CODEN [USA]: IAJPBB ISSN: 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

http://doi.org/10.5281/zenodo.1258060

Available online at: http://www.iajps.com Research Article

ARTERIOVENOUS OXYGEN SATURATION DIFFERENCE: SHOULD IT BE FOLLOWED FOR EXTUBATION AFTER PEDIATRIC CARDIAC SURGERY

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Abstract:
Background: *After pediatric cardiac surgery, the arteriovenous oxygen saturation difference is often used to guide post-operative management and decision for extubation. This prospective study aimed to establish whether the arteriovenous oxygen saturation difference supports the timely extubation or it just delayed the extubation and its relation with extubation failure.*
Material and Methods*: A prospective single blind study conducted in department of PCICU of pediatric cardiac surgical department. There were two groups(A&B) consisted of 76 patients in each group underwent open heart surgeries. Group A patients were extubated once extubation criteria with desired AV difference was achieved while group B patients were extubated once extubation criteria was achieved without considering AV difference. Patients extubation time <6hours or more and extubation failure was monitored.*
Results*: Group A contains patients whom AV difference was used for decision making along with extubation criteria while in group B AV difference was not considered .Both groups were comparable in disease profile . Delayed extubation was observed in 32(42%) and 28(37%) in group A and B respectively (p=.5) . While extubation failure was observed in ten patients with 3 patients in group A and 7 patients in group B(p=.19)*
Conclusion: *Though higher reintubation rate was observed when AV difference was not followed but statistically it was insignificant.*
Key words: *Congenital Heart Defects, Cardiac Surgery, Arteriovenous Oxygen Saturation (AV Difference), Cardiac Output.*

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Please cite this article in press Iqbal Hussain Pathan et al., ***Arteriovenous Oxygen Saturation Difference: Should It Be Followed For Extubation After Pediatric Cardiac Surgery,*** *Indo Am. J. P. Sci, 2018; 05(05).*

INTRODUCTION:

The adequacy of forward blood flow according to metabolic requirement is an essential requirement of life. Blood circulation to the parts of body depends on the integrity of vascular system, blood volume and cardiac contractility to pump blood in the forward direction. Cardiac output, amount of blood volume delivered to the circulation per unit time is generally expressed in liters per minute. In addition to morbid status of heart due to pathological alterations secondary to heart defects, the cardiopulmonary bypass associated SIRS [1-4] and reperfusion injury [5] also influence cardiac output after cardiac surgery.

Differences in oxygen transport secondary to altered cardiac output between the patients operated for congenital heart defects significantly influence postoperative course of these patients. Furthermore abnormalities in oxygen transport variables could identify children at highest risk. After weaning from cardiopulmonary bypass, the most important component for management of these patients is extubation, itself a multidimensional decision. There are well defined criteria for extubation involving hemodynamic, neurologic and pulmonary status [6]. The invasive and noninvasive monitoring of pediatric patients operated for cardiac defects in PCICU is pre requisite of objective guiding for decision making. As these patients are shifted to ICU with ionotropic and vasopressor support , monitoring of cardiac output is very important parameter guiding the functional status of heart, further providing an objective evidence of gross organ perfusion and tissue oxygen supply .There are number of devices and techniques mentioned for assessment of cardiac output like Swan- Ganz catheter, Transoesophageal echocardiography, Pulse contour assessing devices, Oesophageal Doppler for continuous ejection fraction monitoring , Lithium dilution technique , Partial CO2 rebreathing technique , Thoracic electrical bioimpendance [7] , serum lactic acid monitoring , base excess assessment , urine output as well as mixed venous oxygen saturation difference monitoring . These all have their limitation; practical, logistic as well as consensuses. Analysis of mixed venous oxygen saturation and arterial oxygen saturation data and blood lactic acid level are the methods widely used to asses decreased systemic oxygen delivery, requiring early intervention. Therefore instead of depending on complicated and costly gadgets mostly follow AV oxygen saturation difference for assessment of cardiac output [8] to support decision for extubation.

We had conducted a prospective study in our department of pediatric cardiac surgery PCICU to observe the significance of AV oxygen saturation difference in decision making regarding extubation of patients after corrective surgery of congenital heart defects on cardiopulmonary bypass or utilizing roller pump. Here we would like to mention that in our department we routinely follow AV oxygen saturation difference in decision making for extubation.

MATERIAL AND METHODS:

This single blind case control study was prospectively conducted in PCICU department of pediatric cardiac surgery from 8th November 2015 to 5th June 2016 in National Institute of Cardiovascular Diseases Karachi after getting approval of ethical review committee of institute . All the patients operated for definitive correction of congenital heart defects with cardiopulmonary bypass or roller pump support were included in study. While patients requiring urgent or emergency intervention and patients not considered for fast tract extubation would not be included in study. Furthermore patients though initial considered for study but during the course found to be unsuitable for extubation secondary surgical causes like mediastinal bleed or hemodynamic instability requiring increasing ionotropic support would be excluded from study. All the patients operated via median sternotomy using hypothermic cardiopulmonary bypass except for few cases operated for Glenn shunt or total cavopulmonary connection just required roller pump support. In the operation room , induction was done with injection dormicum 0.1mg/kg, injection morphine 0.1mg/kg, atracurium .5mg/kg and propofol 1 to 2mg/kg. Maintenance was done with Inhalational sevoflurane 2.5% and morphine infusion. On cardiopulmonary bypass maintenance was done with isoflurane 1.15%. American Society of Anesthesiologists (ASA) guided monitoring with (heart rate, rhythm with electrocardiogram, invasive and non invasive blood pressure, SO2%, ETCO2, core temperature {oesophageat temperature and rectal temperature} and urine output was conducted in all patients. Arterial blood gases with with Po2 ,Co2, base exces with additional assessment of Hemoglobin, electrolytes like Potassium (baseline, after CPB and preextubation), blood sugar and activated clotting time (ACT){heparinised} were also monitored.

After weaning from cardiopulmonary bypass transoesophageal echocardiography was done as routine to document adequacy of surgical repairs and to avoid significant residual defects and cardiac function. At this time a decision was made regarding postoperative plan about extubation. Patients planned for overnight ventilation were excluded from study. Patients were shifted to PCICU on mechanical ventilation with ionotrop support. In group A weaning from mechanical ventilation was proceed as per extubation criteria further supported by achieving desired AV oxygen saturation difference that is within 30% . While patients in group B extubated as extubation criteria were achieved. Patients were followed for 24hours for extubation time (delayed >6 hours) and reintubation for extubation failure.

Mixed venous blood sample would be obtained from CVP line must be located in mid Right Atrium as confirmed intra operatively except those who underwent single ventricular palliation . Group B patients were extubated only after fulfilling extubation criteria; no AV oxygen saturation difference was done. Extubation criteria followed in our study are mentioned in Table 1. Patients were followed for 24 hour after extubation. Following primary objectives were evaluated
1) Extubation delay (beyond 6 hours)
2) Extubation failure (reintubation within 24 hours)
Data of individual groups is mentioned in Table 2.

Randomization : Two envelopes containing paper mentioning either group A or group B . Once the patient selected for study received at ICU bed side nurse will pick the envelop , patient would be considered in group mentioned in envelop . While next selected patient would be considered in remaining group .

Statistical analysis

Variables are presented as number, percentage and mean with range as appropriate. The x^2 test was used to test for strength of association between the desired variable. The incidence of prolong extubation time and extubation failure rate in both groups were analyzed. Statistical test was two-sided and type I error was controlled at 0.05. Analyses were performed using SPSS 21.

RESULTS:

There are two groups A & B as mentioned above. Group A includes patients whose decision of extubation was supported by AV difference while group B patients extubated once only extubation criteria was fill filed (no AV difference done prior to extubation) determined by closed envelop technique as a single blind technique while second patient would be automatically selected in other group. There were 76 patients in each group as shown in table 2 . Pattern of extubation showed delayed extubation observed in 32(42%) and 28(37%) in group A and B respectively (p=.5). While extubation failure was observed in ten patients with 3 patients in group A and 7 patients in group B (p=.19) .Total 5 patients were expired with 3 patients in group A and 2 patients group B. These includes 2 patients of Tetralogy Of Fallot , ,one patient of Total Anomalous Pulmonary Venous Connection with sever pulmonary hypertension, two patients with ventricular septal defect with sever pulmonary hypertension .

DISCUSSION:

Patients presented with congenital heart defects are often late either due to delay referral due to socioeconomical reasons or long waiting list. Their cardiac function is already compromised due to long standing hypoxia as in cyanotic heart defects or pressure and volume loading condition. Important co morbidity in these patients is presence of pulmonary hypertension and lung damaged secondary to recurrent infection making postoperative course more vulnerable. Therefore postoperative course of these patient require careful decision making regarding extubation and management of hemodynamic support. Cardiac output is one of the most important factors for cardiac function assessment. It gives an idea of whole body perfusion and oxygen delivery. Swan et al was the first who introduced the cardiac output monitoring into clinical practice in early 70's [9] .Cardiac low output syndrome is one of most common complication encountered after cardiac surgery. This is because of preoperative pathological state of heart with superimposed reperfusion injury and pump associated SIRS all contribute variably. The Low cardiac output syndrome if not recognized in time and managed appropriately may be "progressive" leading to multi - organ dysfunction, increased morbidity, prolonged ICU and hospital stay, and even mortality. In order to address it promptly these patient are monitored invasively and none invasively in postoperative period. Often post cardiac surgery these patients shifted to ICU on mechanical ventilation with ionotropic and vassopressor support. Currently there are many techniques of cardiac output monitoring both invasive and non-invasive. There are different instruments like swan gauze catheter most commonly used gadget with its own number of risk profile[10]. In addition the inherent limitation of size and abnormal anatomy may restrict utilizing these devices in pediatric population; these devices also have logistic issues. This require new tools as such easy to use and with minimal technical or logistic issue for cardiac function monitoring such as the oxygen saturation of mixed venous blood, which according to studies by

Krauss et al. and Perner et al. isa reflection of cardiac output [8,11] . However technically it is demanding to get sample from pulmonary artery a real reflection of mixed venous blood. nevertheless sample drawn from mid right atrium nearly correlate with pulmonary artery blood for assessment of cardiac index as suggested by Lee J. etal [12]. Nevetheless, the main criteria for ideal method for cardiac output monitoring are it should be non-invasive, easy to use, accurate, reliable, consistent and compatible in patients [13]. The extraction of oxygen by tissues depends on the physiologic status of tissue and rate of delivery of oxygen determined by cardiac output and integrity of circulatory system .Natural reserve of tissue maintain its survival despite of a fall in cardiac output as long as there is increased oxygen extraction ability wear off .The amount of extraction of a given oxygen from the blood is described as the arteriovenous oxygen difference. When arterial blood have 97% saturation than mixed venous blood should have an average oxygen saturation of 75%;. Thus the normal arteriovenous oxygen saturation difference is about 20%. Maximum oxygen extraction ability of tissue is by the factor of 3. Therefore if arterial saturation remains constant at 97%, full utilization of the extraction strength of tissue ends up in a mixed venous oxygen saturation of 35%. Thus a dropping of mixed venous oxygen saturation as against arterial oxygen saturation alert for low cardiac output. Blood sample derived from pulmonary artery is considered a definitive reflection of mixed venous blood .Therefore true representation of mixed venous oxygen saturation is from blood sample obtained from pulmonary artery .As we know that the blood from the superior vena cava would have greater oxygen content than the blood of the inferior vena cava due to the auoregulation that maintain brain perfusion at the cost of decreased perfusion of splanchnic organs and lower body at the time of low cardiac output syndrome ; therefore, the values of venous oxygen saturation from mid right atrium would better represent low cardiac output than the values of venous oxygen saturation of pulmonary artery . Therefore maintenance of venous oxygen saturation of pulmonary artery values greater than 60% would be an important parameter to guide therapy in postoperative period from the hemodynamic standpoint [14. Sommers et al [15] has observation that mixed venous oxygen saturation reflect strong association with cardiac index in first eight hours in post operative period due to the haemodynamic instability of the patients during the postoperative period. Similar finding were observed in pediatric population operated for congenital heart defects as markers of evolving or early low cardiac output syndrome and associated with increased early morbidity and mortality [16,17] . A reliable and early determination of the parameters like cardiac output, systemic O2 delivery and tissue oxygenation is essential for timely decision making for patient management. Nevertheless it is a common observation for discordance between these sophisticated measurements of these parameters and estimations based on the clinical judgment based interpretation of conventional parameters; heart rate, blood pressure, and right atrial pressure, left atrial pressures [18,19]. Therefore nothing can be alternative of clinical observation for the clinical decision-making process Considering all above observation we conducted the study to find out wither following AV oxygen saturation difference help us in proper timing of extubation or it just delay the period of extubation for delaying till desired AV difference obtained as well as wither failure to follow AV difference resulted in premature extubation with its own hazardous. In our study due to limitation of obtaining blood sample from pulmonary artery we use mix venous sample from mid right atrium as suggested by Duarte, Jj Et Al [20].

Despite of failure of any statistically significant association of AV difference monitoring with patient outcome it is our observation that it may result in delay extubation and in few cases reintubation when it is ignored.

Limitation. Though it was attempted to eliminate bias but major limitation of our study is small sample size and different groups of team on duties with obvious difference in their approach for patient man agent

Table 1 .Extubation criteria followed in our study is mentioned in Table 3

General assessment	Neurological status	Acceptable respiratory mechanics	Acceptable arterial blood gases (ABGs) on 5cm or less of CPAP or PSV
Awake without stimulation	Awake without stimulation	Negative inspiratory force >25cm H2O	. PaO2>70 mmHg on FIO2 of 0.5 or less
Chest tube drainage< 2 mL/kg/h	Moving limbs	Tidal volume >5 mL/kg	PCO2<48 mmHg
Adequate reversal of neuromuscular blockade	Obeying command	Vital capacity >10–15 mL/kg	pH 7.32–7.45
Core temperature>35.5 _		Spontaneous respiratory rate as per desired based on age	
There is consensus between surgical and critical care team for extubation			

Table 2 . Demographic data and diagnosis

Variables	Group A	Group B
Number	76	76
M:f	44(57.9%):32(42.1%)	43(56.6%):33(43.4%)
Age range	<1year=4 patients >1year = 72 patients	>1year =76 patients
Weight range	<5kg(6),5 to 10 kg (12),>10kg (58)	5 to 10 kg (17), >10kg (59)
Diagnosis	32(TOF),13(ASD),18(VSD), 8(VSD+PAH),5(Other)	36(TOF),12(ASD),13(VSD),11(VSD+PAH),4(other)

Tetralogy Of Fallot (TOF), Ventricular Septal Defects (VSD), Atrial Septal defect(ASD) , Pulmonary Hypertension (PAH) Other (Tricuspid Atresia,Right Atrium Myxoma,Total anomalous pulmonary connection, Supravalvular Aortic Stenosis , Pulmonic Stenosis, Mitral Regurgitation, lTGA With Straddling Tricuspid Valve

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