The Correlational Study Between Pa CO2 - ETCO2 gradient and Right Ventricular Outflow tract gradient in relation to Pulmonary blood flow in Patients with Tetralogy of Fallot, Pre and Post Intracardiac Repair

PROJECT REPORT

Submitted during the course of
DM Cardiothoracic and Vascular Anaesthesia

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Jan 2011 – Dec 2013

DECLARATION

*I, **Dr. Omprakash. S** hereby declare that the project in this book was undertaken by me under the supervision of the faculty, Department of Anaesthesiology (Cardiothoracic & Vascular Anaesthesia), Sree Chitra Tirunal Institute for Medical Sciences and Technology.*

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CERTIFICATE

*This is to certify that this project entitled "***The Correlational study between $PaCO_2$ –$ETCO_2$ gradient and RVOT gradient in relation to pulmonary blood flow in patients with Tetralogy of Fallot, pre and post intra cardiac repair***" , has been prepared by Dr. Omprakash .S , a D.M cardiothoracic and vascular anaesthesia resident under the guidance of Dr. Prasanta Kumar Dash, Professor, Department of Anaesthesiology and under my overall supervision and Guidance at Sree Chitra Tirunal Institute for medical sciences and technology , Trivandrum. He has shown keen interest in preparing this project.*

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CERTIFICATE

*This is to certify that this project entitled "***The Correlational study between $PaCO_2$ –$ETCO_2$ gradient and RVOT gradient in relation to pulmonary blood flow in patients with Tetralogy of Fallot, pre and post intra cardiac repair***", has been prepared by Dr. Omprakash .S, a D.M cardiothoracic and vascular anaesthesia resident and has been done under my direct guidance and supervision at Sree Chitra Tirunal Institute for medical sciences and technology, Trivandrum. He has shown keen interest in preparing this project.*

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ACKNOWLEDGEMENT

I am deeply indebted to my guide ***Prof. Prasanta Kumar Dash*** *for his tremendous encouragement, meticulous guidance and constructive criticism throughout the course of this study.*

I am very grateful to my co-guide ***Prof. Rupa Sreedhar*** *for her constant encouragement and valuable suggestions at all stages of this study.*

I owe my sincere thanks to ***Dr. P.R. Suneel*** *for his unconditional help and constant encouragement.*

I am also grateful to ***Prof. Thomas Koshy, Shrinivas .V. Gadhinglajkar, Dr. K.P. Unnikrishnan, Dr. Subrata Kumar Singha and Dr. Satyajeet Mishra*** *for their cooperation and motivation during every phase of my study.*

I express my gratitude to ***Dr. Baiju S. Dharan, Dr. Thomas Mathew and Dr. Sabarinath Menon*** *for their guidance and motivation throughout the course of my study.*

I am always indebted to my Parents, my brother, my sisters and my inlaws for their blessings, support and help in completing this study.

I owe heartful thanks to my friends Dr. G. Arimanickam, Dr. Poornima Kasthuri, Dr. Arul Velan, Dr. N. V . Vinoth Kumar and Dr. K. Yuvaraj who have helped me in a multitude of ways in completing the study.

I sincerely thank my colleagues of my department and of CVTS, anaesthesia technician friends and staffs of PSOT for their constant help.

Special thanks to Ms. Shivaranjani and statistician Mr. Kannan for their help in the making of this study.

I am deeply indebted to my patients and to their parents for their cooperation and sacrifices for the greater good of fellow human beings.

Dedicated to my beloved teacher Dr. Naheed Azhar and my family

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LIST OF ABBREVIATIONS

S.NO	SYMBOLS USED	EXPANSION
1	AwP	Airway Pressure
2	ABG	Arterial Blood Gas analysis
3	ASA	American Society Of Anesthesiologist
4	AHA/ACC	American heart association/American college of cardiology
5	BIS	Bispectral Index
4	C.O	Cardiac Output
5	CVP	Central Venous Pressure
6	$ETCO_2$	partial pressure of End Tidal Carbon dioxide
7	ECG	Electrocardiogram
8	FiO_2	Fractional Inspiratory Oxygen
9	HR	Heart Rate
10	I:E	ratio between Inspiratory and Expiratory time
11	LUPV	left upper pulmonary vein
12	MD	Minute Distance (P v VTI × HR)
13	MAP	Mean Arterial Pressure
14	MAC	Minimum Alveolar Concentration
15	NIBP	Non-Invasive Blood Pressure
16	$PaCO_2$	Partial pressure of Carbon dioxide in arterial blood
17	P v VTI	Pulmonary Venous flow Velocity Time Integral
18	$P(a\text{-}ETCO_2)$	$PaCO_2$- $ETCO_2$ gradient

19	$PACO_2$	Partial pressure of Alveolar Carbondioxide
20	PBF	Pulmonary Blood Flow
21	RVOT	Right Ventricular Outflow Tract
22	R-L	Right to Left
23	ROSC	Return Of Spontaneous Circulation
24	SPO_2	Saturation Pulse Oximetry
25	SaO_2	Arterial blood gas saturation
26	S.D	Standard Deviation
27	TOF	Tetralogy Of Fallot
28	TEE	Trans Esophageal Echocardiography
29	TVI	Velocity Time Integral
30	TVI-S	TVI of Systolic wave
31	TVI- D	TVI of Diastolic wave
32	TVI – A	TVI of Atrial systole
33	USG	Ultra Sonogram
34	V_d/V_t	deadspace to tidal volume ratio
35	VSD	Ventricular Septal Defect
36	Δ	percent change in the parameter taken between Baseline and Post sternotomy
37	Δ MD	delta Minute Distance
38	Δ $PaCO_2$	delta $PaCO_2$
39	Δ $ETCO_2$	delta $ETCO_2$
40	Δ SaO_2	delta Arterial Saturation

CHAPTER 1

INTRODUCTION

Children with Tetralogy Of Fallot (TOF) are a group of cyanotic patients with reduced pulmonary blood flow (PBF). Clinical presentation of TOF varies from severe cyanosis to no cyanosis [1].

Basic components of TOF are large unrestrictive ventricular septal defect (VSD) with Right ventricular outflow tract (RVOT) obstruction. Obstruction in TOF can be at any level, subvalvular, valvular or supravalvular [1]. Ultimate factor responsible for symptoms is the amount of blood flow to pulmonary system, which is highly variable in TOF physiology. In order to maintain PBF, pressure proximal to RVOT is elevated so that blood is propelled across the obstruction, creating a gradient. Gradient across RVOT depends on right ventricular pressure, systemic pressure and systemic vascular resistance. [1]

It is proposed that if CO_2 production and ventilation are relatively constant, $ETCO_2$ reflect the PBF. The $ETCO_2$ approximates $PaCO_2$ in children with normal cardiopulmonary reserve .In children with TOF physiology $ETCO_2$ value is highly variable due to pulmonary hypoperfusion and R-L shunting across VSD. [2-5]

Any reduction in systemic vascular resistance causes reduction in antegrade flow across RVOT leading to reduction in PBF causing desaturation, cyanosis and gross variability in gradient between $PaCO_2$ and $ETCO_2$. [1, 3, 4]

$ETCO_2$ is mainly determined by tissue CO_2 production (VCO_2), alveolar ventilation and C.O (that is, pulmonary blood flow) , when stable metabolic conditions are assumed and minute ventilation is kept constant, acute changes in $ETCO_2$ have been shown to correlate strongly with changes in C.O in experimental and clinical settings [5-11]. Thus $ETCO_2$ has been suggested as a non-invasive alternative for continuous assessment of right ventricular output, in correct sense a monitor of PBF.

In cyanotic heart disease, alteration in PBF associated with right to left shunting result in changes in physiological dead space, venous admixture and P ($a-ETCO_2$). In lesion like tetralogy of Fallot with dynamic outflow tract obstruction with VSD frequently causes variable PBF resulting in more changes in P ($a-ETCO_2$) hence monitoring of $ETCO_2$ as a surrogate for PBF is less reliable[2, 3]. Measurements of PBF in children with tetralogy of Fallot are clinically limited because of their body size, high gradient at the outflow tract and multiple collaterals. The minute distance (MD) calculated from the Velocity time integral calculated from Pulmonary venous blood flow velocity Doppler obtained from left upper pulmonary vein and the heart rate can be used as a surrogate for PBF [12].

Total velocity time integral (TVTI) of pulmonary venous flow is calculated by the formula:-

$TVTI=TVI\text{-}_S+TVI\text{-}_D-TVI\text{-}_{Ar}$ gives the stroke distance in that pulmonary vein. Minute distance (MD) is calculated by multiplying TVTI and heart rate (HR).

$MD=TVTI\times HR$, which correlates with the pulmonary blood flow.

In our study we like to correlate the P ($a-ETCO_2$) gradient with the minute distance calculated from pulmonary venous blood flow velocity Doppler and effect of dynamic nature RVOT on MD, so that the trend the P ($a-ETCO_2$)gradient can be used a marker of PBF .More over assessing the P($a-ETCO_2$)gradient along with RVOT pressure gradient gives better outlook about the pulmonary blood flow, during the phases of dynamic obstruction.

CHAPTER 2

AIMS AND OBJECTIVES

Aim:

- Correlate the gradient between $PaCO_2$ and $ETCO_{2-}$ P (a- $ETCO_2$), with the minute distance (MD) calculated from the pulmonary venous flow Doppler obtained from left upper pulmonary vein (LUPV) -before and after intracardiac repair.

- To find the correlation between Arterial oxygen saturation and the minute distance (MD) calculated from pulmonary venous flow Doppler velocity obtained from (LUPV) before intracardiac repair.

- To find the correlation between per cent change in the PaCO2-$ETCO_2$ gradient (ΔP (a-$ETCO_2$) and per cent change in the minute distanceΔ(MD) before intracardiac repair.

Secondary objectives:

- Compare the $ETCO_2$ and $PaCO_2$ values before and after intracardiac repair

- Correlation between RVOT pressure gradient and minute distance (MD) calculated from pulmonary venous flow Doppler.

- Correlation of minute distance (MD) with $PaCO_2$ and $ETCO_2$ after intracardiac repair.

CHAPTER 3

REVIEW OF LITERATURE

End tidal carbon dioxide monitoring during anaesthesia is one of the recommendations set by American society of anaesthesiology (ASA). ASA in its "standards for basic monitoring" recommends continuous monitoring of $ETCO_2$. $ETCO_2$ is a useful non-invasive monitoring tool to assess both ventilation and perfusion in operating room set up. (13)

3.1 Physiology of $ETCO_2$ monitoring (5) :

Carbon dioxide (CO_2) is the major by-product of aerobic metabolism. Carbon dioxide produced in the tissues is transported via heart to the lungs and finally is excreted by lungs in gaseous form during expiration. This expired CO_2 is measured qualitatively and quantitatively to assess the adequacy of ventilation and perfusion.

Major Factors affecting the $ETCO_2$ are:

- CO_2 production
- Cardiac output or pulmonary blood flow
- Diffusion across pulmonary capillaries and alveoli
- Ventilation and its pattern

Thus $ETCO_2$ act as a surrogate marker for the adequacy of ventilation and perfusion.

3.2 Interpretation of $ETCO_2$ [5] :

There are two types of $ETCO_2$ measurement: volume capnogram and time capnogram. Time capnogram is most commonly used.

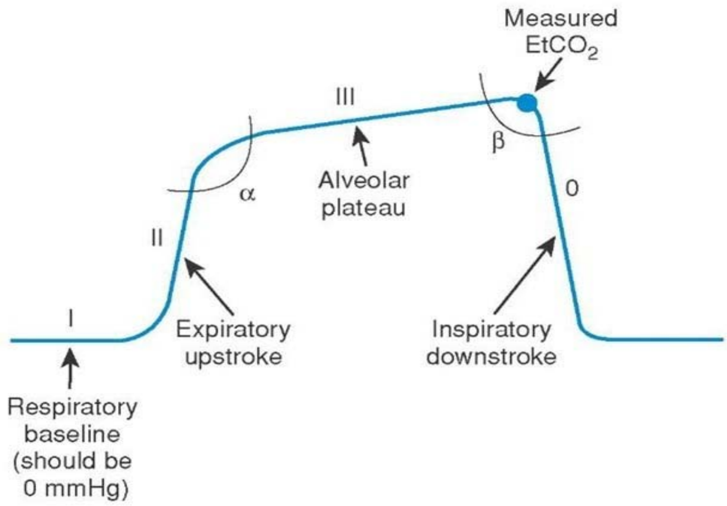


Figure3.1: Normal time capnography waveform (*reproduced from Ventilation (Clinical Essentials) (Paramedic Care) Part 3*)

Normally time capnography wave has got four phases:

- Phase I represents CO_2 free gas from airways
- Phase II is shaped up swinging slope due to mixing of alveolar and airway fresh gas
- Phase III represents the plateau phase when alveolar gas is exhaled.
- Phase 0 which represents inspiration and part of expiratory segment.

At the end of tidal volume, the gas well equilibrated with pulmonary capillary blood is exhaled. Thus end tidal gas is representative of alveolar carbon dioxide (PA CO_2) in turn $PaCO_2$. Inspite of few exceptions there always remains a gradient between $PaCO_2$ and $ETCO_2$.

3.3 $ETCO_2$- monitor for assessment of perfusion:

In healthy individuals (circulatory system in series) any reduction in the cardiac output implies reduction in both systemic and pulmonary circulation to the same extent. Any change in the pulmonary system leads to reduction in CO_2 delivery to the lung. With stable ventilatory pattern change in $PaCO_2$ results in Change in $ETCO_2$ .Thus measured $ETCO_2$ is used as a surrogate for cardiac output. [5]

Shibutani et al [7] in their study conducted on patient operated for abdominal aortic aneurysm clearly explained the relation of $ETCO_2$ with respect to cardiac output. They found strong correlation between per cent decrease in $ETCO_2$ with respect to per cent decrease in cardiac output (C.O) during hemodynamic perturbations. **Askrog et al** [14] also showed inverse relation between P(a-$ETCO_2$) gradient and pulmonary artery pressure which he used as a marker of C.O .**Maslow et al** [15] showed good correlation between $ETCO_2$ and PBF during weaning from cardiopulmonary bypass in adult cardiac surgical patients.

Isserles et al [6] showed linear relationship between changes in $ETCO_2$, and C.O in animals in different hemodynamic conditions and they proposed $ETCO_2$ will be useful as a non-invasive, continuous monitor of a change in C.O during anaesthesia or intensive care. **Grmec**[16] showed strong correlation between mean arterial pressure and P(a- $ETCO_2$) gradient in patients managed for haemorrhagic shock . The same study also mentioned that the $ETCO_2$ acted as a useful guide in fluid resuscitation. In another recently published study by **Young et al** [17] proved that both volumetric and end tidal assessment of carbon dioxide helped in fluid resuscitation.

Livene et al [8] in their study used $ETCO_2$ values to predict the outcome in patients who had out of hospital cardiac arrest. They showed an end-tidal carbon dioxide level of 10 mm Hg or less measured 20 minutes after the initiation of advanced cardiac life support accurately predicted death in patients with cardiac arrest associated with pulseless electrical activity (PEA). There are many studies in literature to support this notion [9-11].Based on the accumulating evidences and reviews **AHA/ACC** [18] in their current guidelines for cardiopulmonary resuscitation made a strong recommendation to use continuous wave capnography to know the placement of airway device and during transportation (Class I, LOE A). They also recommend $ETCO_2$ monitoring to know the efficiency of chest compression and to identify the (Return of spontaneous circulation) ROSC during CPR and to decide upon the administration of vasopressor. Thus $ETCO_2$ has both therapeutic, prognostic and diagnostic value in hemodynamically unstable patient.

3.4 $ETCO_2$ monitor for assessment of ventilation:

In patient with normal cardiopulmonary reserve and stable ventilatory pattern $ETCO_2$ reflects $PaCO_2$. Normally a gradient of 3-5 mmHg exists between $ETCO_2$ and $PaCO_2$. The ability of $ETCO_2$ to reflect $PaCO_2$ clearly explained in different clinical settings like Intubated vs. Unintubated, spontaneously breathing patient under anaesthesia in Operation theatre, breathless patient in emergency room and different age group f patients [19-26]. There were few studies which questioned the stability of P (a-$ETCO_2$) gradient in few settings like multiple trauma, critically ill patients in neurointensive care, those with lung issues and acid base imbalance. [26-30]

Russell et al [29] studied the changes in the arterial to end-tidal carbon dioxide gradient, P (a-$ETCO_2$), in postoperative cardiac surgery patients from the time of admission to the intensive care unit, during changing cardiorespiratory support, and up to the time of tracheal extubation. There was significant correlation between $paCO_2$and $ETCO_2$ when considering the values from entire population. Other significant finding was that no other factor (inotrope vasopressor or body weight or height) influenced the gradient. However, when evaluating individual patients, this relationship had wide variability.

McSwain et al [31] provided clear evidence and explained that physiologic dead space ventilation is a major factor in determining the relationship between capnography monitoring of $ETCO_2$ and measured $PaCO_2$. In patients with a low calculated physiologic dead space to tidal volume ratio ($Vd/Vt \leq 0.40$), there existed excellent correlation ($\rho = 0.95$) between $ETCO_2$ measured noninvasively by capnography and the invasive assessment of arterial carbon dioxide by blood gas measurement. Moderate to strong positive linear correlation coefficients between end-tidal and arterial carbon dioxide measurements were found for all Vd/Vt ranges, although the strength of the relationships decreased slightly as Vd/Vt increased.

3.5 Role of $ETCO_2$ in congenital heart disease:

The $Pa\text{-}ETCO_2$ of children with acyanotic-shunting and mixing congenital heart lesions is stable intraoperatively, although patients with mixing congenital heart lesions may demonstrate large individual variations[2] .

In children with cyanotic-shunting congenital heart lesions, the $Pa\text{-}ETCO_2$ is not stable and predicted $P(a\text{-}ETCO_2)$ calculated from the theoretical formula derived by **Fletcher et al** [32] underestimated observed $P(a\text{-}ETCO_2)$. Thus $ETCO_2$ cannot be used as surrogate for $PaCO_2$ during surgery. Similar finding was observed in children having acyanotic heart disease with congestive symptoms. [2].

According to Fletcher at al [32], factors which govern the gradient in cyanotic heart disease are:

- Arterial oxygen saturation
- Haemoglobin concentration
- Respiratory quotient

With these factor **Fletcher et al** [32] created a theoretical model to predict the $PaCO_2$- $ETCO_2$ gradient. Subsequent **Short et al** [3] evaluating this formula found that the calculated value underestimated the observed value. He proposed that apart from R-L shunting, pulmonary hypoperfusion contributed to the difference in the observed value. At this juncture, if the haemoglobin is kept constant, the main factors that influence gradient are [2, 3, 32-35]

- R-L shunting
- Physiological dead space caused by hypoperfusion
- Diffusion coefficient
- Arterial oxygen saturation

Lung mechanics and diffusion capacity are normal in children with cyanotic heart disease [35]. Moreover physiological dead space depends on pulmonary perfusion. McSwain et al [31] explained that gradient is stable under wide range of physiological dead space.

The only factor that governs the P (a-$ETCO_2$) gradient is the variability in PBF. Even though there exist a correlation between $ETCO_2$ and PBF in Tetralogy of Fallot after shunt surgery [36, 37], it's not so with preoperative uncorrected tetralogy patients. Because of gross ventilation perfusion (V/Q) mismatch $PaCO_2$ and $ETCO_2$ in cyanotic child with R-L shunt remains unchanged even with variable Arterial oxygen saturation[2, 39-41].

3.6 TEE Assessment of Pulmonary Blood Flow Quantification:

Inatsugi et al[42] in his study conducted among the patients posted for cardiac surgical and major vascular surgical procedure showed strong correlation between minute distance calculated from LUPV and C.O measured using thermo dilution technique .

Tanaka et al **[12]** on TOF patients showed minute distance calculated from LUPV showed strong positive correlation with oxygen saturation and showed significant improvement in saturation and minute distance after phenylephrine administration. The minute distance calculated from LUPV can be used as a surrogate for right ventricular output or PBF.

CHAPTER 4

MATERIALS AND METHODS

After obtaining approval from IEC and written Informed consent, study was conducted in 30 children with Tetralogy of Fallot admitted in Department of Cardiovascular Thoracic Surgery (CVTS) – Sree Chitra Tirunal Institute for Medical Sciences and Technology, posted for intracardiac repair.

Inclusion criteria:

- Cyanotic patients older than one yr with TOF physiology with confluent pulmonary artery anatomy confirmed with Trans thoracic echocardiography
- Weight more than 10 kg
- Planned for intracardiac repair.

Exclusion criteria:

- Pre-existing active pulmonary infection or pulmonary disease
- Decompensated congestive cardiac failure.
- Pre-existing systemic arterial to pulmonary arterial palliative shunt or branch stenosis.
- Emergency surgery
- Absolute or relative contraindication for (Transesophageal Echocardiography) TEE insertion.

Materials:

- Datex Ohmeda anaesthesia machine - Aestiva,
- Datex Ohmeda S/5 anaesthesia gas monitor,
- Radiometer ABL 800 blood gas analyser,
- Phillips SONOS7500 with multiplane two dimensional Trans oesophageal echocardiography probe.

Methods:

The techniques of anaesthesia, surgery and cardiopulmonary bypass followed existing standard institutional practice.

One hour before shifting the patient to operating room child was premedicated with syrup Triclofos 70mg/kg and oral atropine 20µg/kg. After shifting to operating room child was induced and i.v access obtained using O_2 + sevoflurane through mask (circuit primed with end tidal concentration of 8 parts per cent slowly titrated to End tidal conc. 3parts per cent). Anaesthesia supplemented with inj.fentanyl 3µg/kg and inj.midazolam 0.1mg/kg intravenously. Simultaneously monitors (SPO_2, 5 lead ECG, NIBP, BIS/Entropy) were be hooked on the patient. After paralysing with inj.Vecuronium 0.15mg/kg, the trachea was intubated with oral/nasal tube .Tube was sized in such a way there is no audible leak present at a pressure below 30 cmH_2O peak inspiratory pressure. Patient was mechanically ventilated with smart vent ventilator, Datex Ohmeda anaesthesia machine with air/oxygen/sevoflurane mixture using circle absorber system. Distal $ETCO_2$

was sampled continuously at a flow rate of 200ml/ min using the agent analyser of the S/5 anaesthesia monitor (GE healthcare, U.K). Both $ETCO_2$ and blood gas analyser was calibrated for every use. Anaesthesia was maintained with inj.fentanyl cumulative dose up to 20µg/Kg and inj. Morphine infusion 40µg/Kg/hr. End tidal concentration of sevoflurane was titrated to 0.5 MAC (Minimum Alveolar Concentration). Inj.midazolam 0.05mg/kg and inj.vecuronium 0.05mg/kg were given after initiation of bypass and during rewarming.

Under ultrasound guidance central venous access was obtained and Arterial line was obtained and both line pressures were transduced. Baseline arterial blood gas analysis was done and fresh gas flow, I: E ratio (inspiratory expiratory ratio) and respiratory rate were adjusted to maintain $FiCO_2$ and peak inspiratory pressure below 30 cmH_20. Tidal volume (8ml/Kg) and respiratory rate according to age were adjusted to keep $PaCO_2$ within range of 30-45 mmHg. Initial RR setting were given below

AGE (yrs.)	Breaths / min
1-3	30
3-6	25
6-12	20

TEE probe inserted and Temperature was monitored using nasopharyngeal probe and rectal probe.

Once child was positioned for surgery, pulmonary venous flow velocity was obtained in left upper pulmonary vein using colour flow Doppler and RVOT pressure gradient measured .RVOT pressure gradient was measured using upper oesophageal arch short axis view, Deep Trans gastric inflow view or deep Trans gastric in/outflow view. Three measurements were made and mean of the three was considered. Typical pulmonary venous Doppler is shown fig (4.1).

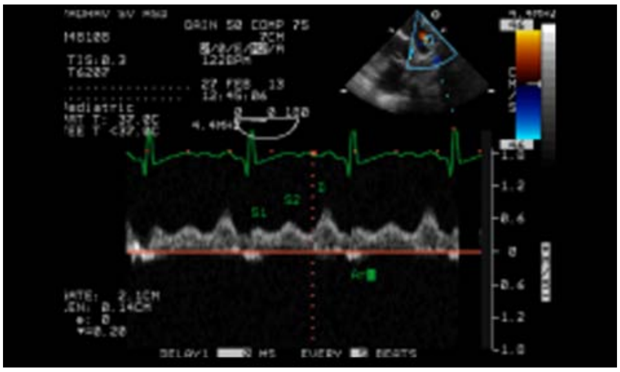


Figure 4.1: Pulmonary venous flow Doppler profile obtained from Left Upper Pulmonary Vein (LUPV)

Normal pulmonary venous flow is composed of systolic wave (s1, s2) and diastolic wave (d) forward flow with a small component of reverse flow (a). Pulmonary venous flow Doppler velocity time integral is depicted in fig. (4.2).

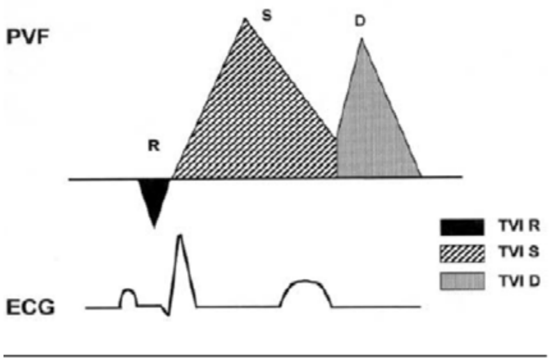


Figure 4.2: TVI--velocity –time integral of Doppler waves S, D and R. (*reproduced from Tanaka.k.et al, "Phenylephrine increases PBF in children with tetralogy of Fallot ", Can J Anaesth , 2003, Volume 50,926-929*)

Total velocity time integral (TVTI) of pulmonary venous flow is calculated by the formula:-

$TVTI=TVI\text{-}_{S}+TVI\text{-}_{D}\text{-}TVI\text{-}_{Ar}$ gives the stroke distance in that pulmonary vein. Minute distance (MD) is calculated by multiplying TVTI and heart rate (HR).

$MD=TVTI\times HR$, which correlates with the pulmonary blood flow.

Simultaneously hemodynamic variables (Mean arterial pressure, Central venous pressure, Airway pressure, $ETCO_2$ and Arterial blood gas) were measured and that reading was considered as baseline. Similar measurements were repeated after sternotomy, after protamine administration and after sternal closure.These times were chosen to minimise hemodynamic perturbation maximize the effects of stimulation and that can have significant influence on $P(a\text{-}ETCO_2)$.

CHAPTER 5

OBSERVATION AND RESULTS

30 children were included in the study with no significance in the demographic data (Table: 5.1). Out of 30 children 5 children were excluded from study (2 children–planned procedures was changed intraoperatively, 3-children unable to measure RVOT due to hemodynamic instability and technical difficulty) and data from 25 cases were considered for analysis.

Data analysis:

All parameters were expressed as mean and standard deviation (Table 5.2). Pearson's correlation was used to correlate between the minute distance and remaining parameters ($PaCO_2$, $ETCO_2$, P (a-$ETCO_2$), SaO_2, RVOT gradient and MAP) (Table 5.3and Table 5.4). Bonferroni's test was used for multiple comparisons among the parameters measured at four different timings.

Results:

Table 5.2 shows all the hemodynamic and blood gas parameters obtained at four timings:

- At the time of induction considered as baseline
- After sternotomy
- After protamine administration
- After sternal closure.

All the individual parameter obtained at four different timings is displayed as mean and standard deviation (Mean (S.D)).

Table 5. 1: Showing gender and weight distribution among the study group.

(Freq- (frequency), % - percentage, μ-mean, σ- standard deviation)

Table: Gender		
Gender	Freq.	%
Female	13	52.0
Male	12	48.0
Total	25	100.0

Table: Weight		
Weight	μ	Σ
	13.6	2.0
	Freq.	%
10	1	4.0
11	1	4.0
12	5	20.0
13	6	24.0
14	6	24.0
15	2	8.0
16	2	8.0
17	1	4.0
19	1	4.0
Total	25	100.0

Table 5.2 : Statistical data of parameters taken before and after intracardiac repair – mean (standard deviation)

Parameter	**Baseline**	**After sternotomy**	**After protamine administration**	**After sternal closure**
PaCO2(mmHg)	36.08(6.1)	40.3(6.1)	39.0(6.1)	40.3(5.4)
ETCO2 (mmHg)	30.48(5.1)	30.5(4.3)	33.3(4.9)	34.1(5.4)
P(a-ETCO2) (mmHg)	**5.59(4.2)**	**9.8 (7.1)***	**5.7(2.8)**	**6.18(2.2)**
Minute distance #(cm/min)	***14.32(5.36)***	***13.3 (6.2)***	***20.1(7.4)***	***23.1(7.6)***
RVOT pressure gradient # (mmHg)	***55.8(14.3)***	***57.1(17.8)***	***20.6(7.6)***	***15.8(5.4)***
Saturation# (%)	***91.1(9)***	***88(12)***	***99(1)***	***98(2)***
MAP (mmHg)	72.08(11.8)	69(11)	67.2(10.5)	64(6.7)
CVP#(mmHg)	***7(2)***	***7(2)***	***11(1)***	***10(1)***
Hb (g%)	14.4(2.7)	14.3(3)	13.5(0.4)	13(0.3)
AwP (mmHg)	12.8(2)	12.4(2)	-	-

***-** significant at a p value <0.05, **#**- significant between before and after ICR values at P< 0.05. Mean time taken for sampling between baseline and sternotomy was 12+/- 1 minute. Airway pressure were not considered in the analysis for post ICR period

We noted **P (a-ETCO$_2$) value obtained after sternotomy** was significantly (p value <0.05) higher than the P (a-ETCO$_2$) values (fig.5.1) measured at Baseline and values obtained after intracardiac repair (Table 5.2).

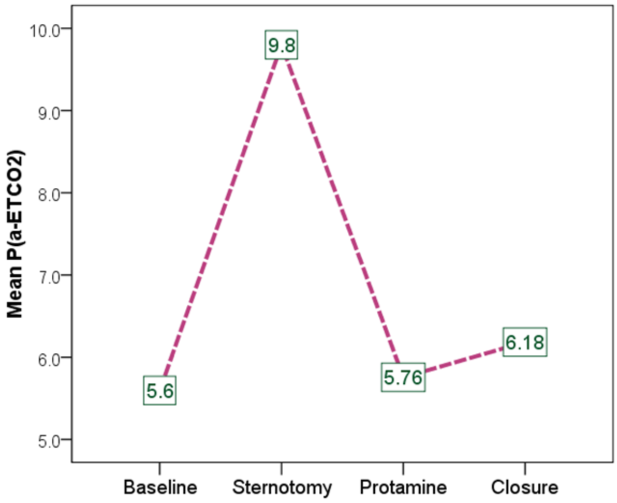


Figure 5.1: Means plot of P (a-ETCO$_2$) taken at different sample points

There was no significant difference found among the rest of the parameters: ETCO$_2$, PaCO$_2$ (fig.5.3), RVOT gradient, minute distance (fig.5.2), saturation, MAP, CVP measured between Baseline values and after sternotomy values (Table: 5.2). This implies there were no clinically significant hemodynamic perturbations between two sampling points. The mean sampling time difference between baseline value and after sternotomy value was 12 min. there was no significant difference in the airway pressure between baseline and after sternotomy values (Table 5.2). But there was statistically significant difference between values acquired before and after intracardiac repair among Minute distance (fig.5.2), RVOT, Arterial oxygen saturation and CVP.

No significant difference was made between $ETCO_2$ and $PaCO_2$ values before and after intracardiac repair (Fig: 5.3).

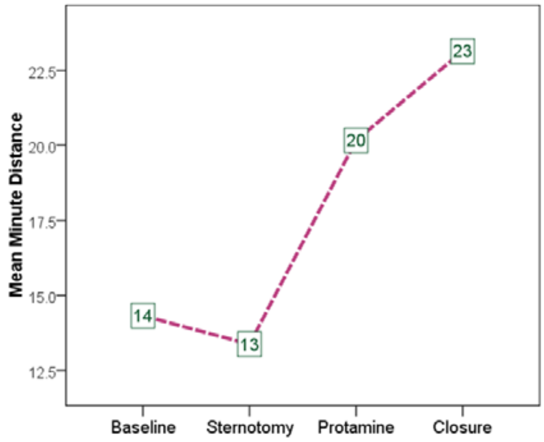


Figure 5.2: Means plot of minute distance taken at different sample points

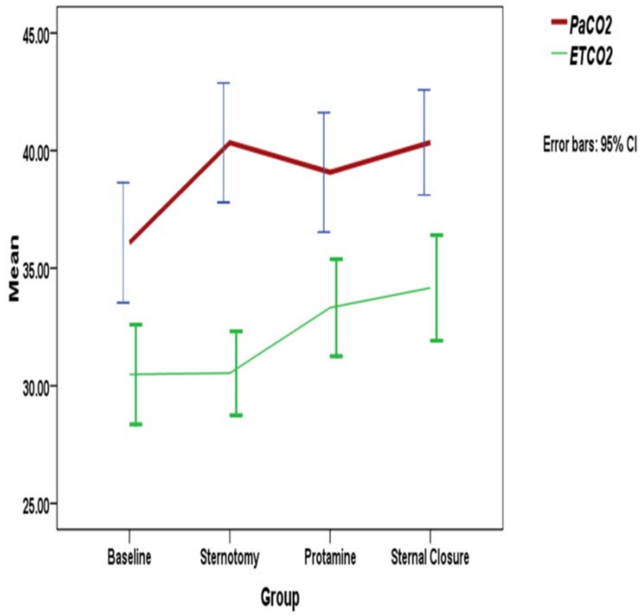


Figure: 5.3: Error bar of $ETCO_2$ and $PaCO_2$ values taken on different sampling time

Table 5.3: Pearson's correlation of individual parameters with minute distance during baseline and after sternotomy (* - significant at p value < 0.01)

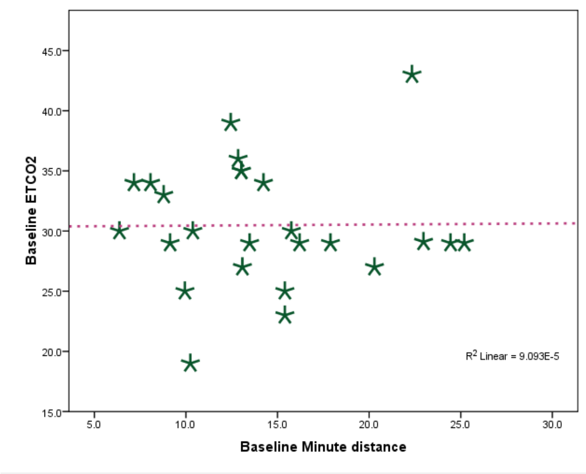
Baseline-components	**Descriptive statistics- mean(S.D)**	**Pearson correlation**	
Minute distance (cm/min)	14.32(5.36)		
ETCO2 (mmHg)	30.48(5.1)	0.010	0.482
PaCO2* (mmHg)	36.08(6.1)	-0.477	0.008*
P(a-ETCO2)* (mmHg)	5.59(4.2)	-0.703	0.000*
RVOT* (mmHg)	55.8(14.3)	-0.464	0.010*
Oxygen Saturation* (%)	91.12(9.07)	0.652	0.000*
MAP* (mmHg)	72.08(11.8)	0.570	0.001*
Sternotomy-Components	**Descriptive statistics- Mean (S.D)**	**Pearson correlation**	
Minute Distance (cm/min)	13.3 (6.2)	coefficient	Sig.
ETCO2 (mmHg)	30.5(4.3)	0.261	0.201
PaCO2 (mmHg*)	40.3(6.1)	-0.683*	0.000*
P(a-ETCO2) (mmHg*)	9.8 (7.1)	-0.747*	0.000*
RVOT (mmHg*)	57.1(17.8)	-0.536*	0.006*
oxygen saturation(%)*	88(12)	0.689*	0.000*
MAP (mmHg)	69(11)	0.156	0.455

Table 5.4: Showing descriptive statistics and Pearson's correlation between (Δ P (a-$ETCO_2$), Δ$ETCO_2$, Δ$PaCO_2$, and ΔSaO_2) and ΔMinute distance

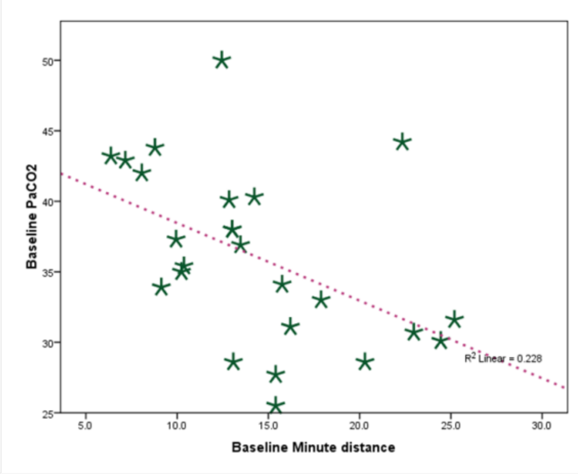
Before ICR- Components	**Descriptive statistics- Mean (S.D)**	**Pearson correlation**	
Delta minute distance %	18.8(41)		
Delta P(a-ETCO2)%	*26.2(55)#*	*-0.525**	*0.007**
Delta PaCO2%	-9.3(15.8)	-0.221	0.288
Delta ETCO2%	0.65(16.4)	0.173	0.409
Delta Arterial oxygen saturation%	3.7(6.1)	0.313	0.128

(*- significant at p value < 0.01, # - significant among the means (value < 0.05))

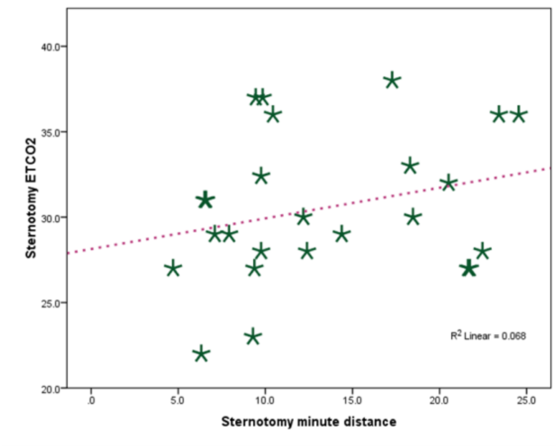
The individual values of ***P (a-$ETCO_2$)*** (fig.5.5) ***and Arterial oxygen saturation*** (fig.5.6) in baseline and after sternotomy, showed strong correlation with minute distance calculated in both groups (p value <0.01) (Table 5.3). The correlation between minute distance and $PaCO_2$ was moderate in baseline group and strong in the after sternotomy group (fig.5.4). When correlation between the per cent change in the baseline and sternotomy values of $PaCO_2$ (Δ$PaCO_2$), ETCO2 (Δ$ETCO_2$), Arterial oxygen saturation (Δ SaO_2) and P (a-$ETCO_2$) (Δ P (a-ETCO2) were considered with per cent change in minute distance (ΔMD), we found ***statistically significant correlation between ΔMD and Δ P (a-$ETCO_2$)***. There was no significant correlation between ΔMD with the rest (fig.5.7 and fig.5.8). The percentage of change from the mean value (26+/-55%) is significant in ΔP (a - $ETCO_2$) than rest of the values in the presented hemodynamic conditions (Table 5.6).



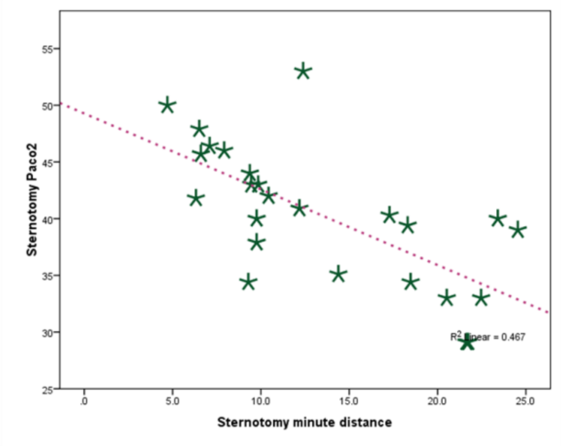
(a)



(b)

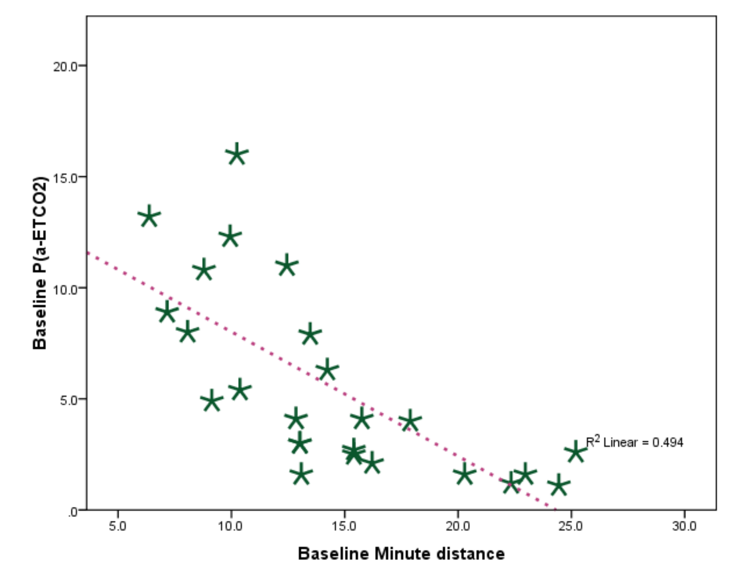


(c)

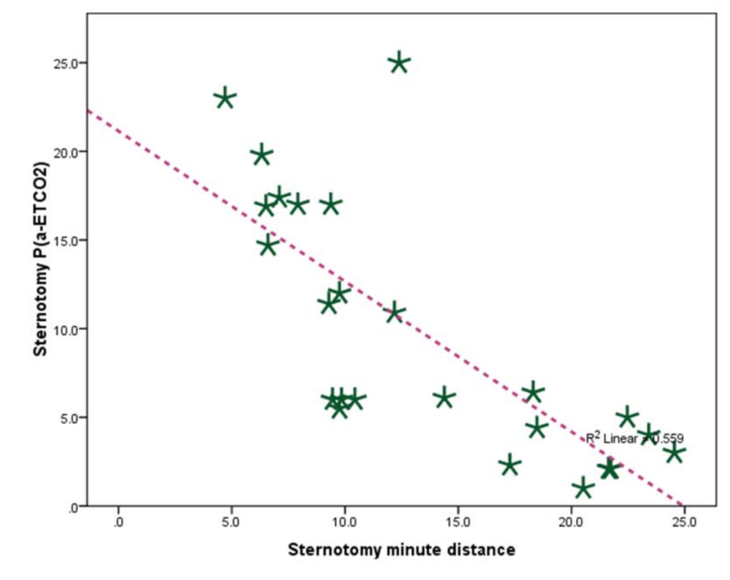


(d)

Figure 5.4: Showing the Pearson's correlation of minute distance with $PaCO_2$ and $ETCO_2$ between the values measured during baseline (a, b) and after sternotomy (c, d).

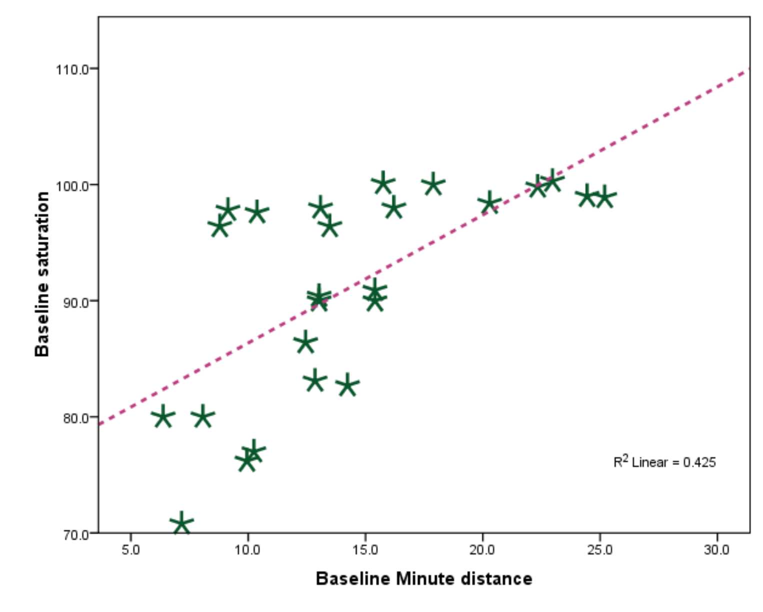


(a) Baseline

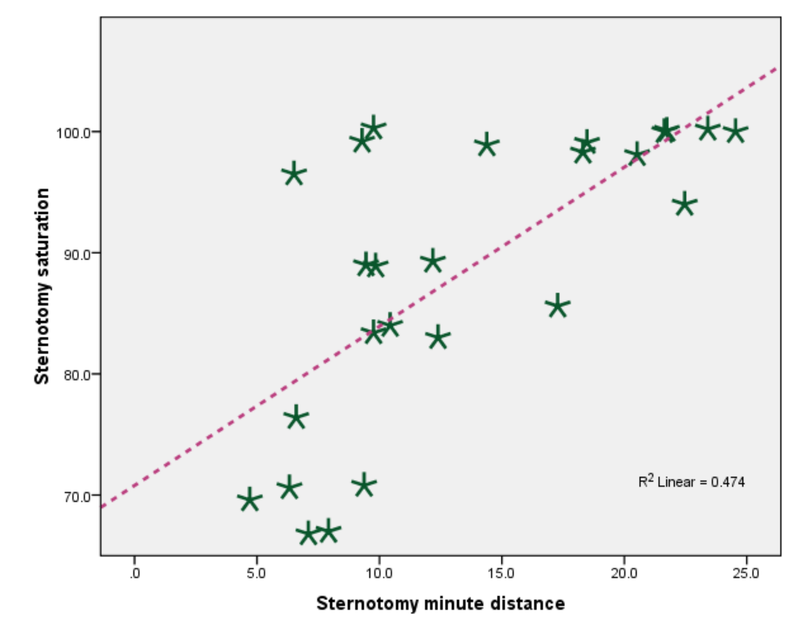


(b) After sternotomy

Figure 5.5: Pearson's correlation between minute distance and P (a-$ETCO_2$) values taken during baseline (a) and after sternotomy (d).



(a) Baseline



(b) After sternotomy

Figure: 5.6 Pearson's correlation between the minute distance and Arterial oxygen saturation during baseline (a) and after sternotomy (b).

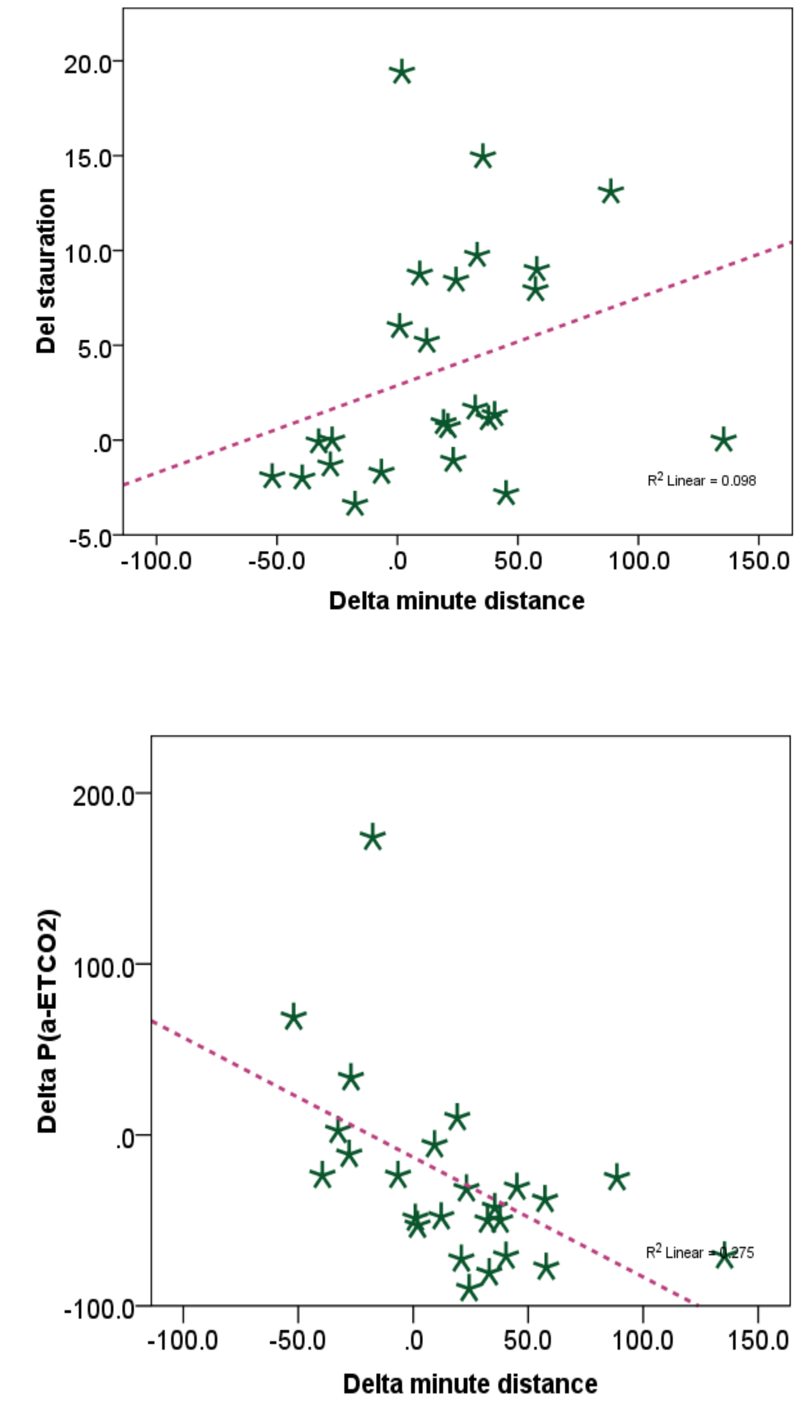


Figure: 5.7: Pearson's correlation - ΔP (a-ETCO$_2$) and Δ SaO$_2$ with Δ minute distance

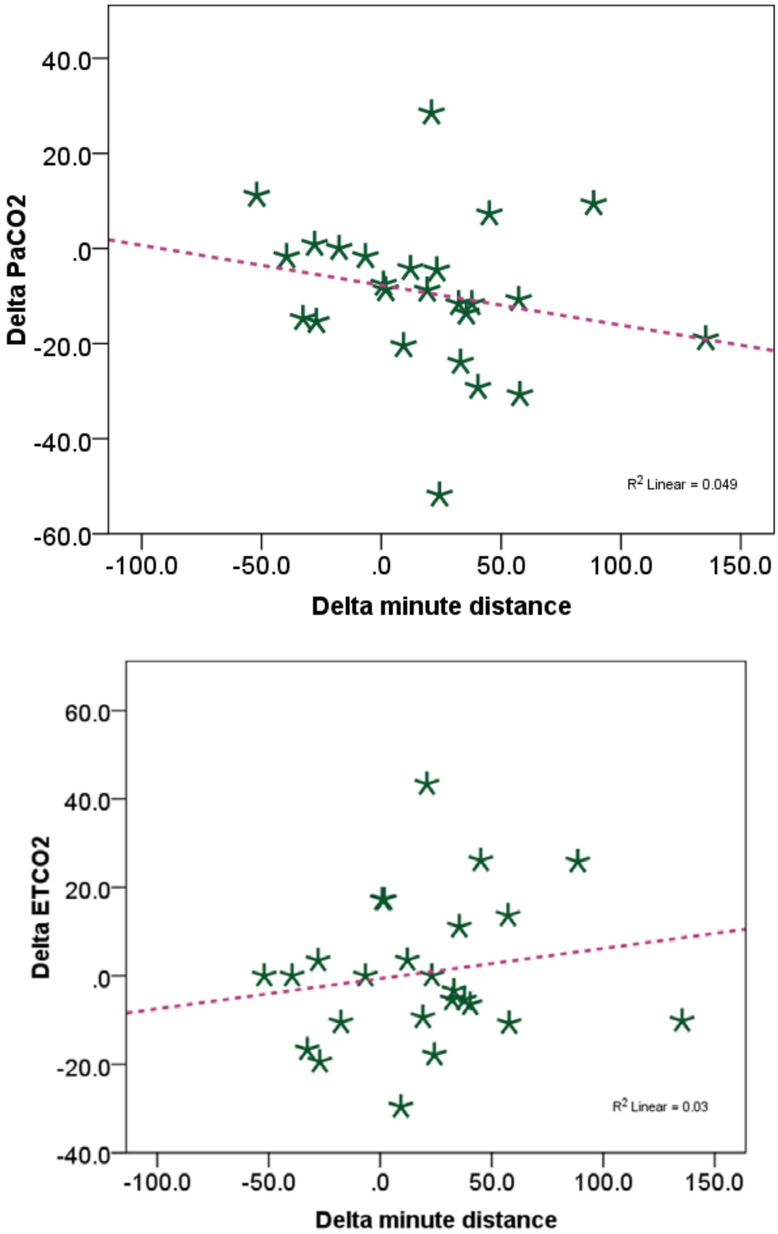


Figure 5.8: Pearson's correlation – Δ Minute distance with $\Delta PaCO_2$ and $ETCO_2$

Table 5.5 : Pearson's correlation of parameters with minute distance after protamine and after sternal closure

Protamine (Components)	**Descriptive Statistics-mean(S.D)**	**Pearson Correlation**	
Minute distance (cm/min)	20.1(7.4)		
ETCO2 (mmHg)	33.3(4.9)	-0.125	0.552
PaCO2 (mmHg)	39.0(6.1)	-.266	0.199
P(a-ETCO2) (mmHg)	5.7(2.8)	-0.355	0.082
Sternal Closure (Components)	**Descriptive Statistics-mean (S.D)**	**Pearson Correlation**	
Minute Distance cm/min	23.1(7.6)		
ETCO2 (mmHg)*	34.1(5.4)	0.440*	0.028*
PaCO2 (mmHg)	40.3(5.4)	0.348	0.088
P(a-ETCO2) (mmHg)	6.18(2.2)	-0.223	0.284

(*-- Significant at p value < 0.05)

After intracardiac repair there was no correlation between minute distance and any of the parameters like $PaCO_2$, $ETCO_2$ and P (a-$ETCO_2$). We found moderate correlation between $ETCO_2$ and minute distance values after sternal closure. But $PaCO_2$ and gradient failed to show any significant correlation with minute distance (Table 5.5).

CHAPTER 6

DISCUSSION

Clinically cyanotic heart disease patients are classified into patients with increased pulmonary blood flow (PBF) and those with decreased pulmonary blood flow. Most of cyanotic patients with increased PBF will have mixing type of lesions were right and left sided blood gets mixed. This effective mixing or the shunt decides the systemic Arterial oxygen saturation [(1).]

In patient with decreased pulmonary blood flow, the one which decides the arterial oxygen saturation is the extent of PBF and extent to which the desaturated blood mixes with the systemic saturated blood. These are cyanotic patients with shunting lesion [(2)]. Tetralogy of Fallot is a classic example of cyanotic patients with shunting lesion.

$ETCO_2$ monitoring is one of the recommended monitoring techniques during anaesthesia in remote or operation theatre settings, from deep sedation to general anaesthesia. It is a useful non-invasive monitor of ventilation as well as perfusion in patients with normal cardiopulmonary reserve [(13)]. Role of $ETCO_2$ monitoring is strongly criticised in the setting of cyanotic congenital heart disease more precisely in children with cyanotic heart disease with shunting (tetralogy of Fallot). In cyanotic heart disease, alteration in PBF associated with right to left shunting result in changes in ***physiological dead space, venous admixture and*** ***$PaCO_2$-$ETCO_2$***[(2-4).]In tetralogy of Fallot where dynamic right ventricular outflow tract obstruction and VSD frequently cause variable PBF resulting in more changes in $PaCO_2$-$ETCO_2$.Monitoring of $ETCO_2$ as a surrogate for PBF is less reliable but Under stable ventilatory settings we presumed that the P(a-$ETCO_2$) gradient can reflect the change in pulmonary blood flow. So we studied the correlation between the P (a-$ETCO_2$) and PBF to show that $ETCO_2$ monitoring can be still effectively used in patient with TOF physiology.

Measurements of PBF [12] in children with tetralogy of Fallot are clinically limited. The reasons are as follows:

- Placement of the pulmonary artery catheter is limited in small children
- Measurement of the pulmonary artery flow velocity with pulsed Doppler echocardiography is difficult because of the very high flow velocity produced by pulmonary stenosis
- The blood flow from the collateral vessels or previous anastomosis cannot be measured from the pulmonary artery approach.

Considering the above facts Tanaka et al [12] used pulsed Doppler signals of pulmonary venous flow (PVF) velocity by using transesophageal echocardiography (TEE) in children with tetralogy of Fallot. They showed that pulmonary venous blood flow velocity in left upper pulmonary vein can be used as an indicator of pulmonary blood flow.

The main factors which govern the P (a-$ETCO_2$) gradient in cyanotic heart disease are [32] :

- Oxygen saturation
- Haemoglobin concentration
- Respiratory quotient

Subsequently Short et al proposed that apart from R-L shunting, pulmonary hypo perfusion contributed to the difference in the P (a-$ETCO_2$) gradient.

In our study the haemoglobin was kept almost at the constant value in baseline and during sternotomy.

Lung mechanics and diffusion capacity are normal in children with cyanotic heart disease [(35)].We didn't expect any change in the physiological dead space apart from the one caused by the effect of pulmonary hypoperfusion because difference in the sampling time between baseline and after sternotomy group was 12 min which is much shorter than Lazzell [(2)] et al (43+/- 18) and fletcher et al [(41)] and more over Pleura was intact in all the patients at the time of sample collection. McSwain (31) et al explained that P (a-ETCO2) gradient is stable under wide range of physiological dead space. So the main factors that influence gradient are

- R-L shunting
- Physiological dead space caused by hypoperfusion
- Diffusion coefficient, and
- Arterial oxygen saturation

So the ultimate factor that governs the gradient is the variability in pulmonary blood flow. There are published reports showing good correlation between $ETCO_2$ and PBF in Tetralogy of Fallot on comparing the values obtained before and after shunt surgery [(36, 37)]. There is no study in the literature considering $ETCO_2$ and PBF in the TOF physiology before any definitive or palliative repair. In our study **we found no correlation between $ETCO_2$ value and the minute distance calculated** from the pulmonary venous Doppler which we considered as a surrogate of pulmonary blood flow.

Moreover we found no significant difference in **$ETCO_2$ and $PaCO_2$ value acquired in baseline sample and sample taken post sternotomy.** Similar finding was reported by Lazzell et al[2] and Lee et al[38] in patients with TOF physiology. This phenomenon was explained by the fact that TOF patients do have gross V/Q mismatch. So in patient with R-L shunt, $ETCO_2$ remains unchanged even with variable arterial oxygen saturation [2, 37-39].$ETCO_2$ value can't be used as a monitor for assessing the pulmonary blood flow.

In our study individual values of P (a-$ETCO_2$) gradient had strong negative correlation and SaO_2 had strong positive correlation with the corresponding values of minute distance (p value <0.01). Our finding was similar to that of Tanaka [12] et al, where he found significant correlation between Arterial oxygen saturation and minute distance. But in addition to that finding we found strong correlation between minute distance and P (a-$ETCO_2$) which was new to us.

When we tried to correlate between per cent change in minute distance (ΔMD) and with per cent change values of the each parameter ΔP (a-$ETCO_2$), $\Delta PaCO_2$, $\Delta ETCO_2$ and ΔSaO_2, there was significant correlation only with ΔP (a-$ETCO_2$) (p value < 0.05) . This finding can be explained by two facts

- Baseline and post sternotomy values were obtained in stable hemodynamic condition, with an average sampling time interval of 12 minutes and there was no significant change in haemoglobin values.
- When considering the per cent change, change in P(a-$ETCO_2$) was remarkable 26.2+/-55 % , considering other parameters like $ETCO_2$→0.65+/-16.4 %, $PaCO_2$ →-9.3+/-15.8% and Arterial oxygen saturation(SaO_2)→3.7+/- 6.1%. The per cent change was least with $ETCO_2$, followed by SaO_2 and $PaCO_2$.

We noticed mean values of minute distance, saturation, RVOT pressure gradient and MAP acquired after sternotomy was lower than the means of Baseline value, but they were not statistically significant. But we noticed significant difference between baseline and sternotomy value of P (a-ETCO$_2$). This finding was not seen in the other studies .Right to left shunting in TOF physiology is a dynamic component the extent of shunting decides the clinical condition. Shunting should be minimal with stable hemodynamics. In our study we had a minimal change in the minute distance and saturation, but change in the gradient P (a-ETCO$_2$) was significant because gradient was not only influenced by venous admixture(R-L shunting).

The relative pulmonary hypoperfusion caused by R-L shunting created additional effect by increasing the physiological dead space[2-4] . Thus single event (R-L shunting) created double effect (venous admixture and Pulmonary hypoperfusion) exaggerating the gradient between $PaCO_2$ and $ETCO_2$ .Thus in patients with TOF physiology under stable hemodynamic condition trend in the P (a-ETCO$_2$) can act as a sensitive indicator of PBF than $ETCO_2$ and saturation. Moreover Trend in P (a-ETCO$_2$) along with SaO_2 can give a better outlook on PBF in different clinical settings.

There are two different types of clinical presentation in TOF. They can present with severe cyanosis or no cyanosis called Pink TOF. Both these patients will have high RVOT gradients. What decides is the relative resistance across RVOT created by stenotic valve, small annulus or branch stenosis [1]. RVOT obstruction with no resistance across will have good PBF even with high gradient. **We found significant negative correlation between RVOT pressure gradient and minute distance calculated from LUPV.** Accurate assessment of the degree of stenosis at each level of obstruction is not possible by Doppler. In the presence of distal obstruction, the obstruction at the proximal level is underestimated (fig. 5.1) [(1).] So patient can have very less PBF with low gradient and similarly they can have good PBF with high gradient.

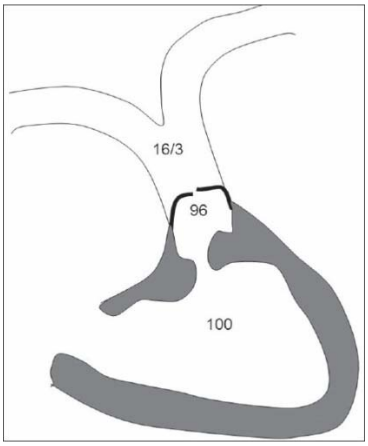


Figure: 6.1: Showing effect of obstruction distal to RVOT obstruction (*reproduced from Kannan .BR, "Tetralogy of Fallot", Ann Pediatr Card, 2008,1:135-8*.)

Though it has got significant correlation with minute distance, because of uncertainty mentioned above it has to be further substantiated by a procedure like needle gradient at different levels followed by multivariate analysis depending upon the resistance distal to RVOT.

Similar to the Lee et al[(38)] there was no significant difference in $PaCO_2$,$ETCO_2$ and P(a-$ETCO_2$) values among baseline and the values obtained after intracardiac repair (after protamine administration and after sternal closure).

RVOT gradient, minute distance and oxygen saturation values improved significantly after intracardiac repair.**After sternal closure we were able to find a significant correlation with the minute distance (p value < 0.05) and $ETCO_2$.** Sternal closure causes reduction in anatomical dead space and the alveolar deadspace increases leading no net effect on physiological dead space and CO_2 production will also come to normal level causing no significant effect in the P (a-$ETCO_2$). [40, 41]. After intracardiac repair and sternal closure the circulation becomes in series, and this explains the correlation of $ETCO_2$ with minute distance and its better reflection of $PaCO_2$ value.

There are some limitations in the study:

- Even though our sample is enough for statistical calculation and to derive a conclusion, it is small to extrapolate to a larger group of population.

- We were able to collect only two TEE measurements before CPB – to have stable hemodynamic condition and minimal interference from surgical manipulation.
- We did not consider the effect of Biventricular/LV diastolic function on pulmonary venous flow Doppler.
- We conducted our study under stable hemodynamic condition; validity of the data in unstable hemodynamic conditions should be evaluated.

To conclude, in patients with TOF physiology with stable hemodynamic condition P (a-$ETCO_2$) can be considered as a sensitive marker of pulmonary blood flow. Trend in the $ETCO_2$ is a poor indicator of ventilation as well as perfusion. Anatomical constraints are to be considered before taking the RVOT into consideration. Minute distance calculated from LUPV Doppler can be used as a surrogate for PBF.

CONCLUSION

- In patients with TOF, Minute distance calculated from pulmonary venous Doppler velocity can be used as a surrogate for pulmonary blood flow.

- In our study we found strong negative correlation between P (a-$ETCO_2$) and minute distance calculated from left upper pulmonary vein. Thus trend in P (a-$ETCO_2$) can be a sensitive indicator for changes in pulmonary blood flow before intracardiac repair.

- We found strong positive correlation between arterial oxygen saturation and minute distance. Arterial oxygen saturation is a useful indicator of pulmonary blood flow in children with TOF physiology.

- In our study performed under stable hemodynamic condition Change in P (a-$ETCO_2$) better correlated with change in minute distance than rest of the parameters like MAP, SaO2, $ETCO_2$, and $PaCO_2$. Thus P (a-$ETCO_2$) acts as a sensitive indicator of PBF.

- In our study we found no statistical difference in individual values of $PaCO_2$ and $ETCO_2$ before and after intracardiac repair and they vary minimally with wide range of minute distance calculated from pulsed wave Doppler from LUPV.

- In our study $ETCO_2$ and $PaCO_2$ never had any correlation with minute distance and both are poor indicator of ventilation as well as perfusion – before and after ICR.

- Trend in RVOT pressure gradient had better correlation with minute distance calculated from LUPV flow Doppler. As it is influenced by anatomical factors it is not a prudent indicator for assessing PBF.

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ANNEXURE

PROFORMA

Name :

Age / sex :

Wt. kg/ ht.cm:

BSA :

Parameters	$ETCO_2$	Pa-$ETCO_2$	RVOT gradient	P v VTI			HR	MD
				S	D	A		
Baseline T_1								
Sternotomy T_2								
After protamine T_3								
After sternal Closure T_4								

Timing / Parameter	baseline	sternotomy	After protamine	After sternal Closure
HR				
SPO_2				
S/D(M)				
CVP				
AWP				
Fio_2				
ΔO_2				

ABG	PH	PO_2	PCO_2	HCO_3	SBE	Hb	SaO_2
1							
2							
3							
4							

(Name and signature of the investigator)

CONSENT FORM

Study title:

The Correlational study between $PaCO_2$–$EtCO_2$ gradient and RVOT pressure gradient in relation to pulmonary blood flow in patients with Tetralogy of Fallot, pre and post intracardiac repair.

Study number:

We request you to participate in this study in which we are planning to correlate blood investigation values with Trans oesophageal echocardiogram values of 30 children immediately before and after the surgical procedure.

What is the tetralogy of Fallot?

One of the condition causing blue babies at birth or during growing phase. Normally human heart has two pumping chambers right ventricle and left ventricle. Right side blood is pumped into lungs, where blood is purified by means of oxygenation from where it is drained into left side of the heart .from the left side, blood is pumped into rest of the body, where oxygen is used as fuel. Basic issue is - defect in the septum separating two chambers of the heart along with obstruction of the outlet of the right side pump causing two issues 1) The blood with reduced oxygen mixes with oxygenated blood in L side and pumped into the rest of body causing blue colour .2) obstruction of the right side outflow - causing reduced oxygen delivery.

What is the treatment?

Treatment for the above condition is intracardiac repair under general anaesthesia using cardiopulmonary bypass. Procedure involves closure of defect and relieving the obstruction.

How child is anaesthetised?

Anaesthetic technique used is called General anaesthesia. Anaesthetic drug is injected into the blood and make the child sleep in deep plane. Appropriate size endotracheal tube is placed into windpipe through mouth. Gas exchange and anaesthesia is maintained through the tube. During anaesthesia patient's all vital parameters are maintained in normal range with the help of invasive and non-invasive monitors and arterial blood analysis. Invasive monitors are arterial line placed in an artery in thigh or hand and central venous line placed in the neck vein. Pressure is measured from artery and vein which gives pumping pressure and filling pressure respectively.

What is transesophageal echocardiography (TEE)?

TEE is ultrasonic equipment useful in monitoring the cardiac function during surgery. The TEE probe is introduced through the mouth into the oesophagus (food pipe of our body) and stomach and the heart is imaged with ultrasound waves. TEE is recommended during all cardiac surgical procedures.

What are the side effects of TEE?

TEE may be associated with difficulty in swallowing (1 in 1000), injury to teeth (3 in 1000) and bleeding from stomach (3 in 100000). Rare complications include oesophageal perforation and vocal cord paralysis.

What is the need for blood sampling during surgery?

Normally during cardiac surgery frequent sampling of arterial blood is done to assess

- Gas exchange, oxygen transfer and carbon dioxide removal.
- blood Hb
- Normal cell activity and oxygen consumption and excretion of by-products.

Why are we doing the study?

In this study we are trying to figure out the extent of blood flow to lungs using the difference in carbon dioxide dissolved in blood and exhaled gas, So that the gradient can be used as a monitor of pulmonary blood flow.

Can you withdraw from this study after it starts?

Your participation in this study is entirely voluntary and you are also free to decide to withdraw permission to participate in this study. If you do so, this will not affect your child's usual treatment at this hospital in any way.

What will happen if you develop any study related injury?

We do not expect any injury to happen to you but if you do develop any side effects or problems due to the study, these will be treated at no cost to you. We are unable to provide any monetary compensation, however.

Will you have to pay for the study?

No.

Will your child's personal details be kept confidential?

The result of this study will be published in a medical journal but your child will not be identified by name in any publication or presentation of results .however the medical notes will be reviewed by people associated with the study, without your permission, should you decide to participate in this study.

If you have any further questions, please ask:

Dr. Omprakash senior resident cardiac anaesthesia (Tel: 9048441942) or mail me: omtelsi@sctimst.ac.in

Dr. Prasanth Kumar Dash professor cardiac anaesthesia (tel: 09349336584)

Dr.Rupa Sreedhar professor dept, of cardiac anaesthesia (Tel: 9446314043)

DECLARATION

I, ____ ,

Parent /guardian of __________________________________ (Please tick boxes) • Participant's name: Date of Birth / Age (in years)

Declare that I have read the above information provide to me regarding the study:

The Correlational study between $PaCO_2$ –$EtCO_2$ gradient and RVOT pressure gradient in relation to pulmonary blood flow in patients with Tetralogy of Fallot, pre and post intracardiac repair.

And have clarified any doubts that I had. [ ]

- I also understand that my child's participation in this study is entirely voluntary and that I am free to withdraw permission to continue to participate at any time without affecting my usual treatment or my legal rights [ ]
- I understand that the study staff and institutional ethics committee members will not need my permission to look at my child's health records even if I withdraw from the trial. I agree to this access [ ]
- I understand that my child's identity will not be revealed in any information released to third parties or published [ ]
- I voluntarily agree to take part in this study [ ]
- I received a copy of this signed consent form [ ]

Name:

Signature:

Name of witness:

Relation to participant:

Date:

(Person Obtaining Consent)

I attest that the requirements for informed consent for the medical research project described in this form have been satisfied. I have discussed the research project with the participant's parent/guardian and explained to him or her in nontechnical terms all of the information contained in this informed consent form, including any risks and adverse reactions that may reasonably be expected to occur. I further certify that I encouraged the participant's parent/guardian to ask questions and that all questions asked were answered.

_________________________________ ____________________

(Name and Signature of Person Obtaining Consent)

<u>സമ്മതപത്രം</u>

പഠനപദ്ധതിയുടെ പേര്:

ഓപ്പറേഷനു മുൻപും പിൻപും, ടെട്രോളജി ഓഫ് ഫാലറ്റ് ഉള്ള രോഗികളിലെ ശ്വാസകോശത്തിലേക്കുള്ള രക്തപ്രവാഹവും, രക്തത്തിലെയും ഉച്ഛ്വാസവായുവിലെയും കാർബൺഡൈ ഓക്സൈഡ് അളവുകളിലുള്ള വ്യതിയാനവും റൈറ്റ് വെൻട്രിക്കിൾ ഔട്ട്ഫ്ളോ ട്രാക്റ്റ് ഗ്രേഡിയന്റും തമ്മിൽ ഉള്ള താരതമ്യ പഠനം

പഠനത്തിന് വിധേയമാക്കപ്പെടുന്നവരുടെ എണ്ണം:

ടെട്രോളജി ഓഫ് ഫാലറ്റ് എന്ന അസുഖമുള്ള കുട്ടികളിൽ ഓപ്പറേഷനു മുൻപും പിൻപും, ചില ബ്ലഡ് ടെസ്റ്റുകളിൽ നിന്നും ലഭിക്കുന്ന വിവരങ്ങളും ട്രാൻസ് ഈസോഫാജിയൽ എക്കോ എന്ന ടെസ്റ്റിൽ നിന്നും ലഭിക്കുന്ന വിവരങ്ങളും ചികിത്സയ്ക്കായി വരുന്ന 30 ഓളം കുട്ടികളിൽ താരതമ്യം ചെയ്യാനാണ് ഈ പഠനത്തിലൂടെ ഉദ്ദേശിക്കുന്നത്.

ടെട്രോളജി ഓഫ് ഫാലറ്റ് എന്നാൽ എന്ത്?

ജനനസമയത്തോ അതിനുശേഷമോ കുട്ടികളിൽ നീലനിറമുണ്ടാക്കുന്ന ഹൃദയസംബന്ധമായ ഒരു അസുഖമാണ് ടെട്രോളജി ഓഫ് ഫാലറ്റ്. ഒരു സാധാരണ മനുഷ്യ ഹൃദയത്തിന് ഇടതും വലതും അറകൾ ഉണ്ട് ഹൃദയത്തിന്റെ വലത്തെ അറകൾ രക്തത്തെ ശ്വാസകോശത്തിലേക്ക് പമ്പു ചെയ്ത്, അവിടെ വച്ച് ഓക്സിജൻ രക്തത്തിലേക്കുള്ള ആഗീരണം സാധ്യമാക്കി, ഹൃദയത്തിന്റെ ഇടത്തെ അറകളിലേക്കു കൈമാറുന്നു. ഇവിടെ നിന്നും രക്തം ശരീരത്തിന്റെ എല്ലാ ഭാഗങ്ങളിലേക്കും പമ്പു ചെയ്ത് ഓക്സിജൻ ലഭ്യത കുട്ടികളിൽ ഹൃദയത്തിന്റെ ഇടത് - വലത് അറകളെ തമ്മിൽ വേർതിരിക്കുന്ന ഭിത്തിയ്ക്കുള്ള ദ്വാരവും, വലത്തെ അറ ശ്വാസകോശത്തിലേക്ക് തുറക്കുന്ന ഭാഗത്തുള്ള തടസ്സവും രണ്ട് പ്രശ്നങ്ങൾ ഉണ്ടാക്കുന്നു.

1. വലത്തെ അറകളിൽ നിന്നുള്ള അശുദ്ധ രക്തം ഇടത്തെ അറകളിലുള്ള ശുദ്ധ രക്തവുമായി കലരുന്നതു മൂലം കുട്ടിയ്ക്ക് നീലനിറമുണ്ടാകുന്നു.
2. ഓക്സിജൻ സമ്പുഷ്ടമായ ശുദ്ധ രക്തം ശരിയായ രീതിയിൽ ശരീരത്തിന്റെ എല്ലാ ഭാഗത്തും എത്തിയ്ക്കാൻ കഴിയാതെ വരുന്നു.

എന്താണ് ഇതിനുള്ള ചികിത്സ

മൊത്തമായി മയക്കി (ജനറൽ അനസ്തീഷ്യ നൽകി) കാർഡിയോ - പൾമണറി ബൈപ്പാസ് എന്ന സംവിധാനത്തിന്റെ സഹായത്തോടെ ഹൃദയത്തിന്റെ അറകളെ 'റിപ്പയർ' ചെയ്യുക എന്നതാണ് ഇതിന്റെ ചികിത്സ. ഇതിലൂടെ ഹൃദയഭിത്തിയിലുള്ള സുഷിരം അടയ്ക്കുകയും, ഹൃദയത്തിന്റെ വലത്തെ അറയിൽ നിന്നും ശ്വാസകോശത്തിലേക്കുള്ള രക്തപ്രവാഹത്തിനുള്ള തടസ്സത്തെ മാറ്റുകയും ചെയ്യുന്നു.

എങ്ങനെയാണ് കുട്ടിയ്ക്ക് മയക്കം (അനസ്തീഷ്യ) കൊടുക്കുന്നത്?

ഈ ഓപ്പറേഷന് 'ജനറൽ അനസ്തീഷ്യ' ആണ് ഉപയോഗിക്കുന്നത്. ഒരു ചെറിയ സൂചിയിലൂടെ അനസ്തീഷ്യ മരുന്നുകൾ രക്തത്തിലേക്ക് കുത്തിവയ്ക്കുന്നതോടെ, കുട്ടി വേദനയോ ചുറ്റും നടക്കുന്ന കാര്യങ്ങളോ അറിയാത്ത തരത്തിൽ മയക്കപ്പെടുന്നു. ഫലപ്രദമായി ശ്വാസോച്ഛ്വാസം കൊടുക്കുന്നതിനു വേണ്ടിയും വാതകരൂപത്തിലുള്ള അനസ്തീഷ്യ മരുന്നുകൾ കൊടുക്കുന്നതിനു വേണ്ടിയും, ഇതിനുശേഷം വായിലൂടെ ശ്വാസനാളത്തിലേയ്ക്ക് ഒരു കുഴൽ ഇടുന്നു. കുട്ടിയ്ക്ക് അനസ്തീഷ്യ നൽകപ്പെട്ടിരിക്കുന്ന സമയം മുഴുവനും, പരമപ്രധാനമായ ശാരീരിക പ്രവർത്തനങ്ങൾ കൃത്യമായി നടക്കുന്നുണ്ടെന്നു ഉറപ്പു വരുത്താൻ വിവധതരം മോണിറ്ററിങ്ങ് ഉപകരണങ്ങളും രക്തപരിശോധനകളിലൂടെ ലഭിക്കുന്ന വിവരങ്ങളും സഹായിക്കുന്നു. തുടയിലോ കൈയിലോ ഉള്ള രക്തധമനിയിലേക്കിടുന്ന ചെറിയ കാനുലകളും (ചെറിയ പ്ലാസ്റ്റിക കുഴലുകൾ) കഴുത്തിലെ സിരകളിലിടുന്ന കത്തീറ്ററുകളും (നിളമുള്ള നേർത്ത പ്ലാസ്റ്റിക് കുഴലുകൾ) ആണ് ഈ രക്ത പരിശോധനകൾ സാധ്യമാക്കുന്നത്. ഇതിലൂടെ രക്തധമനികളിലെയും സിരകളിലേയും രക്തസമ്മർദ്ദം നിരീക്ഷിക്കാനും സാധിക്കുന്നു.

TEE എന്നാൽ എന്ത്?

ഹൃദയ ശസ്ത്രക്രിയ സമയത്ത് ഹൃദയത്തിന്റെ പ്രവർത്തനങ്ങൾ തുടർച്ചയായി നിരീക്ഷിക്കുവാൻ സഹായിക്കുന്ന ഒരു പ്രത്യേക പരിശോധനാരീതിയാണ് ഇത്. TEE ഉപകരണം വായിൽകൂടി അന്നനാളത്തിലേക്കും ആമാശയത്തിലേക്കും കടത്തി, ശബ്ദതരംഗങ്ങൾ വഴി ഹൃദയത്തിന്റെ പ്രവർത്തനങ്ങൾ നിരീക്ഷിക്കുന്നു. TEE എല്ലാ വിദത്തിലുളള ഹൃദയശസ്ത്ര ക്രിയകൾക്കും ഉപയോഗിക്കേണ്ടാതാണ്.

TEE യുടെ പാർശ്വ ഫലങ്ങൾ എന്തൊക്കെയാണ്?

TEE ഉപയോഗിക്കുന്നതുകൊണ്ട് വിഴുങ്ങുവാനുള്ള ബുദ്ധിമുട്ട് (1000 പേരിൽ ഒരാൾക്ക്) പല്ലിന് ക്ഷതം (1000 പേരിൽ മൂന്ന് പേർക്ക്) വയറ്റിൽ രക്തസ്രാവം (100,000 പേരിൽ മൂന്ന് പേർക്ക്) എന്നിവ ഉണ്ടാകാം. അപൂർവ്വം ആയിട്ട് കണ്ഠനാളിയ്ക്കും (വോക്കൽകോർട്) അന്നനാളത്തിനും ക്ഷതം ഉണ്ടാകാം.

എന്തിനാണ് ഓപ്പറേഷനിടയിൽ രക്തപരിശോധന നടത്തുന്നത്?

1. രക്തത്തിലെ ഓക്സിജന്റെയും കാർബൺ ഡൈ ഓക്സൈഡിന്റെയും അളവ് അറിയാൻ.
2. ഹീമോഗ്ലോബിന്റെ അളവ് അറിയാൻ
3. കോശങ്ങളുടെ ഉപാപചയ പ്രവർത്തനങ്ങൾ ശരിയായി നടക്കുന്നുവെന്ന് ഉറപ്പു വരുത്താൻ

എന്തിനാണ് ഈ പഠനം നടത്തുന്നത്?

രക്തത്തിലേയും ഉച്ഛ്വാസവായുവിലെയും കാർബൺഡൈ ഓക്സൈഡിന്റെ അളവുകൾ തമ്മിലുളള വ്യത്യാസത്തിൽ നിന്നും, ശ്വാസകോശത്തിലേക്കുളള രക്തപ്രവാഹത്തിന്റെ ഏകദേശ അളവ് നിർണയിക്കാൻ സാധിക്കുമോ എന്നറിയാനാണ് ഈ പഠനം നടത്തുന്നത്.

ഈ പഠനം തുടങ്ങിയതിനുശേഷം ഇതിൽ നിന്നും പിൻമാറാൻ നിങ്ങൾക്ക് സാധിക്കുമോ ?

നിങ്ങളുടെ തീർത്തും സ്വമേധയാലുള്ള തീരുമാനത്തിലൂടെയാണ് ഈ പഠനത്തിൽ പങ്കുചേരുന്നതും, അതുപോലെ തന്നെ ഇതിൽ താൽപര്യമില്ലെങ്കിൽ നിങ്ങൾക്ക് പിൻമാറാവുന്നതുമാണ്. പിൻമാറിയാലും ഈ ആശുപത്രിയിലെ നിങ്ങളുടെ. പതിവുപോലെയുള്ള ചികിത്സയെ അത് ഒരു വിധത്തിലും ബാധിക്കുകയില്ല.

ഈ പഠനം മൂലം നിങ്ങളുടെ ആരോഗ്യത്തിന് ദോഷകരമായ ഫലങ്ങൾ ഉണ്ടാകുകയാണെങ്കിൽ എന്തു ചെയ്യും?

ഈ പഠനം മൂലം നിങ്ങളുടെ ആരോഗ്യത്തിന് യാതൊരു ദോഷഫലങ്ങൾ ഉണ്ടാകുമെന്ന് പ്രതീക്ഷിക്കുന്നില്ല. എന്നിരുന്നാലും എന്തെങ്കിലും പാർശ്വഫലങ്ങൽ ഉണ്ടായാൽ അതിനുള്ള ചികിത്സ നിങ്ങൾക്ക് ചിലവുകളൊന്നുമില്ലാതെ തന്നെ ഇവിടെ നൽകുന്നതാണ്. ധനസഹായങ്ങളൊന്നും നൽകാൻ സാധിക്കുകയില്ല.

ഈ പഠനത്തിന് നിങ്ങൾക്ക് എന്തെങ്കിലും ചിലവുകൾ വഹിക്കേണ്ടി വരുമോ?

ഇല്ല

നിങ്ങളുടെ സ്വകാര്യ വിവരങ്ങൾ രഹസ്യമായി സൂക്ഷിക്കുമോ?

ഈ പഠനഫലമായി കിട്ടുന്ന അന്തിമ വിവരങ്ങൾ ഒരു പ്രബന്ധമായിട്ടും, അതു പോലെ മെഡിക്കൽ ജേർണലുകളിലും പ്രസിദ്ധികരിക്കും. എന്നാൽ നിങ്ങളുടെ പേരു വിവരങ്ങളും മറ്റും രഹസ്യമായി തന്നെ സൂക്ഷിക്കും. എങ്കിലും ആ പഠനവുമായി ബന്ധപ്പെട്ട ആളുകൾക്ക്, നിങ്ങളുടെ രോഗവിവരങ്ങൾ, ഇനി ഒരു സമ്മതം കൂടാതെ തന്നെ പുനഃപരിശോധന നടത്താവുന്നതാണ്.

പുതുതായി നിങ്ങൾക്ക് എന്തെങ്കിലം ചോദിക്കിവാനുണ്ടെങ്കിൽ, താഴെ പറയുന്ന ഡോക്ടർമാരെ സമീപിക്കാവുന്നതാണ്.

ഡോക്ടർ ഓം പ്രകാശ് (9048441942) അല്ലെങ്കിൽ Email: omtelsi@sctimst.ac.in

പ്രഫസർ, ശ്രീചിത്തിര തിരുനാൾ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് മെഡിക്കൽ സയൻസ് ആന്റ് ടെക്നോളജി (ഫോൺ നമ്പർ 09349336584)

ഡോക്ടർ രൂപ ശ്രീധർ, അനസ്തേഷ്യ വിഭാഗം പ്രഫസർ, ശ്രീചിത്തിര തിരുനാൾ ഇൻസ്റ്റിറ്റ്യൂട്ട് ഓഫ് സയൻസസ് ആന്റ് ടെക്നോളജി (ഫോൺ നമ്പർ - 9446314043).

<u>പ്രഖ്യാപനം</u>

--- (കുട്ടിയുടെ പേര്)ന്റെ (പിതാവ് / മാതാവ്/ രക്ഷകർത്താവ്) ആയ ഞാൻ ശ്രീ/ ശ്രീമതി ----------------------------

(താഴെ കാണുന്ന ബ്രാക്കറ്റുകളിൽ √ അടയാളം ഇടുക)

ഈ പ്രത്യേക പഠനത്തെക്കുറിച്ച് മുകളിൽ പറഞ്ഞിരിക്കുന്ന വിശദവിവരങ്ങൾ വായിച്ച് മനസ്സിലാക്കിയതായി പ്രഖ്യാപിക്കുന്നു.

എനിക്കുണ്ടായിരുന്ന എല്ലാ സംശയങ്ങളും ചോദിച്ച്മനസ്സിലാക്കിയിട്ടുണ്ട് ( )

- ഈ പഠനത്തിലുള്ള കുട്ടിയുടെ പങ്കാളിത്തം തികച്ചും സ്വമനസ്സാലെയുള്ള തീരുമാനമാണെന്നും, കുട്ടിയുടെ ചികിത്സയെ പ്രതികൂലമായി ബാധിക്കാതെയും,. കുട്ടിയുടെ നിയമപരമായ ആവശ്യങ്ങൾക്ക് കോട്ടം തട്ടാതെയും, എപ്പോൾ വേണമെങ്കിലും എന്റെ കുട്ടിക്ക് ഇതിൽ നിന്നും പിൻമാറാൻ സാധിക്കുമെന്നും ഞാൻ മനസ്സിലാക്കുന്നു ( )

- ഈ പാഠ്യപദ്ധതിയിൽ നിന്ന് പിൻമാറിയാലും, എന്റ അനുവാദമില്ലാതെ തന്നെ, ഈ പഠനം നടത്തുന്ന ഡോക്ടർമാർക്കും ഈ സ്ഥാപനത്തിലെ എത്തിക്കൽ കമ്മറ്റി അംഗങ്ങൾക്കും കുട്ടിയുടെ രോഗവിവര രേഖകൾ പരിശോധിക്കാവുന്നതാണെന്ന് ഞാൻ മനസ്സിലാക്കുന്നു. ഇതിന' എനിക്ക് സമ്മതമാണ് ( )

- എന്റെ കുട്ടിയെക്കുറിച്ചുള്ള വിശദവിവരങ്ങൾ പരസ്യപ്പെടുത്തുകയോ, മൂന്നാമ തൊരാളിന' കൈമാറുകയോ ചെയ്യുന്നില്ലെന്നുള്ള വസ്തുതയും ഞാൻ മനസ്സിലാ ക്കുന്നു.()

- ഈ പാഠ്യ പദ്ധതിയിൽ എന്റെ കുട്ടിയെ പങ്കുചേർക്കുന്നതിന് ഞാൻ സ്വമനസ്സാലെ സമ്മതിച്ചിരിക്കുന്നു.()

- ഈ സമ്മതപത്രത്തിന്റെ കയ്യൊപ്പുള്ള ഒരു പകർപ്പ് ഞാൻ കൈപ്പറ്റിയിരിക്കുന്നു ( )

പേര്	:
ഒപ്പ്	:
തീയതി	:
സാക്ഷി	:
രോഗിമായുള്ള ബന്ധം	:

തീയതി :

(സമ്മതം വാങ്ങുന്ന വ്യക്തി)

ഈ പ്രത്യേക വൈദ്യശാസ്ത്രപഠന പദ്ധതിക്കുവേണ്ടിയുള്ള സമ്മതപത്രത്തിന് ആവശ്യമായ എല്ലാവിവരങ്ങളും വളരെ തൃപ്തികരമായ രീതിയിൽ ഇതിൽ അടങ്ങിയിട്ടുണ്ടെന്ന് ഞാൻ സാക്ഷ്യപ്പെടുത്തികൊള്ളുന്നു. ഇതിൽ പങ്കാളികളായ രോഗികളുടെ രക്ഷകർത്താക്കാളോട് ഈ പഠനത്തെപ്പറ്റി വിശദമായി സംസാരിക്കുകയും, ഈ സമ്മതപത്രത്തിൽ അടങ്ങിയിരിക്കുന്ന വിവരങ്ങൾ സാധാരണ സംസാരഭാഷയിൽ തന്നെ പറഞ്ഞു മനസ്സിലാക്കുകയും ചെയ്തിട്ടുണ്ട്. ഇതിനിടയിൽ ഉണ്ടായേക്കാവുന്ന അപകട സാധ്യതകളെയും, പ്രതികൂലഫലങ്ങളെയും കുറിച്ച് വിശദമായി പറഞ്ഞ് മനസ്സിലാക്കിയിട്ടുണ്ട്. ഇതിനെപ്പറ്റിയുള്ള കൂടുതൽ വിവരങ്ങൾ ചോദിക്കുവാൻ ഈ രോഗികളുടെ രക്ഷകർത്താക്കളെ പ്രോത്സാഹിപ്പിക്കുകയും, എല്ലാ ചോദ്യങ്ങൾക്കും വ്യക്തമായ മറുപടി നൽകുകയും ചെയ്തിട്ടുണ്ടെന്ന് ഇതിനാൽ ബോധ്യപ്പെടുത്തുന്നു.

സമ്മതം വാങ്ങുന്ന വ്യക്തിയുടെ

പേര് :

ഒപ്പ് :

MASTER CHART

sno	sex	weight	base ETCO2	base PaCO2	base P(a-ETCO2)	base RVOT	base S	base D	base A	base HR	base MD	base OXY	base MAP	base SAT	base Hb	base CVP	Paw baseline
1	m	14	30	34.1	4.1	50.7	0.105	0.084	0.01	88	15.752	5	70	100.1	11.4	6	9
2	m	15	29.1	30.7	1.6	47.9	0.157	0.047	0.006	116	22.968	4	84	100.3	12.2	4	10
3	m	13	25	27.7	2.7	53.9	0.097	0.054	0.011	110	15.4	3	91	90.9	13	7	15
4	f	14	25	37.3	12.3	58.1	0.078	0.041	0.006	88	9.944	3.4	66	76.2	20.9	8	13
5	f	12	36	40.1	4.1	27	0.097	0.05	0.001	88	12.848	4	54	83.1	14.8	7	12
6	m	13	30	43.2	13.2	58	0.042	0.013	0.001	118	6.372	3	73	80	18.4	6	13
7	f	12	39	50	11	58	0.064	0.069	0.006	98	12.446	5	56	86.4	15	5	13
8	m	14	30	35.4	5.4	58.1	0.053	0.036	0.006	125	10.375	4	68	97.6	12.5	10	13
9	f	13	43	44.2	1.2	48.7	0.144	0.081	0.006	102	22.338	6	94	99.8	11.5	4	16
10	m	12	35	38	3	57.2	0.087	0.054	0.001	93	13.02	5.1	70	90.4	17.7	7	13
11	f	15	29	30.1	1.1	67.2	0.188	0.113	0.01	84	24.444	4	82	99	14.6	8	13
12	f	16	27	28.6	1.6	47.3	0.118	0.086	0.007	103	20.291	3.4	84	98.4	17.9	8	15
13	f	12	34	40.3	6.3	51.3	0.091	0.048	0.006	107	14.231	5	74	82.7	11.9	8	13
14	m	13	29	36.9	7.9	74.6	0.072	0.118	0.015	77	13.475	5	69	96.4	13.6	6	14
15	f	14	34	42.9	8.9	72.4	0.0648	0.044	0.012	74	7.1632	5	59	70.8	17.9	7	13
16	m	17	29	31.1	2.1	55	0.108	0.112	0.001	74	16.206	4	87	98	16.7	15	18
17	m	19	29	31.6	2.6	30.7	0.153	0.072	0.004	114	25.194	4	82	98.9	13.6	4	12
18	f	13	29	33.9	4.9	91	0.024	0.066	0.003	105	9.135	4	78	97.8	11.4	8	16
19	f	14	33	43.8	10.8	71	0.041	0.062	0.002	87	8.787	4	68	96.4	14.6	5	11
20	m	12	19	35	16	66.2	0.056	0.026	0.002	128	10.24	5.3	62	77	18.3	13	12
21	f	11	29	33	4	44.9	0.134	0.084	0.01	86	17.888	5	54	100	11.5	9	14
22	m	10	23	25.5	2.5	53	0.1	0.05	0.01	110	15.4	3	70	90	12.5	7	11
23	m	14	35	38	3	58	0.09	0.05	0	93	13.02	5.1	70	90	13.4	6	13
24	f	13	27	28.6	1.6	29.8	0.098	0.036	0.007	103	13.081	3.4	84	98	11.5	6	9
25	f	16	34	42	8	65	0.07	0.04	0.001	74	8.066	5	53	80	14	7	10

sno	ster ETCO2	ster PaCO2	sterP(a-ETCO2)	ster RVOT	ster S	ster D	ster A	ster HR	ster MD	ster OXY	ster MAP	ster Hb	ster SAT	ster CVP	Paw stern
1	36	40	4	58.1	0.17	0.103	0.007	88	23.408	4	76	11.4	100.2	3	10
2	32.4	37.9	5.5	48.6	0.049	0.042	0.009	119	9.758	5	95	12.6	100.3	4	10
3	28	40	12	55	0.049	0.042	0.009	119	9.758	4	73	12.7	83.4	7	14
4	22	41.8	19.8	62.2	0.053	0.036	0.031	109	6.322	2.4	63	21.9	70.6	7	11
5	36	42	6	30	0.062	0.037	0.005	111	10.434	5	55	14.6	84	7	12
6	27	50	23	62	0.04	0.01	0.008	112	4.704	3	66	17.6	69.6	8	14
7	31	45.7	14.7	59	0.048	0.028	0.01	100	6.6	4	58	15.6	76.4	8	13
8	29	35.1	6.1	62.2	0.078	0.041	0.003	124	14.384	3	72	12.4	98.9	8	14
9	30	34.4	4.4	42.5	0.161	0.043	0.001	91	18.473	3	57	11.3	99.1	3	15
10	37	43	6	54.2	0.04	0.068	0.001	92	9.844	4.9	74	18.1	88.9	8	12
11	32	33	1	47.9	0.117	0.078	0.005	108	20.52	4	77	14.2	98.1	9	13
12	27	29.1	2.1	28.1	0.143	0.073	0.007	104	21.736	3.3	80	17.6	100.1	7	10
13	38	40.3	2.3	56.6	0.114	0.053	0.004	106	17.278	5	73	12	85.6	8	13
14	23	34.4	11.4	82.4	0.065	0.061	0.018	86	9.288	53	74	13.3	99.2	8	14
15	29	46.4	17.4	74	0.06	0.0287	0.017	99	7.0983	4	59	18.5	66.8	8	13
16	30	40.9	10.9	64	0.08	0.065	0.005	87	12.18	4	81	17.9	89.3	14	18
17	28	33	5	37.2	0.152	0.072	0.008	104	22.464	4	77	13.3	94	6	11
18	31	47.9	16.9	109	0.017	0.053	0.008	105	6.51	4	87	10.2	96.5	8	15
19	33	39.4	6.4	69	0.08	0.12	0.001	92	18.308	5	64	14.2	98.3	3	9
20	27	44	17	68.3	0.048	0.026	0.003	132	9.372	5.2	54	18.4	70.8	9	14
21	36	39	3	52.4	0.16	0.1	0.007	97	24.541	4	56	12.2	100	7	11
22	28	53	25	55	0.06	0.05	0.005	118	12.39	4	72	12.2	83	8	13
23	37	43	6	54	0.04	0.072	0.007	90	9.45	4.9	74	12.6	89	7	12
24	27	29.1	2.1	28	0.143	0.072	0.007	104	21.632	3.3	80	11	100	10	10
25	29	46	17	70	0.06	0.03	0.002	90	7.92	4	52	13.6	67	7	10

sno	pro ETCO2	pro P(a-ETCO2)	pro RVOT	pro S	pro D	pro A	pro HR	pro PaCO2	pro MD	pro OXY	pro MAP	pro sat	pro Hb	pro CVP
1	36	2.8	20.8	0.14	0.049	0.018	138	38.8	23.598	6	65	100	13.2	10
2	35	1.8	41	0.105	0.198	0.012	99	36.8	28.809	5	95	100.5	13.6	10
3	27	1.8	17	0.136	0.136	0.024	122	28.8	30.256	4	78	99.9	13.4	9
4	28	10	5.48	0.054	0.016	0.012	120	38	6.96	3.8	51	96.8	13.5	9
5	39	7.9	29.8	0.14	0.049	0.018	138	46.9	23.598	5.2	64	100	14	10
6	34	10.2	24.8	0.064	0.051	0.018	130	44.2	12.61	4	70	99.8	14.3	11
7	35	9.6	28.9	0.105	0.071	0.025	125	44.6	18.875	4	69	100	14	11
8	39	7.9	29.8	0.14	0.049	0.018	138	46.9	23.598	5.2	64	100	13.6	10
9	37	6.7	27.5	0.117	0.032	0.007	123	43.7	17.466	5	53	93	13.5	11
10	37	3.3	17.3	0.053	0.1	0.04	122	40.3	13.786	5.3	60	100	13.4	12
11	37	4.6	25.8	0.133	0.104	0.017	120	41.6	26.4	4	65	99.5	13.3	12
12	32	4.9	24	0.148	0.126	0.05	120	36.9	26.88	3.8	74	100.2	13.3	11
13	34	4	22.1	0.059	0.065	0.012	119	38	13.328	5	65	100	13.5	12
14	26	3.8	13.5	0.075	0.075	0.019	111	29.8	14.541	5.2	82	100	14.2	9
15	30	6.2	17.4	0.105	0.198	0.012	99	36.2	28.809	4	57	97.9	14.4	9
16	34	10.3	12	0.071	0.077	0.001	130	44.3	19.11	4	65	97.6	13.7	12
17	27	9.6	10.7	0.04	0.093	0.005	132	36.6	16.896	3	67	99.8	13.4	11
18	25	4.1	20.6	0.042	0.068	0.002	130	29.1	14.04	3	85	100.1	13.6	14
19	46	8.4	14.7	0.057	0.064	0.015	130	54.4	13.78	8	58	99.8	13.8	13
20	33	7	14	0.04	0.06	0.01	128	40	11.52	3	55	98	13.5	12
21	36	2.8	22	0.1	0.03	0.02	117	38.8	12.87	6	65	100	13.2	11
22	27	1.8	17	0.136	0.136	0.024	122	28.8	30.256	4	78	99	13	12
23	37	3.3	17	0.054	0.1	0.04	122	40.3	13.908	5.3	60	100	13.1	13
24	32	4.9	18	0.142	0.122	0.001	123	36.9	32.349	3.8	75	100	12.9	14
25	30	6.2	26	0.102	0.2	0.001	99	36.2	29.799	4	60	98	12.7	11

sno	clos ETCO2	clos P(a-ETCO2)	clos RVOT	clos S	clos D	clos A	clos HR	clos PaCO2	clos MD	clos Sat	clos MAP	clos oxy	clos Hb	clos CVP
1	38	6.8	12.7	0.146	0.079	0.006	139	44.8	30.441	99.8	58	6	13.3	11
2	32	1.8	32.9	0.14	0.049	0.018	138	33.8	23.598	100.4	76	3	13	12
3	26	3.8	13.5	0.075	0.075	0.019	111	29.8	14.541	99.7	67	3.9	12.8	11
4	24	8	5.48	0.078	0.048	0.024	137	32	13.974	97.7	53	3.8	12.9	10
5	40	2	17.8	0.146	0.079	0.006	139	42	30.441	99.9	56	4.8	13.4	12
6	28	8	19.7	0.11	0.054	0.009	127	36	19.685	88	67	4	14.2	10
7	33	5.6	22.1	0.121	0.055	0.006	125	38.6	21.25	99.3	64	4	14	9
8	39	4.1	17.8	0.146	0.079	0.006	139	43.1	30.441	100	58	4.8	13	10
9	45	4.7	16.8	0.155	0.066	0.007	121	49.7	25.894	96.5	66	7	13.1	9
10	36	7.9	6.8	0.142	0.093	0.03	126	43.9	25.83	98.4	63	5.4	12.9	10
11	40	3.9	22.1	0.148	0.091	0.011	120	43.9	27.36	100.2	61	5	12.9	10
12	30	9.3	17	0.115	0.077	0.008	120	39.3	22.08	100.4	67	3.8	13.2	9
13	34	6.3	13.8	0.129	0.056	0.005	120	40.3	21.6	99.8	56	5	13	12
14	37	3.3	17.3	0.153	0.1	0.04	122	40.3	25.986	100.2	72	3	13.1	12
15	30	7.9	12.1	0.126	0.16	0.024	99	37.9	25.938	96.1	60	5	12.8	11
16	35	8.2	14	0.077	0.117	0.001	130	43.2	25.09	93.6	80	5	12.9	13
17	30	5.3	18	0.11	0.11	0.011	133	35.3	27.797	98.2	72	2	12.8	11
18	38	5.5	21	0.114	0.227	0.011	132	43.5	43.56	99.9	72	5	12.9	12
19	43	7.4	11.4	0.091	0.096	0.002	142	50.4	26.27	99	63	6	13.7	11
20	35	9	12	0.028	0.071	0.001	126	44	12.348	97	56	3.2	12.8	13
21	38	6.8	14	0.05	0.01	0.01	120	44.8	6	99	58	6	12.6	13
22	26	3.8	13	0.07	0.06	0.019	111	29.8	12.321	99	67	3.9	12.8	10
23	36	7.9	16.8	0.082	0.09	0.03	126	43.9	17.892	98	63	5.4	13	11
24	31	9.4	16	0.113	0.08	0.007	124	40.4	23.064	100	67	3.8	13.1	11
25	30	7.9	13	0.12	0.15	0.02	100	37.9	25	97	60	5	12.9	10

sno	D MD	D sat	D PaCO2	D ETCO2	D P(a-ETC	bld sap time
1	-32.71	-0.10	-14.75	-16.67	2.50	13
2	135.38	0.00	-19.00	-10.19	-70.91	13
3	57.82	8.99	-30.75	-10.71	-77.50	12
4	57.29	7.93	-10.77	13.64	-37.88	11
5	23.14	-1.07	-4.52	0.00	-31.67	15
6	35.46	14.94	-13.60	11.11	-42.61	12
7	88.58	13.09	9.41	25.81	-25.17	13
8	-27.87	-1.31	0.85	3.45	-11.48	12
9	20.92	0.71	28.49	43.33	-72.73	11
10	32.26	1.69	-11.63	-5.41	-50.00	12
11	19.12	0.92	-8.79	-9.38	10.00	11
12	-6.65	-1.70	-1.72	0.00	-23.81	12
13	-17.64	-3.39	0.00	-10.53	173.91	11
14	45.08	-2.82	7.27	26.09	-30.70	11
15	0.91	5.99	-7.54	17.24	-48.85	10
16	33.05	9.74	-23.96	-3.33	-80.73	12
17	12.15	5.21	-4.24	3.57	-48.00	12
18	40.32	1.35	-29.23	-6.45	-71.01	13
19	-52.00	-1.93	11.17	0.00	68.75	12
20	9.26	8.76	-20.45	-29.63	-5.88	12
21	-27.11	0.00	-15.38	-19.44	33.33	14
22	24.29	8.43	-51.89	-17.86	-90.00	11
23	37.78	1.12	-11.63	-5.41	-50.00	13
24	-39.53	-2.00	-1.72	0.00	-23.81	12
25	1.84	19.40	-8.70	17.24	-52.94	13