changes are certainly followed by progressive end-organ dysfunction.⁴⁻⁸

According to PRIMACORP (Prophylactic Intravenous Use of Milrinone After Cardiac Operation in Pediatrics) study, LCOS occurred in about 25.9% of the pediatric patients undergoing open heart surgery who were treated by placebo (placebo group) in 6-18 hours postoperative period.² Nearly half of the patients with clinical LCOS had

more than 30% difference in their arterial-mixed venous oxygen saturation values.^{2,3}

The purpose of the present study was to evaluate arterial-mixed venous oxygen saturation difference as a predictive factor for poor clinical outcome resulting from postoperative LCOS.

Materials and methods

This cross-sectional study was conducted on 100 (49 male and 51 female) patients in the Cardiac ICU of the Tabriz Shahid Madani Heart hospital between September 2006 and September 2007. Eligible patients for this study were children under twelve years old with CHD undergoing surgical repair using CPB. Exclusion criteria included preoperative renal insufficiency (Creatinine < 0.9 mg/dl), preoperative left ventricular (LV) dysfunction and postoperative left-to-right shunt based on echocardiographic evaluation.

Data collection

Blood samples were obtained simultaneously from arterial and central venous lines in 6-hour intervals in the first 24 hours postoperative period (0, 6, 12, 18, and 24 hours). The arterial-mixed venous oxygen saturation difference values were determined as the difference between the arterial oxygen saturation minus the central venous (representing mixed venous) oxygen saturation in every patient. Intubation times were also documented from the hospital anesthesiology files.

Outcome evaluation

The postoperative outcome of the patients was evaluated and categorized as: No complication, CNS complications (as seizure), Non-CNS complications (cardiopulmonary arrest, renal insufficiency, and pulmonary insufficiency, disturb on mechanical ventilation requiring reintubation within 48 hours after extubation). Shock defined as systolic blood pressure less than $90+2\times\text{age}$ needing vasotonic infusion Renal insufficiency defined as decreased urine output to less than 1 ml/kg/h or rising creatinine to more than 0.3 mg/dl in the first 24 hour.

Data analysis

The correlation between the arterial-mixed venous oxygen saturation difference values and the postoperative outcome was studied between two groups (complicated and non-complicated) using Pearson correlation test and Mann-Whitney U test in each group by SPSS 15 software. The findings were considered to be statistically significant at a P value of <0.05 .

Results

100 patients including 49 males and 51 females with the mean age of 6.07 ± 3.84 years entered the study. The types of congenital heart defects have been classified in Table 1. Thirty nine patients had postoperative complications

(19 males, and 20 females). There was no statistically significant correlation between gender and postoperative outcome ($P > 0.05$). A statistically significant difference was observed between the mean ages of the complicated and the non-complicated groups (4.88 ± 3.67 vs. 6.81 ± 3.89 years, $P < 0.05$), as the complicated group was generally younger than the uncomplicated group.

Arterial and mixed venous oxygen saturation difference values were significantly higher in the complicated group compared to the non-complicated group ($P < 0.05$). The widest differences were at 0 hour (immediate postoperative ICU entry) decreasing over time. In complicated patients at the end of operation, the mean A-V difference of oxygen saturation is 44% that could increase to as much as 57%; however, this difference decreased over 24 hours post operation. In non-complicated group, the mean A-V oxygen saturation difference was 34%. In both complicated and non-complicated groups, this difference decreased as time passed. This difference was significant between complicated and non-complicated groups up to 18 hours post operation. At 24 hours post operation, the average of A-V oxygen saturation was 34% and 30% in the complicated and non-complicated groups respectively. This difference in O_2 saturation could decrease to as low as 21% in 24 hours post operation in both groups (complicated and non-complicated).

The mean intubation time was 25.57 ± 39.20 hours. The intubation time was significantly higher in the complicated group than in the uncomplicated group (47.19 hrs vs. 11.74 hrs, $P = 0.01$); however, there was no statistical correlation between the intubation time and the arterial-mixed venous oxygen saturation difference values ($P > 0.05$). Complications occurred in 45 out of 100 cases (45%). Central nervous system complications occurred in 6 out of 100 whereas non-central nervous system complications were observed in 39 out of 100 cases. Six out of 100 cases passed away. (Figure 1,2)

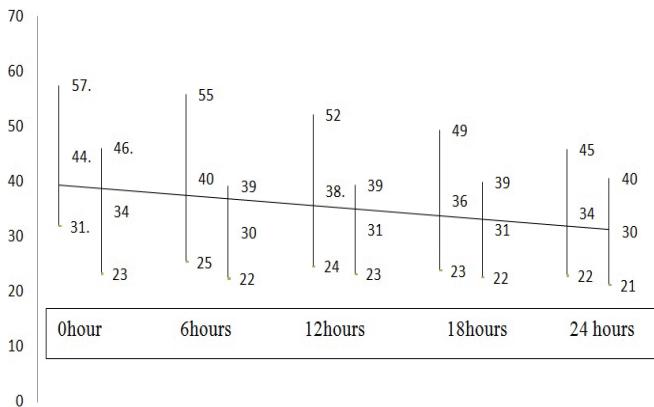


Figure 1. Difference of A-V oxygen % saturation in hours 0,6,12,18 and 24 post cardiac operation left: complicated and right: non complicated in each five groups

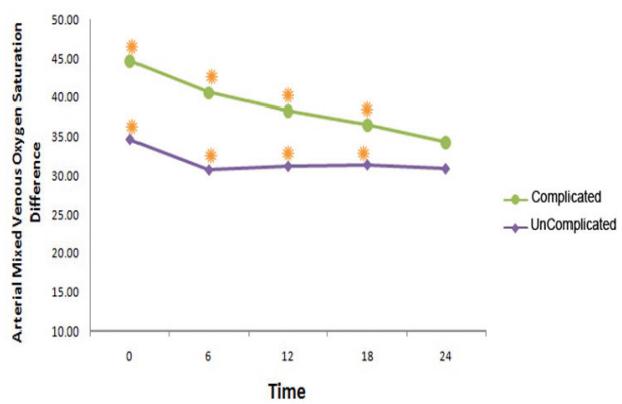


Figure 2. Arterial- mixed venous oxygen saturation differences decreased over time in both complicated and uncomplicated groups. These measures in first 18 hours are higher in complicated group significantly (* = $P < 0.05$) versus uncomplicated group.

Table 1. The types of congenital heart diseases

Types of anomalies	N
TOF (Tetralogy of Fallot)	31
ASD+VSD	7
PS (Pulmonary Stenosis)	1
AS (Aortic stenosis)	1
MR+VSD(Ventricular Septal Defect)	1
ASD+PDA (Patent Ductus Arteriosus)	4
AI	1
VSD+PAH(Pulmonary Artery Hypertension)	24
ASD(Atrial Septal Defect)	18
ASD+PS	7
TGA	1
MR+AI(Aortic Insufficiency)	2
MR (Mitral Regurgitation)	2

Discussion

Previous similar studies have suggested complication rates ranging between 25.9% and 39%.^{2,9,10} In one study by Azakie *et al.*, the mortality rate was reported to be 5.2%.¹¹ According to the literature, complications occur in younger age rather than older age children as younger children are naturally more vulnerable to postoperative complications. Compared to older children undergoing open heart surgery, neonates and young infants have more serious cardiovascular defects. However, children surviving to older age obviously must have had less detrimental defects, and consequently higher hemodynamic tolerance to major cardiovascular surgery. In addition, the younger the pediatric patient is, the less the tissue oxygen reserve would be, increasing the eventual end-organ dysfunction^{1,11,12} and pulmonary dysfunction caused by atelectasis, pneumonia, pleural effusion, etc.^{3,12-15}

A strong relation between A-V oxygen differentiation and complication occurrence and outcome has been introduced by the previously conducted studies^{3,12-15} in which the highest A-V difference has been reported during 4 to 8 hours post operation.^{3,4,12,14}

In our study, complications and mortality rates are 45% and 6% respectively that are both slightly higher than other studies.^{2,9-11} Complications also occurred more frequently in younger children compared to older children (4 yrs vs. 6 yrs) as well as prolonged intubation (47 hours vs. 11 hours in complicated vs. non-complicated groups).

Arterial-mixed venous oxygen saturation difference values in the first 18 hours of immediate post-operative ICU period were significantly higher in the complicated group than in the non-complicated group, with a gradual decline in values over the course of ICU care. Although in complicated cases including non-CNS and CNS complications, A-V oxygen saturation difference was high, this difference could not predict intubation time. In contrast to other studies, our study revealed that A-V oxygen saturation difference is at its highest value immediately post operation decreasing to the values of non-complicated group over time. It seems that this high measure at post operation may be due to bypass time and

prolonged cold period during operation as it has been shown that operation technique and prolongation could affect outcome of patients and these measures can be comparable with non-complicated group after 18 hours during recovery time with repairing of tissue perfusion.

Conclusion

Complications are common events during cardiac surgery (45%); however, mortality may occur in 6%. A-V oxygen difference can be a predictive index for complications up to 18 hours reaching to as high as 57% immediately post operation or to as low as 23%; this wide range of changes could be due to diverse quality of tissue perfusion during bypass time.

Ethical issues: The local ethics committee of Tabriz University of Medical Sciences approved the study and all patients signed informed consent.

Conflict of interests: The authors declare no conflicts of interest.

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