"A PROSPECTIVE, RANDOMIZED STUDY TO ASSESS THE EFFECT OF PNEUMOPERITONEUM ON ARTERIAL AND ENDTIDAL CARBONDIOXIDE PRESSURE GRADIENT DURING LAPAROSCOPIC SURGERY IN ADULTS"

Dissertation submitted to

THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY

In partial fulfilment for the award of the degree of

DOCTOR OF MEDICINE

IN

ANAESTHESIOLOGY

BRANCH X

INSTITUTE OF ANAESTHESIOLOGY AND CRITICAL CARE

MADRAS MEDICAL COLLEGE

CHENNAI- 600003

APRIL 2016

CERTIFICATE

This is to certify that the dissertation entitled **"A PROSPECTIVE, RANDOMIZED STUDY TO ASSESS THE EFFECT OF PNEUMOPERITONEUM ON ARTERIAL AND ENDTIDAL CARBONDIOXIDE PRESSURE GRADIENT DURING LAPAROSCOPIC SURGERY IN ADULTS"** submitted by Dr. UMA MAHESWARI.P, in partial fulfilment for the award of the degree of Doctor of Medicine in Anaesthesiology by the Tamil Nadu Dr. M.G.R. Medical University, Chennai., is a bonafide record of the work done by her in the **INSTITUTE OF ANAESTHESIOLOGY AND CRITICAL CARE,** Madras Medical College and Government Hospital, during the academic year 2013-2016.

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CERTIFICATE BY THE GUIDE

"A PROSPECTIVE, RANDOMIZED STUDY TO ASSESS THE EFFECT OF PNEUMOPERITONEUM ON ARTERIAL AND ENDTIDAL CARBONDIOXIDE PRESSURE GRADIENT DURING LAPAROSCOPIC SURGERY IN ADULTS" submitted by Dr. UMA MAHESWARI.P, in partial fulfilment for the award of the degree of Doctor of Medicine in Anaesthesiology by the Tamil Nadu Dr. M.G.R. Medical University, Chennai., is a bonafide record of the work done by her in the INSTITUTE OF ANAESTHESIOLOGY AND CRITICAL CARE, Madras Medical College and Government Hospital, during the academic year 2013-2016.

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DECLARATION

"A PROSPECTIVE, RANDOMIZED STUDY TO ASSESS THE EFFECT OF PNEUMOPERITONEUM ON ARTERIAL AND ENDTIDAL CARBONDIOXIDE PRESSURE GRADIENT DURING LAPAROSCOPIC SURGERY IN ADULTS" submitted by Dr. UMA MAHESWARI.P, in partial fulfilment for the award of the degree of Doctor of Medicine in Anaesthesiology by the Tamil Nadu Dr. M.G.R. Medical University, Chennai., is a bonafide record of the work done by her in the INSTITUTE OF ANAESTHESIOLOGY AND CRITICAL CARE, Madras Medical College and Government Hospital, during the academic year 2013-2016. under the guidance of **DR. B.KALA, M.D., D.A.,** Director, Institute of Anaesthesiology and Critical Care, Madras Medical College, Chennai – 3 and submitted to The Tamil Nadu Dr. M.G.R. Medical University, Guindy, Chennai – 32, in partial fulfilment for the requirements for the award of the degree of M.D. Anaesthesiology (Branch X), examinations to be held on April 2016.

I have not submitted this dissertation previously to any university for the award of degree or diploma.

Place: Chennai Dr. UMA MAHESWARI.P

Date:

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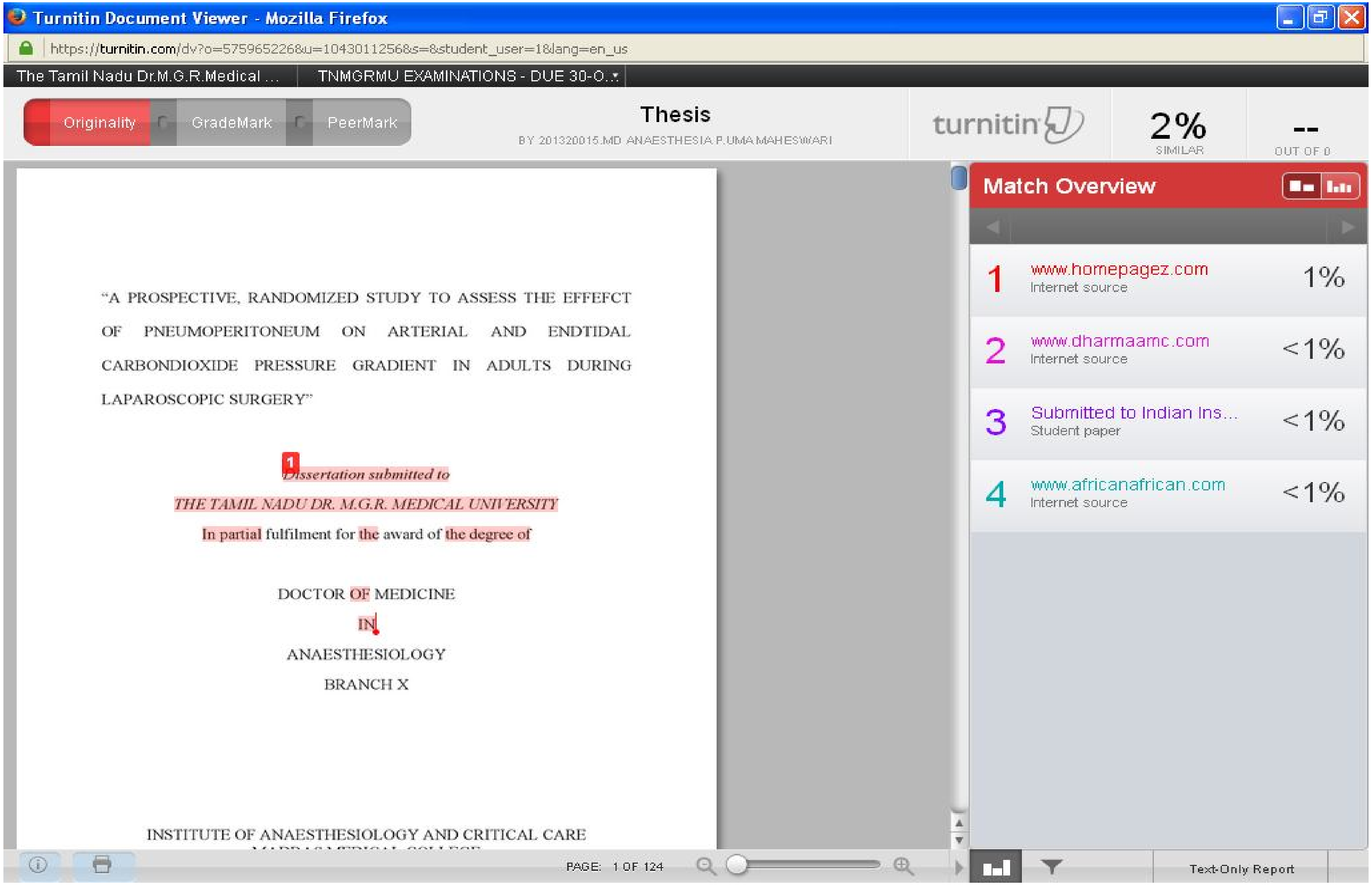
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ABBREVIATIONS:

ASA – American Society of Anaesthesiologists

ABG – Arterial Blood Gases

BMI – Body Mass Index

BP - Blood Pressure

CO2 – Carbon Dioxide

ECG – Electrocardiogram

EtCO2 – End Tidal Carbon Dioxide

FRC- Functional Residual Capacity

HCO3-Bicarbonate

IAP – Intra-Abdominal Pressure

mmHg – Millimetres of Mercury

MV – Minute Ventilation

NIBP – Non Invasive Arterial Blood Pressure

PACO2 – Alveolar Partial Pressure of Carbon Dioxide

PaCO2 - Arterial Partial Pressure of Carbon Dioxide

PEEP – Positive End Expiratory Pressure

TcPCO2 - Transcutaneous Carbon Dioxide

PvCO2 – Venous Partial Pressure of Carbon Dioxide

SpO2- Arterial Saturation of Oxygen by Pulse Oximetry

SVR – Systemic Vascular Resistance

V/Q – Ventilation- Perfusion ratio.

CONTENTS

ABSTRACT

INTRODUCTION:

During laparoscopic surgery ,Carbondioxide pneumoperitoneum is created resulting in hypercarbia which has complex effects on various systems of our body.

PURPOSE:

To asses the effects of pneumoperitoneum on arterial and end tidal carbondioxide pressure gradient during laparoscopic surgery in adults .

METHODOLOGY:

60 patients of ASA 1&2 between the age of 20 to 60 years posted for elective laparoscopic appendicectomy or cholecystectomy were selected ,They were anaesthesized ,Intubated,paralysed and ventilated with constant ventilator settings(TV=10ml/kg,RR=12 to 14/mins).Intra abdominal pressure was maintained between 10-12 mmHg.Arterial blood sample were collected preinsufflation of CO2 and also intra operatively 15 minutes after CO2 pneumoperitoneum

We decided to study the changes in PaCO2 ,ETCO2 ,P(a-Et)CO2 gradient ,and PHand bicarbonate.Also studied the hemodynamic changes due to pneumoperitoneum.

RESULTS:

There was significant increase in ETC02 ,PaCO2, P(a-Et)CO2 gradient, after CO2 insufflation but within clinically normal range. There was decrease in pH without change in bicarbonate concentration. And also slight increase in heart rate and diastolic blood pressure.

CONCLUSION:

There was increase in ETCO2 and PaCO2, P(a-Et)CO2 gradient significantly higher than pre insufflation value but with in physiological range.The arterial and endtidal carbondioxide pressure gradients are under the normal limits even after CO2 pneumoperitoneum in ASA 1 and 2 patients .The normal pressure P(a-Et)CO2 gradient implies adequate ventilation to alveoli and perfusion .ETCO2 correlate well with PaCO2 .So it is best parameter to diagnose hyper carbia.

INTRODUCTION

- Laparoscopy is a minimally invasive surgery allowing endoscopic access to peritoneal cavity after insufflation of gas to create a space between anterior abdominal wall and viscera for safe manipulation of instruments and organ.
- Hans Christian Jacobaeus of Sweden performed the first laparoscopic surgery on humans in 1910.The provision of better equipment and facility with increased knowledge and understanding of anatomy and pathology, has allowed the development of endoscopy for diagnostic and operative procedures.
- Laparoscopy was initially confined to gynaecological surgeries in 1970. In late 1980 it was extended to laparoscopic cholecystectomy, now a days laparoscopy is used in colonic ,gastric ,splenic ,hepatic and urologic surgeries.
- Reduction of post-operative pain and ileus, better cosmetic results , less hospital stay less post-operative atelectasis , and wound infection are the advantages of laparoscopy.
- Carbon dioxide is the most commonly used gas for pneumoperitoneum Alternatives are helium , argon , nitrogen , oxygen , nitrous oxide . CO2 has been found to be superior because it is non inflammable, inert, non irritant , readily available

, low cost and cheap, with a high blood gas partition coefficient (0.48) .

- It is rapidly buffered in the blood by bicarbonate and excreted via the lungs.Absorption of carbon dioxide from the pressurised pneumoperitoneum causes clinically relevant cardiopulmonary and hemodynamic alteration.
- Carbon dioxide is 20 times more soluble than oxygen ; which is insufflated in a pressurised form at 10 to 12 mmHg. If duration of surgery is prolonged, systemic absorption of carbon dioxide will be more. Due to its high solubility , the incidence of gas embolism is rare . However , it is a peritoneal irritant .
- The pneumoperitoneum and patient position required for laparoscopy induce pathophysiological changes that complicate anaesthetic management.
- Therefore to determine the adequacy of alveolar ventilation it is important to know $PaCO_2$ .Capnography constitute a useful and non-invasive means of continuously measuring $ETCO_2$. which reflects the $PaCo_2$.
- In normal individuals arterial and end tidal carbondioxide difference may vary from 2 to 5 mmHg.

- Use of capnography monitoring can reliably and quantitatively provide vital respiratory parameters in intubated patients. Alterations in cardiac output , distribution of pulmonary blood flow and metabolic activity can also be reflected by the change of carbondioxide concentration in expired gas.
- American society of anaesthesiologists mandates the use of capnography in all patient under going anaesthesia .
- In this study I am analysing the effects of pneumoperitoneum on $PaCO_2$-$ETCO_2$ gradient during laparoscopic appendicectomy and cholecystectomy .
- This study was conducted in the INSTITUTE OF ANAESTHESIOLOGY AND CRITICAL CARE Madras Medical College hospital, Chennai. The period of study is from march 2015 –July 2015.

AIM OF THE STUDY

The aim of the study is to assess the effect of pneumoperitoneum on $PaCO_2$-$EtCO_2$ gradient during laparoscopic appendicectomy and cholecystectomy in adults.

VENTILATORY AND RESPIRATORY CHANGES DURING LAPAROSCOPY:[20]

Ventilatory Changes:

- Normally ,there is decrease in thoraco-pulmonary compliance by 30 to 50% in healthy and obese patients during laparoscopy. Compliance is not affected further by subsequent patient tilting or by increasing the minute ventilation required to avoid intra operative hypercarbia.
- Reduction in functional residual capacity and development of atelectasis due to elevation of diaphgram and changes in the distribution of pulmonary ventilation and perfusion from increased airway pressure can be expected.
- However , increasing intra-abdominal pressure to 14mmHg with a patient in a 10 to 20 degree head up or head down position does not significantly modify either physiological dead space or shunt in patients without cardiovascular problems.

CAUSES OF INCREASED $PaCO_2$ DURING LAPARPSCOPY:

During CO_2 pneumoperitoneum , the increase of $PaCO_2$ may be multifactorial:

1 . absorption of carbon dioxide from the peritoneal cavity,

2. impairment of pulmonary Ventilation and perfusion by mechanical factors such as :

- Abdominal distension
- Position of patient
- Volume Controlled mechanical ventilation
- Increased metabolism
- Depression of ventilation by anaesthetics
- These mechanism are exaggerated in sick patients ,obese individuals, and patients with compromised cardiopulmonary function.
- The observation of an Increase in $PaCO_2$ when CO_2 is used ,but not with nitrous oxide or helium as insufflating agents suggests that the mechanism of increased $PaCO_2$ during CO_2 pneumoperitoneum is due to absorption of CO_2 rather than the mechanical ventilatory repercussions of increased intra abdominal pressure.

- CO_2 is rapidly absorbed across the peritoneal membrane into blood stream and equilibrates quickly , as it has a diffusion coefficient 20 times that of oxygen and 40 times that of nitrogen. The rapid equilibration of carbon dioxide results in significant hypercarbia and acidosis, which in turn, may influence cardiac and pulmonary function.
- Normally carotid and aortic body chemoreceptors respond to hypercarbia by relaying afferent impulses to respiratory centres that result in hyperventilation and increased elimination of CO_2 through lungs .Most of the laparoscopic procedures are performed with controlled ventilation under general anaesthesia
- During general anaesthesia the normal compensatory hyperventilation does not occur. Hypercarbia persists unless the respiratory rate or tidal volume is increased .

RELATIONSHIP OF $PaCO_2$ AND VCO_2:

- Accordingly , direct measurement of CO_2 elimination (VCO_2) using a metabolic monitor combined with the investigation of gas exchange showed a 20 to 30 % increase in VCO_2 without significant changes in physiological dead space in healthy patient undergoing pelvic laparoscopy (IAP OF 12-14mmHg) in head down position or laparoscopic cholecystectomy in head up position.

- [17]Lister and colleagues investigated the relationship between CO_2 elimination (VCO_2) and intraperitoneal CO_2 insufflation pressure in pigs. For an intra abdominal pressure upto 10 mmHg , increased Vco2 accounts for increased $PaCO_2$.
- At higher intra abdominal pressures , the continued rise of $PaCO_2$ without a corresponding increase in VCO_2 results from an increase in respiratory dead space ,as reflected by the widening of the arterial and endtidal carbon dioxide pressure gradient.
- Because CO_2 diffusibility is high , absorption of large quantities of CO_2 into the blood and the subsequent marked increases in $PaCO_2$ would be expected to occur .The limited rise of $PaCO_2$ actually observed can be explained by the capacity of the body to store CO_2 and by impaired local perfusion due to increased intra abdominal pressure.
- During uneventful carbon dioxide pneumoperitoneum ,the partial pressure of arterial CO_2 progessively increases to reach a plateau in 15 to 30 minutes after the beginning of CO_2 insufflation in patients under controlled ventilation during gynaecologic laparoscopy in trendelenburg position or laparoscopic cholecystectomy.

- Any significant increase in $PaCO_2$ after this period requires the search for other causes such as subcutaneous emphysema .
- Although increased $PaCO_2$ is well tolerated by young, healthy patients . Extent to which hypercapnia is acceptable has not been determined and probably varies according to the patient's physical status. Hence it is wise to maintain $PaCO_2$ within the physiological range.
- Capnography and pulse oximetry provide reliable monitoring of paco2 and arterial oxygen saturation in healthy patients and in the absence of acute intraoperative disturbances .

- Although the mean gradient between $PaCO_2$ and end tidal carbon dioxide doesnot change significantly during peritoneal insufflation of CO_2 ;individual data regularly show variation of this difference during pneumoperitoneum.
- Arterial and end tidal carbon dioxide pressure gradient increases more in ASA2 and 3 patients than ASA1 patients .These findings have been documented in patients with chronic obstructive pulmonary disease and in children with cyanotic congenital heart disease.

RESPIRATORY COMPLICATION [20]

Co2 subcutaneous emphysema :

This develop as a complication of accidental extraperitoneal insufflation but it can also be considered as unavoidable side effects of certain laparoscopic surgical procedures that require intentional extraperitoneal insufflation , such as inguinal hernia , renal surgery and pelvic lymphadenectomy .In these circumstances , VCO2 , PaCO2, and PETCO2 increase. Any increase in PETCO2 occuring after PETCO2 has plateaued should suggest this complication. It resolves once insufflation has ceased.

Pneumothorax,pneumomediastinum,**pneumopericardium**

- embryonic remnants providing potential channels of communication
- Defects in diaphragm or weak points in aortic or oesophageal hiatus tha can cause cause gas leakage into thorax.
- During fundoplication of hiatal hernia
- Rupture of pre-existing bullae during pneumoperitoneum.
- These complication are potentially serious and may lead to respiratory and hemodynamic disturbances .

Management :

1. Stop nitrous oxide administration
2. Increase Fio2 to correct hypoxia
3. Application of PEEP
4. Maintain close communication with surgeon
5. Avoid thoracocentesis as pneumothorax resolves spontaneously

ENDOBRONCHIAL INTUBATION

–Pneumoperitoneum results in cephalad movement of carina leading to endobronchial intubation,it is diagnosed by fall in oxygen saturation and increase in plateau airway pressure

GAS EMBOLISM

-Most feared and dangerous complication although it is rare. It may follow direct needle or trochar placement into a vessel or as a consequence of gas insufflation in to an abdominal organ . Diagnosed by symptoms of tachycardia ,hypotension,cyanosis,arrhythmias ,millwheel murmur,presence of right heart strain in ecg.

TREATMENT

- Immediate cessation of insufflation and release of pneumoperitoneum.
- Placing the patient in steep head down and lateral position(DURANT)

- Discontinuation of nitrous oxide and ventilation with 100%oxygen
- Aspiration of gas through CVP or pulmonary catheter
- External cardiac massage causes fragmentation of emboli.

HEMODYNAMIC CHANGES DURING LAPAROSCOPY[20,14]

- Hemodynamic changes observed during laparoscopy results from the combined effects of pneumoperitoneum ,patient position, anaesthesia and hypercapnia from absorbed carbon dioxide .
- Heart rates remain unchanged or increase only slightly.
- The mechanism of decrease in cardiac output is multifactorial.The decrease in cardiac output is directly proportional to the increase in intra abdominal pressure.
- The threshold pressure that has minimal effects on haemodynamic function is <12 mmHg.
- But if the peritoneal insufflation pressure higher than 15 mmHg, it results in caval compression and pooling of blood in the legs. This causes a decline in venous return which parallels a decrease in cardiac output.

- It also causes rise in the systemic vascular resistance , and the pulmonary vascular resistance leading to an increased after load.
- Cardiac output has also been reported to be increased or unchanged during pneumoperitoneum . These discrepancies might be caused by difference in rates of carbon dioxide insufflation,IAP,time interval between insufflation and collection of data,steepness of patient, tilt,techniques used to assess hemodynamics and anaesthetic techniques.
- However most studies have shown a fall of cardiac outptut (10% to 30%) during peritoneal insufflation irrespective of , whether the patient was placed in head down or head up position.
- The combined effects of anaesthesia ,head up tilt and peritoneal insufflation (increased IAP) can reduce the cardiac index by 50 per cent.
- These hemodynamic changes are well tolerated by healthy individuals , but may have deleterious consequences in patients with cardiovascular disease.
- Reduction in venous return and cardiac output can be attenuated by increasing circulating volume before the pneumoperitoneum is produced.

- Ejection fraction of the left ventricle assessed by echo cardiography,doesnot appear to decrease significantly when intra abdominal pressure increases to 15 mmHg .
- However all studies describe an increase in systemic vascular resistance during the existence of the pneumoperitoneum .This increase in after load is not a reflex sympathetic response to decreased cardiac output .
- Systemic vascular resistance was reported to be increased in studies where no decrease in cardiac output was found.Although normal heart tolerates increase in after load under physiological conditions,the increases in after load produced by the presence of pneumoperitoneum can be deleterious to the patients with cardiac diseases.
- The increase in systemic vascular resistance is thought to be mediated by mechanical and neurohumoral factors .Catecholamines,the renin angiostenin system and vasopressin are all released during the presence of pneumoperitoneum and may contribute to increase in the after load. Increases in plasma vasopressin concentration correlates with changes in intra thoracic pressure and transmural right arterial pressure .

- Mechanical stimulation of peritoneal receptors also results in increased vasopressin release;systemic vascular resistance and arterial pressure.
- The increasing systemic vascular resistance ,systolic and diastolic blood pressure and tachycardia result in a large increase in myocardial workload. consequently myocardial ischemia may result .
- The increase in systemic vascular resistance can be corrected by administration of vasodilating anesthetic agents such as isoflurane or direct vasodilator drugs like nitroglycerine,nicardipine.
- Use of alpha 2 adrenergic agonists such as clonidine or dexmedetomidine and of beta blocking agents significantly reduces hemodynamic changes.

RENAL FUNCTION

Increase in IAP more than 20mmHg reduces the renal blood flow by mechanical obstruction , increased sympathetic activity , elevation of plasma ADH and raised plasma renin angiotensin activity . The above factors increases the renal vascular resistance leading to fall in glomerular filtration rate,which inturns leads to fall in urine output by 50% from baseline. Urine output significantly increases after deflation.

CEREBRAL CIRCULATION

Cerebral blood flow velocity increases during carbon dioxide pneumoperitoneum in response to increased PaCO2. When normocarbia is maintained ; pneumoperitoneum doesnot induce harmful changes in intracranial dynamics.

GASTRO INTESTINAL SYSTEM

Patients undergoing laparoscopy are usually considered to be at high risk of acid aspiration syndrome due to gastric regurgitation that might occur as a result of rise in intra gastric pressure consequent to increase in IAP. However , during pneumoperitoneum , the lower oesophageal sphincter tone far exceeds the intra gastric pressure and the raised barrier pressure limits the incidence of regurgitation.

MESENTERIC CIRCULATION

The visceral vascular bed is the primary site of compression during raised IAP resulting in organ dysfunction because of the collapse of capillaries and small veins. Hypercapnia induced sympathotonia , mechanical compression of abdominal organs , reverse Trendelenburg position and release of vasopressin are some of the contributory factors of reduced mesenteric circulation .

HEPATOPORTAL CIRCULATION

A rise in the IAP (> 20 mmHg) leads to an increased resistance to blood flow in the abdominal vasculature . Hormonal release during pneumoperitoneum further increases the mesenteric vascular resistance causing a significant fall in hepatic and splanchnic blood volume .

An IAP of > 20 mmhg produces a 60 percent decrease in the portal venous blood flow resulting in liver dysfunction , which persists for a longer duration in the post operative period . there is an overall reduction of blood supply to all the organs except the adrenal gland .

INTRA OCULAR PRESSURE

Intraocular pressure is not affected by pneumoperitoneum in a patient with no pre-existing eye disease.

THROMBOEMBOLISM

An IAP above 14mmHg, reverse Trendelenburg position, obesity ,pelvic surgery and surgery of long duration reduce venous flow in the lower extremities increasing the chances of thromboembolism . At least two of the three factors in virchow's triad (venous stasis and hypercoagulability) are affected during increased IAP .

Therefore patients who are undergoing prolonged laparoscopic procedures in the reverse trendelenburg position are prone to thromboembolism .

PHYSIOLOGICAL CHANGES DURING PATIENT POSITIONING:[27]

Before the veress needle is inserted patients are placed in trendlenburg position so that abdominal viscera move cephalad . Further positioning depends on the type of surgery . The magnitude of physiological changes depends on steepness of the tilt.

CARDIOVASCULAR CHANGES

Trendelenburg Position

- In 15 degree head down position there is only a small volume shift to the central circulation and that does not cause much change in central venous pressure or cardiac output.
- However in patients with coronary artery disease ,particularly with compromised ejection fraction; causes deleterious effects on myocardial oxygen demand

Reverse Trendelenburg Position

Cardiac output and mean arterial pressure falls secondary to decreased venous return. Venous stasis in this position may predispose to deep vein thrombosis and pulmonary embolism in post operative period. These effects are more marked in a patient who is hypovolemic or compromised cardiovascular status.

RESPIRATORY CHANGES

Head up tilt is favourable for respiration , while head down tilt causes reduction in vital capacity , functional residual capacity and total lung volume. There is decreased lung compliance due to impairment of diaphgramatic excursions and increased pulmonary blood volume. This may lead to atelectasis.

NERVE INJURY

Nerve compressions are a potential complication of head down position. Overextension of the arm should be avoided. Common peroneal nerve is particularly vulnerable and should be protected during lithotomy position.

CAPNOGRAPHY[1]

Capnography - derived from the greek word kapnos ("smoke") and graphein ("to write") is the graphic display of the measurement of CO2 in the respired gases and has become an integral part of anaesthesia monitoring.

In 1978 , Netherlands became the first country to adopt capnography as a standard monitor during anaesthesia.

Capnography is the continuous graphic record of carbon dioxide concentrations in the respired gases during a respiratory cycle. The CO2 waveform is called as capnogram and the device that generates the CO2 waveform is called a capnography.

Capnography is an indirect non invasive technique to monitor paco2. Use of capnography monitoring can reliably and quantatively provide vital information in intubated patients.

Alteration in cardiac output ,distribution of pulmonary blood flow,and metabolic activity can also be reflected by change in CO2 concentration of expired gases.

Many intensive care units utilise capnography as an adjunct to assure patient safety and the adequacy of ventilation.

The (a-ET)PCO2 is a measure of alveolar dead space. Changes in alveolar dead space correlate well with changes in (a-ET)PCO2; so (a-ET)PCO2 is an indirect estimate of V/Q mismatch lung.

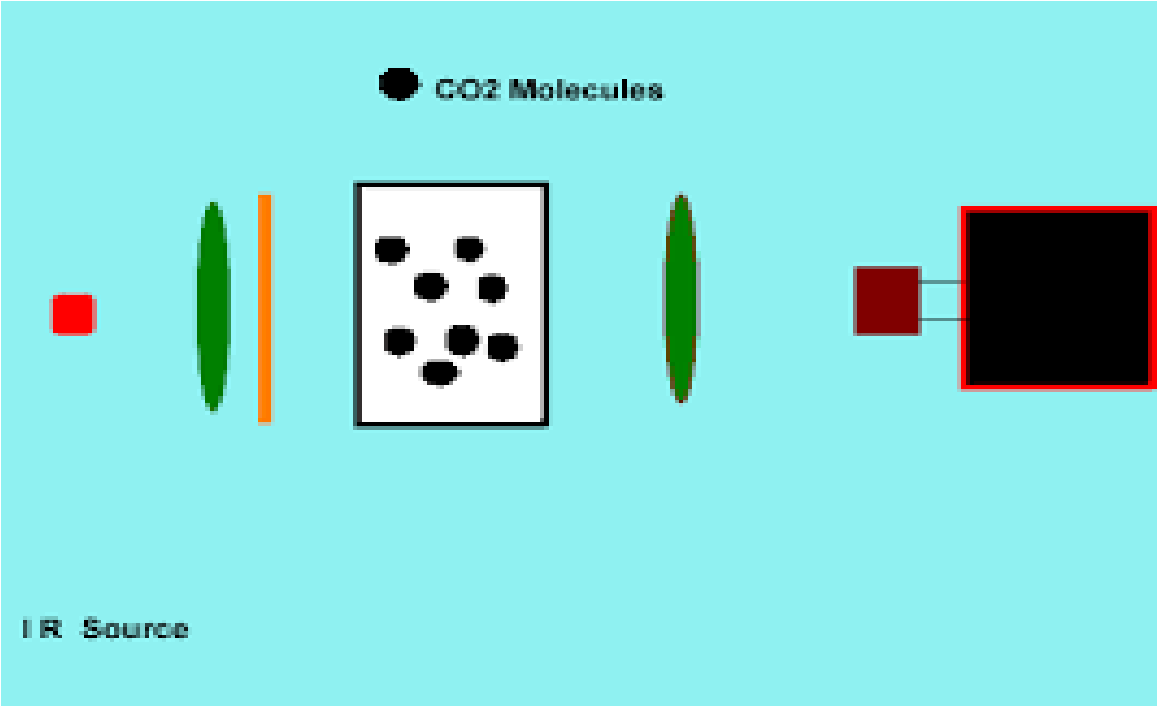
PHYSICS:[13,20]

There are 5 methods for detecting CO2 :

1. Infrared spectroscopy
2. Molecular correlation spectroscopy
3. Raman spectroscopy
4. Photoacoustic spectroscopy
5. Mass spectroscopy.

Infra red spectroscopy is the most widely used and cost effective method for detecting CO2 and is found in most portable ETCO2 devices . In IR spectroscopy , beams are emitted from a light source into a sample from which CO2 absorbs a specific wavelength of light (4.3milli microns) .This measurement is used to calculate the amount of CO2 in the sample.

INFRA RED SPECTROSCOPY

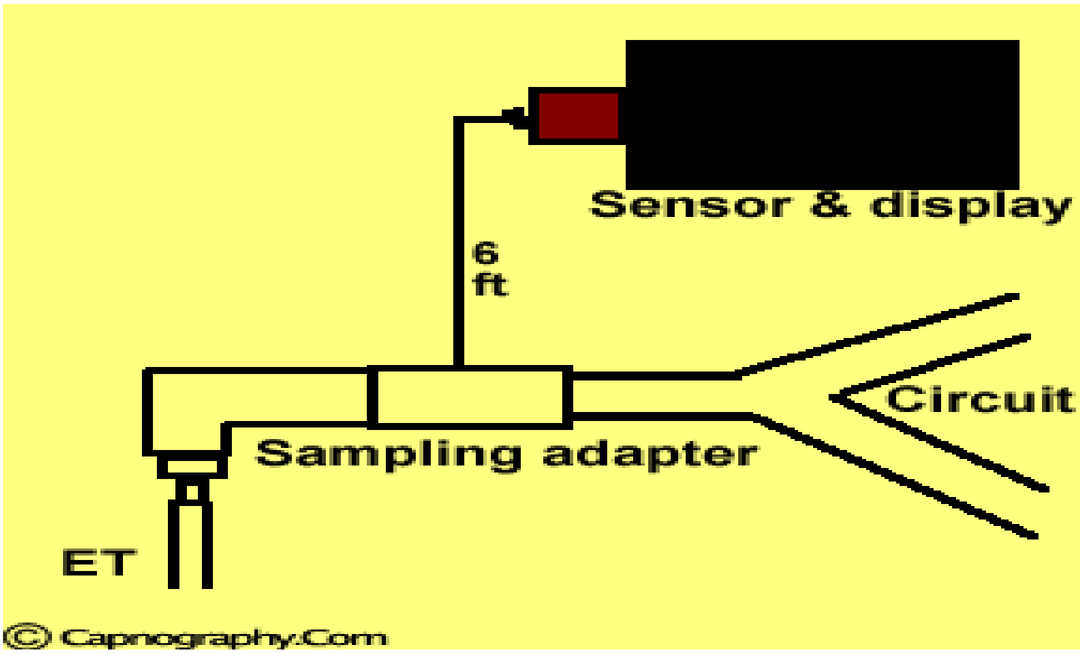


Methods for CO2 detection :

There are 2 ways to measure ETCO2

1. Side stream analyser.
2. Main stream analyser.

SIDE STREAM ANALYSIS CAPNOGRAPHS:



In this type , the CO_2 sensor is located in the Mainstream itself and a tiny pump aspirates samples from the patient's airway through a 6 feet long capillary tube into the main unit .

The sampling tube is connected to a T- piece inserted at the endotracheal tube or anesthesia mask connector.

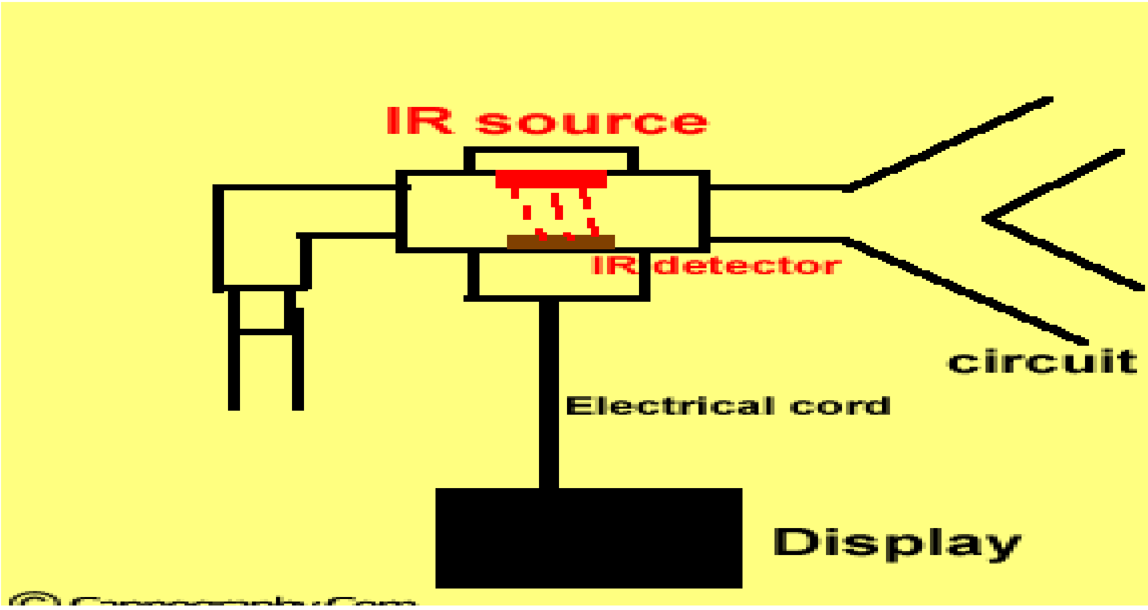
Advantages

1. It is inexpensive ,
2. can be used in collaboration with simultaneous oxygen administration via nasal prongs .
3. Easy to use when patient is in unusual positions such as in prone position
4. No problems with sterilisation .
5. Can be used in awake patients.

Disadvantages

1. Delays in recording due to movement of gases from the ET to the unit ,
2. sampling tube obstruction ,
3. pressure drop along the sampling tube affects CO_2 measurements .
4. water vapour pressure changes affect CO_2 concentrations.
5. Deformity of capnograms in children are due to dispersion of gases in sampling tubes.

MAINSTREAM CAPNOGRAPHS



In the main stream capnograph , a cuvette containing the CO_2 sensor is inserted between the breathing circuit and the endotracheal tube .

The IR rays traverse the respiratory gases to an IR detector within the cuvette obviating the need for gas sampling and scavenging.

Therefore the CO_2 analysis is performed within the airway.

To prevent condensation of water vapour which can cause falsely high CO_2 reading , all main stream sensors are heated above body temperature to about 39 degrees.

The mainstream analyser generates a capnogram almost instantly as the gas passes through a cuvette almost immediately after exiting the lungs.

Advantages

- No sampling tube ,
- No obstruction ,
- Suitable for neonates and children.
- No pressure drop.
- No changes in water vapour pressure.
- No pollution.
- No deformity of capnograms due to non dispersion of gases.
- No delay in recording.

D**isadvantages**

- Expensive

- Heavy sensor imposes a traction on the endotracheal tube ,
- Long electrical cord ,
- facial burns may occur because of the proximity of the heated cuvette to the patient,
- clogging of sensor windows with secretions,
- Difficult to use in unusual patient positioning such as in prone positions,
- Difficult to sterilise.

PHYSIOLOGY:

At the end inspiration ,assuming that there is no rebreathing ,the airway and the lungs are filled with CO_2 free gases.carbon dioxide diffuses into the alveoli and equilibrates with end alveolar capillary blood($PACO_2=PaCO_2=40$mmhg).

The actual concentration of CO_2 in the alveoli is determined by the extent of ventilation and perfusion into the alveoli i.e V/Q ratio;

The alveoli with higher ventilation in relation to perfusion (high V/Q ALVEOLI) have lower CO_2 compared to alveoli with low V/Q ratio.

As one moves proximally in the respiratory tract ,the concentration of CO_2 falls gradually to zero at some point.

The volume of CO_2 free gas is termed respiratory dead space and here there is no exchange of oxygen and CO_2 between the inspired gases and the blood.

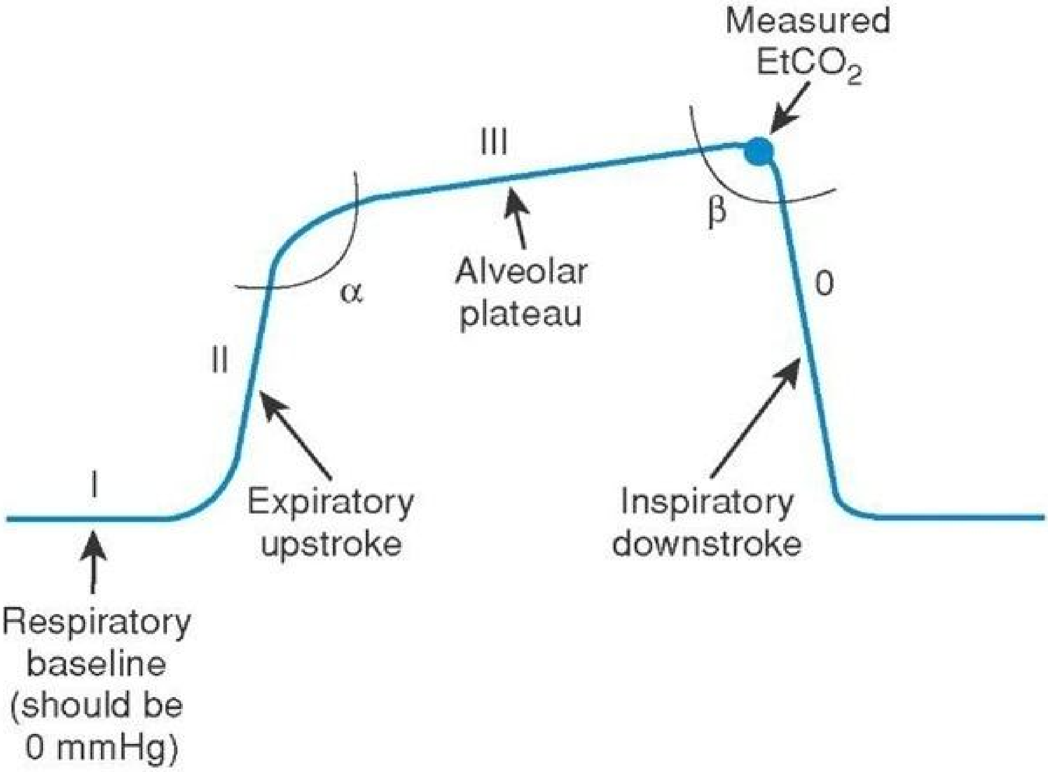
As the patient exhales ,a CO_2 sensor at mouth will detect no CO_2 as the initial gas sampled will be the CO_2 free gas from the dead space.

As exhalation continues ,CO_2 concentration rises gradually and reaches a peak as the CO_2 rich gases from the alveoli make their way to the CO_2 sensing point at the mouth .

At the end of exhalation , the CO_2 concentration decreases to zero (baseline)as the patient commences inhalation of CO_2 free gases.

The evolution of CO_2 from the alveoli to the mouth during exhalation, and inhalation of CO_2 free gases during inspiration gives the characteristic shape to the CO_2 curve which is identical in all humans with healthy lungs. Any deviation from this identical shape should be investigated to determine a physiological or a pathological cause producing the abnormality.

CAPNOGRAM:[1]



- A capnogram can be displayed as co2 verus time ,or versus volume (volume capnogram), the time capnogram however,is the method most commonly used in anaesthesia and other clinical practices.Since volume capnogram needs elaborate equipment for plotting the trace.

- A standard nomenclature has been assigned for delineating various phases of capnogram.
- A capnogram can be considered as two segments,an inspiratory segment and an expiratory segment,and two angles ,an alpha and beta angle.

EXPIRATORY SEGMENT:

The expiratory segment of a time capnogram is divided into 3 phases. Phases 1 ,2,3, and occasionally phase 4 ,which represents the terminal rise in CO_2concentration.

PHASE1

- Represents the CO_2 free gas from the airways (anatomical and apparatus dead space)

PHASE2:

- Consists of rapid S- shaped upswing on the tracing (due to mixing of the dead space gas with the alveolar gas

PHASE3:

Consists of alveolar plateau representing CO_2 rich gas from the alveoli . It is almost always has a positive slope , indicating a rising PCO_2. CO_2 concentration at the end of plateau is referred to end tidal carbondioxide ($PETCO_2$)

- $PETCO_2$ is the best reflection of alveolar CO_2($PaCO_2$).
- Normally ,the arterial CO_2 and $ETCO_2$ difference is about 2 - 5mmHg due to dead space.
- Expiratory dead space is not an isocapnic trace ; rather it progresses with a very slight and steady increase in the $PaCO_2$ as the alveolar fraction is expelled from the lungs.

PHASE0:

- As the patient begins to inspire , fresh gas is entrained and there is a steep downsrtoke back to the baseline.

ANGLES:

- The angle between phase 2 and phase 3 is called the alpha angle,which increases as the slope of phase 3 increase;
- Normally it is about 100-110 degrees,
- Airway obstruction increases the angle due to increase in the slope.
- The response time of the capnograph ,sweep speed,and the respiratory cycle time also affects the angle.

- The angle between phase 3 and phase 0 is called the beta angle .
- Normally it is about 90 degree .During rebreathing ,this angle increases .
- Occasionally , an upward blip or spike known as phase 4can occur towards the end of phase 3. This akin to that the phase 4 of single breath nitrogen curve.this terminal elevation represents emptying of alveoli with long time constants containing higher co2 concentration.

PETCO2 AS AN ESTIMATE OF PaCO2:

- Measurements of PETCO2 constitute a useful non-invasive tool to monitor PaCO2 and hence, ventilator status of patients during anaesthesia.
- In normal individuals , (a-ET)PCO2 may vary from 2-5 mmHg.it can vary from patients to patient and is dependent on several factors.
- It increases with age, pulmonary disorder(emphysema),pulmonary embolism ,decreased cardiac output and hypovolemia.
- It decreases with large tidal volume and low frequency ventilation.
- In pregnant subjects ,as well as in infant and small children,the (a-ET)PCO2 is lower than in non-pregnant adults ,and PETCO2 reflects PaCO2.

- Changes in $PETCO_2$ can often be regarded as indicative of changes in $PaCO_2$.
- The $PETCO_2$ is more useful if its relationship to $PaCO_2$ can be established initially by blood gas analysis.There after ,changes in $PaCO_2$ may be assumed to occur in parallel withthose in $PETCO_2$ thus avoiding repeated arterial puncture.
- However, the variations in(a-ET)PCO_2 during major surgery may be of the same magnitude as the inter individual variations and caution must be used in the precise prediction of $PaCO_2$ from $PETCO_2$ measurements.
- Several factors such as change in body position,temperature,and pulmonary blood flow as well as mechanical ventilation and cardiopulmonary bypass ,can result in changes in ventilation perfusion status of lungs.

FACTORS AFFECTING PETCO2 DURING ANAESTHESIA

INCREASE IN PETCO2

1.Due To Increase In Co2 Production

- Increase in metabolic rates
- Sepsis
- Malignant hyperthermia
- Shivering/seizure.
- Sepsis
- Hyperthyroidism

2.Due To Decrease In CO_2 Elimination

- Hypoventilation
- Rebreathing
- CO_2 absorber exhaustion

3.Due To Artefact

- Malfunction of CO_2 measuring system

DECREASE IN PETCO2:

1.Due To Decrease In Co 2 Production

- Hypothermia
- Hypothyroidism
- Decrease in metabolic rate

2.Due To Increasing CO_2 Elimination

- Hyperventilation.

3.Due To Decrease In Alveolar CO_2 Delivery

- Hypoperfusion
- Pulmonary embolism.

APPLICATION OF CAPNOGRAPHY[3]

ADJUSTING OF FRESH GAS FLOW RATES IN REBREATHING SYSTEMS

The fresh gas flow's required in various rebreathing systems during anaesthesia can be adjusted precisely by continuous monitoring of PETCO2 and doing so prevents hypercarbia due to inadequate flow rates.

ACCIDENTAL ESOPHAGEAL INTUBATION:

When compared with the standard technique of listening to breath sounds ,CO2 monitoring is probably the best way to detect oesophageal intubation.

DETECTION OF PULMONARY AIR EMBOLISM

A rapid decrease of PETCO2 in the absence of changes in blood pressure, central venous pressure,and heart rate indicates air embolism without systemic hemodynamic consequences.however ,as the size of air embolism increases, a reduction in cardiac output occurs which further decrease PETCO2 measurement.

A reduced cardiac output by itself can decrease PETCO2. Therefore ,in the event of a rapid decrease in PETCO2 associated with a reduction in cardiac output, a rise in the pulmonary arterial pressure confirms the occurrence of pulmonary embolism.

[32]Drummond et al defined the relative sensitivities of end tidal carbon dioxide analysis ,end tidal nitrogen analysis, and pulmonary artery pressure monitoring in the detection of venous air embolism in a study. Serial injections of air (0.25,0.5.0.75, 1.0 and 1.5 ml/kg) was performed in six mongrel dogs. The frequency with which positive responses (pulmonary artery pressure > 2mmhg; end tidal carbon dioxide decreases > 0.2% ; end tidal nitrogen analysis increase 0.04%) were observed following venous air embolism was not different in the three methods. However, the response time was significantly more rapid for pulmonary artery pressure and end tidal nitrogen analysis than for ETCO2 ; although the range for the three methods was narrow. The time to return to baseline levels was significantly more rapid for ETN2 and ETCO2 which in turn was significantly faster than pulmonary artery pressure.

PULMONARY THROMBO-EMBOLISM

Pulmonary thrombo embolism is also associated with a decrease in PETCO2 as seen in pulmonary air embolism. Breen et al , in an animal study ,found that PETCO2 decreases when right pulmonary artery (RPA) was occluded in anaesthestized , ventilated, thoracotomized dogs. One minute after RPA occlusion , CO2 volume exhaled decreased from 9.3

to 7 ml and end tidal carbon dioxide decreased from 28.7 to 21.8 mmHg . During ensuing 70 min,VCO2/ breath increased back to baseline but PETCO2 was still 13% less than the base line. Both PaCO2 (41.5 to 55.1) and PvCO2 (48.2 to 62.80) mmHg steadily increased and approached equibrium by 45 minutes of RPA occlusion . Cardiac output did not change significantly. The increase in PaCO2 was not detected by PETCO2 which remains decreased due to increased alveolar dead space consequent to RPA occlusion.

Breen et al further showed in another study that intra operative monitoring of PETCO2 can be used to monitor resolution of pulmonary embolus . Resolution of embolus results in progressive increases in PETCO2 measurements.

VENOUS CO2 EMBOLISM

End tidal CO2 monitoring is essential during laparoscopy , as it may help in the early detection of venous CO2 embolism (accidental insufflation of CO2 into veins).In addition CO2 is also absorbed from abdominal cavity. A transient but rapid raise in PETCO2 has been suggested as a useful early sign of venous CO2 embolism.however, when CO2 embolus increases in size thereby producing a mechanical obstruction , end tidal CO2 decreases.

HYPERMETABOLIC STATES

Dangerous hypermetabolic conditions such as malignant hyperthermia ,thyrotoxic crisis , severe sepsis can be detected by CO_2 monitoring. Increased metabolic rates cause greater CO_2 production, which cause $PETCO_2$ to increase . An increasing $PETCO_2$ may, therefore , be an early warning sign of an impending crisis.

CARDIOPULMONARY RESUSCITATION

End tidal carbon dioxide monitoring during closed chest compression is one of the most exciting recent developments in CPR . It holds the promise of making available information about the effectiveness of resuscitative efforts,

It indicates reversal of spontaneous circulation.

If the blood flow improves ,more alveoli are perfused and $PETCO_2$ will increase. Under these circumstances the co_2 presentation to the lungs is the major limiting determinant of $PETCO_2$ and it has been found that $PETCO_2$ correlates well with measured cardiac output during resuscitation .

Therefore $PETCO_2$ can be used to judge the effectiveness of resuscitative attempts and thus bring about changes in technique that could improve the outcome.

Further the $PETCO_2$ may have a prognostic significance . it has been observed that non survivors had lower $PETCO_2$ than the survivors and no patient with PETCO2 < 10 mmHg could be successfully resuscitated.

LARYNGEAL MASK AIRWAY AND CAPNOGRAPHY

PETCO2 measured via LMA or endotracheal tube correlate well with PaCO2 during mechanical ventilation in children. However , it doesnot accurately reflect the PaCO2 in spontaneously breathing children.

In adults , the mean difference between PaCO2 and PETCO2 measured via LMA is similar to that measured via endotracheal tube.

CARDIAC OUTPUT AND (a-ET)PCO2 :

Reduction in cardiac output and pulmonary blood flow result in a decrease in PETCO2 and an increase in (a-ET)PCO2. The percentage decrease in PETCO2 is directly correlates with the percentage decrease in cardiac output . Also, the percent decrease in CO2 elimination correlated with the percent decrease in cardiac output similarly. The changes in PETCO2 and CO2 elimination following hemodynamics perturbation were parallel. These findings suggest that decrease in PETCO2 quantitatively reflect the decrease in CO2 elimination.

Increases in cardiac output and pulmonary blood flow results in better perfusion of the alveoli and a rise in PETCO2.

Relationship between PETCO2 and pulmonary blood flow was studied during separation from cardiopulmonary bypass. This shows that

$PETCO_2$ is a useful index of pulmonary blood flow. A $PETCO_2$ greater >30mmHg was invariably associated with a cardiac output more than > 4 L/min or a cardiac index > 2L/min. furthermore when $PETCO_2$ exceeded 34mmHg ,pulmonary blood flow was more than 5l/min.

Thus, under conditions of constant lung ventilation ,$PETCO_2$ monitoring can be used as a measure of pulmonary blood flow.

Recently, using Fick's principle, cardiac out put is being determined non-invasively by NICOr cardiac output monitor. The technique implements periods of CO_2 rebreathing. During this interval CO_2 partial pressure of oxygenated mixed venous blood is estimated from the measured exponential rise of the $PETCO_2$ value. In addition ,oxygen uptake,carbon dioxide elimination, end tidal PCO_2,oxygen saturartion, and tidal volume can be determined .Physiological dead space can also be estimated. Its a non-invasive determination of cardiac output that is very encouraging in patients with healthy lungs, where as the results are controversial when the lungs are diseased. Determination of cardiac output using endtidal CO_2 is a valuable asset added to our monitoring armamentarium.

INTEGRITY OF ANAESTHETIC APPARATUS

Anaesthetic mishaps due to airway problems,leaks and disconnections in the anesthesia system often develop and may become apparent only when crisis occurs.

Circuit leaks, which decrease the minute volume , may not be indicated by airway pressure monitoring but may be detected by CO2 monitoring because the PETCO2 increases gradually .

Airway pressure monitors used to detect breathing system leaks occasionally fail to detect some disconnections. Under these circumstances a CO2 monitor would detect disconnection instantaneously in paralysed patients.

Carbon dioxide monitoring gives an early warning of CO2 retention by the patients due to faulty bains anesthetic system , an exhausted CO2 absorbent in a semi closed anaesthetic system , leaks in the anaesthetic system , disconnections within the machine or malfunction of valves in circle anesthetic systems.

Further, a total occlusion or accidental extubation of the endotracheal tube results in an abrupt decrease in PETCO2 ,whereas a partially kinked or obstructed tube can result in either increased or decreased PETCO2 , or show no change in PETCO2 depending on the severity of the obstruction.

Capnography is considered more valuable than capnometry in detecting partially kinked endotracheal tube , as distortions in CO_2 waveforms (prolonged phase 2, steeper phase 3 , irregular height of the CO_2 waveforms) occur earlier than changes in $PETCO_2$. However ,it should be noted that endotracheal tube obstruction must be severe (atleast 50% occlusion) to produce changes in $PETCO_2$ or in the CO_2 waveforms.

ADEQUACY OF SPONTANEOUS RESPIRATION

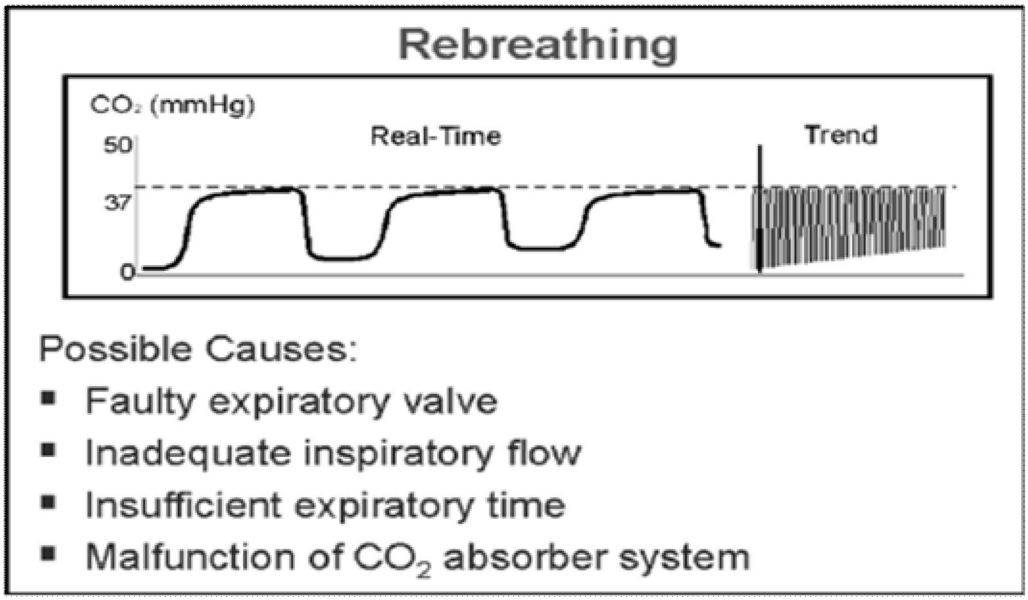
Capnography can be used to monitor the adequacy of spontaneous ventilation, not only during general anaesthesia and recovery but also in the awake non intubated patient either in intensive care unit or during regional anaesthesia.

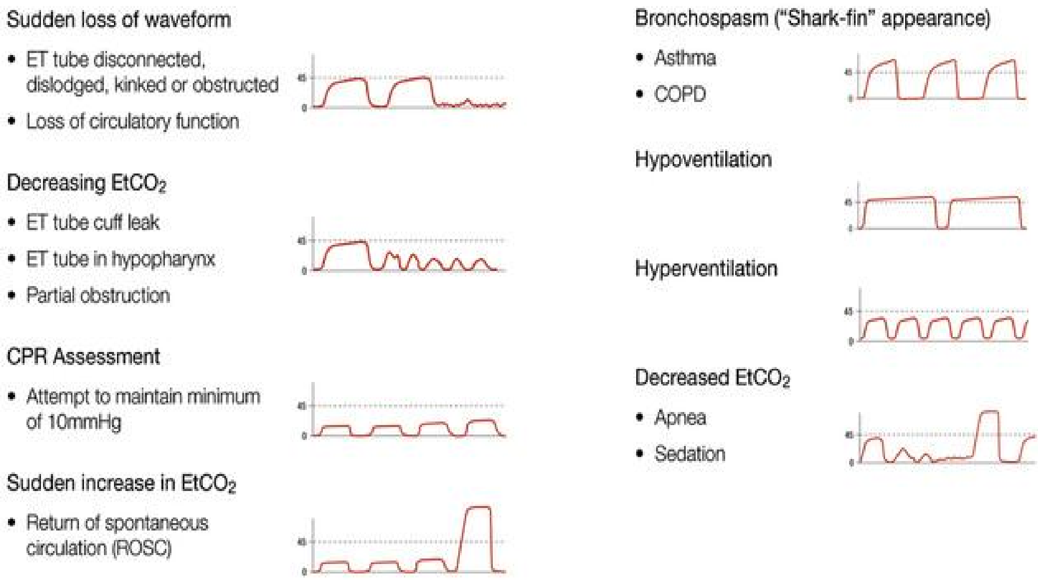
In addition, CO_2 monitoring can serve as apnoea monitor. The samples can be drawn from the nasal cavity using nasal cannula or adaptors. Gases can also be sampled from the nasal cavity during the administration of oxygen using simple modification of the `standard cannula . End tidal carbon dioxide thus measured , is a good predictor of $PaCO_2$ even when oxygen is being administrated simultaneously .

This may be of particular benefit in monitoring the ventilatory status of patients with chronic respiratory failure where excessive oxygen therapy can produce CO_2 narcosis .

However , the major limiting factor is the admixture of end tidal gas with air or insufflated oxygen resulting in a falsely low $PETCO_2$ particularly in mouth breathing patients, or in those who may require more than 4 L/min of nasal oxygen , or in hypoventilating patients.

ABNORMAL CAPNOGRAMS





REVIEW OF LITERATURE

1.R.L.MARSHALL et al

Circulatory effects of carbon dioxide insufflation of the peritoneal cavity for laparoscopy ,br j anaesth 1972 ; 44; 680-84. Measurements of cardiac output , mean arterial pressure , central venous pressure and heart rate were made in seven patients undergoing laparoscopy . Measurements were made before and after insufflation of the peritoneum with carbon dioxide , and no significant change in cardiac output followed peritoneal insufflation , but there was a significant increase in mean arterial pressure , central venous pressure and heart rate. Blood gas analysis in five patients showed a rise in $PaCO_2$ and fall in pH after insufflation with carbon dioxide.

2. WITTGEN CM et al

Analysis of hemodynamic and ventilatory effects of laparoscopic cholecystectomy arch surg 1991 ; 126 : 997 -1001. Studied 20 patients with normal preop cardio pulmonary status and 10 patients who had previously diagnosed cardiac pulmonary disease. Demographic ,hemodynamic, arterial blood gas analysis and ventilatory data were collected before insufflation and at intervals during surgery . During

CO_2 insufflation significant decreases in arterial pH values significant increases in $PaCO_2$ occurred in group 2 patients compared to group 1.

3..P.L.TAN, et al

Carbon dioxide absorption and gas exchange during pelvic surgery . can j , sept 1992 volume 39 , 677-681. 20 ASA 1and 2 patients were studied to quantify the effects of CO_2 insufflation and the Trendelenburg position on CO_2 elimination and pulmonary gas exchange and to determine minute ventilation required to maintain normocapnia during CO_2 insufflation.This study demonstrated that by increasing the tidal volume , it is sufficient to eliminate excess CO_2 load and maintain normal pulmonary oxygen exchange during pelvic laparoscopy.

4.Jean L .JORIS MD , et al

Hemodynamic changes during laparoscopic cholecystectomy Anesth analg 1993;76:1067-71.This study was carried out on 15 nonobese ASA 1 patients .hemodynamics were measured before anaesthesia , after induction of anaesthesia 5 min, 15 min,and 30 min after peritoneal insufflation, and 30 min after desufflation. During surgery, intra abdominal pressure was maintained at 14 mmHg . and It was concluded that laparoscopy induce significant hemodynamic changes even in healthy patients and cause increases of SVR and PVR , an increase of MAP , and a reduction of cardiac output. While , these cardiovascular changes are not hazardous in healthy patient .

5.R.W.M. WABHA et al

Ventilatory requirement during laparoscopic cholecystectomy can.j. anaesth 1993 / 40:3/206-10. Inthis study they measured $PaCO_2$,$PETCO_2$, expired minute volume standardised for body surface area , airway and intra abdominal pressure during general anaesthesia ,just before and 30 minute after creation of a CO_2 pneumoperitoneum in 28 ASA 1 and 2 patients. This study summarised the correlation between $PaCO_2$ and $PETCO_2$ indicated that $PETCO_2$, if < 41 mmHg , can be used as index of $PaCO_2$ with the provision that the clinician be aware of an increased (a-ET)PCO_2 , which reflects reduced cardiac output . ,The increasing minute ventilation by 12-16 % during laparoscopic cholecystectomy in a healthy patient maintained $PaCO_2$ at acceptable levels and that $PETCO_2$ monitoring should be used as an estimate of $PaCO_2$ with caution.

6. BARAKA A et al

Surg laparosc endosc 1994 ; can pulse oximetry and end tidal capnography reflect arterial oxygenation and carbon dioxide elimination during laparoscopic cholecystectomy ? An investigation was carried out in 13 ASA 1 and 2 patients undergoing laparoscopic cholecystectomy ;

ETCO2 was continuously monitored by capnography and the arterial haemoglobin oxygen saturation by pulse oximetry . Also , repeated measurements of arterial blood gases were done. The report showed that both ETCO2 and arterial PCO2 progessively increased following CO2 insufflation, to reach a maximal value after 30 minutes; with no significant change in arterial –alveolar pco2 gradient .The results suggest that end tidal capnography and pulse oximetry can be used as non invasive technique for monitoring arterial oxygenation and carbon dioxide elimination during laparoscopic cholecystectomy.

7.SHIBUTANI .K, et al

Anesth analg .1994, Do changes in end tidal pco2 quantitatively reflect changes in cardiac output? . In 24 patients undergoing abdominal aortic aneurysm surgery with constant ventilation , prospectively performed 33 measurements of cardiac output , PETCO2 and CO2 elimination within 10 minutes of haemodynamic changes.the percentage decrease in PETCO2 directly correlates with percentage decrease in cardiac out put. Also, the percent decrease in VeCO2 correlated with the percent decrease in cardiac output. The changes in PETCO2 and VeCO2 following hemodynamic perturbation were parallel. Thus decrease in PETCO2 quantitatively reflects the decrease in CO2 elimination.

8.HIRVONEN et al

Ventilatory effects, blood gas changes and oxygen consumption during laparoscopic hysterectomy .anaesthesia and analgesia may 1995 vol 80 issue 5:961-966,evaluated the ventilatory effects and blood gas changes of prolonged CO_2 pneumoperitoneum in normoventilated patients and examined the respiratory and gas exchange consequences of head down position and CO_2 insufflation into peritoneal cavity in 20 ASA 1 patients and summarised that small increase in the $P(a\text{-}ET)CO_2$ gradient , indicating some increase in alveolar dead space during laparoscopy . normocapnia during laparoscopy in healthy patients was achieved by maintaining the $PETCO_2$ at somewhat lower level than normal, preferably by increasing the tidal volume.

9.P.PEOLSI et al

Effects of carbondioxide insufflation for laparoscopic cholecystectomy on the respiratory system .anaesthesia , 1996 , volume 51, 744-749; they measured lung and chest wall compliance and resistance , functional residual capacity , end tidal carbondioxide and oxygen saturation in 10 patients (group 1).. in addition to this arterial blood gas analysis and endtidal carbon dioxide tension were measured in second group (10 patient). Measurements in both group were obtained in the reverse Trendelenburg position at 15 minutes after induction of anaesthesia , 5 min,and 45 min after insufflation and at 15 min after deflation,, thus concluded that carbondioxide insufflation cause reduction in compliance of respiratory systm , and of functional residual capacity . marked increase in the resistance of the respiratory system ; no change in oxygenation , but an increase in the endtidal carbon dioxide tension (which is correlated closely with arterial carbon dioxide tension), these changes are not affected by duration of anaesthesia.

10.V.GANDARA et al

Acid base balance alterations in laparoscopic cholecystectomy , surg endosc july 1997 , vol 11, issue 7, 707-710 .Methodology 132 patients were divided into 3 groups according to anaesthetic technique used. Arterial blood gas were performed before pneumoperitoneum , at 20 min, and every 30 min and in post operative period . demonstrated pneumoperitoneum with CO_2 , originate alterations of the acid base balance , mostly of metabolic type. This could mean that besides CO_2 absorption , there is a tissue hypoperfusion due to the increase of abdominal pressure.

11.BHAVANI SHANKAR et al

Arterial to end tidal carbondioxide pressure difference during laparoscopic surgery in pregnancy . anaesthesiology 93:370,2000.

Methodology ; eight pregnant women underwent laparoscopic appendectomy under general anaesthesia at 17 weeks to 30 weeks of gestation ; carbondioxide pneumoperitoneum was created after obtaining arterial blood for gas analysis and serial blood gas analysis was done. Results suggest that there was no significant difference in PaCO2 – ETCO2 ; capnography is adequate to guide ventilation during laparoscopic surgery in pregnant patient ; repiratory acidosis did not occur when PETCO2 was maintained at 32 mmHg during CO2 pneumoperitoneum.

12.DAE-KEE CHOI et al

Arterial to end tidal carbon dioxide pressure gradient increases with age in the steep trendelenburg position with pneumoperitoneum. Korean j anesthesiol.2012 sep;63(3):209-215. Evaluated relationship between age and P(a-ET)CO2 during pneumoperitoneum in the steep Trendelenburg position in 92 patients between two age group , (45 -65) and > 65 years. and Concluded that the magnitude of P(a-ET)CO2 increased gradually with time during pneumoperitoneum and also with advancing age .

13.E.OZYUVACI et al

Comparison of transcutaneous , arterial and endtidal measurements of carbondioxide during laparoscopic cholecystectomy in patients with chronic obstructive pulmonary disease.journal of international medical research ;2012; 40, 1982-1987. This study was conducted in ASA 2 and 3 patients TcPco2 , PETCO2 , PaCO2 were measured preoperatively , after induction , during insufflation , and post operatively .concluded that , TcPCO2 was a valid and practical measurement as compared with ETCO2 . In patients with COPD undergoing laparoscopic surgery , TcPCO2 and ETCO2 could be used instead of arterial blood gas sampling.

14.MAKWANA et al.

A comparison of ETCO2 and PaCO2 in laparoscopic sugery during general anaesthesia; gcsmc j med sci vol 3 , no:1 , January 2014. Methodology 50 patients of ASA 1 and 2 , of age between 20 to 65 years posted for elective laparoscopic surgery were selected; arterial blood sampling were collected preoperatively and at regular intervals intraoperatively ;This study concluded ,that the ETCO2 and PaCO2 were significantly higher than the preinsufflation value but within physiological range . The pH reduces significantly . In normal healthy patients ETCO2 correlated well with PaCO2 , So it is best parameter to guide ventilation to maintain ETCO2.

MATERIALS AND METHODS

- Sixty patients of ASA status 1 and 2 undergoing elective laparoscopic appendicectomy or laparoscopic cholecystectomy lasting a minimum of 45 minutes.
- Patients belonging to the age group of 20- 60 years of both sexes were selected.
- It is a prospective randomised study. The study was approved by institutional ethical committee and a written consent was obtained from patients.

INCLUSION CRITERIA

- ASA physical status 1and 2
- Patients undergoing laparoscopic cholecystectomy or laparoscopic appendectomy.
- SURGERY:elective.
- Weight : BMI < 25 kg/m2
- Patient who has given valid informed consent.

EXCLUSION CRITERIA

- Patient not satisfying inclusion criteria .
- History of haemorrhagic diathesis and clotting disorder.
- Patients suffering from respiratory disease like chronic bronchitis, emphysema, bronchial asthma , respiratory failure.
- Congestive heart failure
- Renal failure
- Known allergy or sensitivity to the drugs
- Patient posted for emergency procedure.

MATERIALS

- MULTIPARAMETER monitor with electro cardiogram , pulse oximetry , end tidal carbon dioxide monitoring and non invasive blood pressure.
- 2 ml heparinised plastic syringe , flask and ice for transportation of ABG sample.
- GE anesthesia work station.

METHODS:

- Sixty patients scheduled for laparoscopic appendectomy or laparoscopic cholecystectomy.
- Measurements at steady state (before pneumoperitoneum)
- Measurements after 15 minutes of pneumoperitoneum .

PARAMETERS MEASURED

- Heart rate(beats/min)
- Systolic blood pressure(mmHg)
- Diastolic blood pressure(mmHg)
- Mean arterial blood pressure (mmHg)
- End tidal CO_2 (mmHg)
- $PaCO_2$(mmHg)
- pH
- Bicarbonate (mmHg)
- $P_{(a-ET)}CO_2$ mmHgpressure gradient
- Peak airway pressure cmH_2O

PREPARATION OF PATIENT

- Patients were advised overnight fasting – 8 hours.
- All patients were given T. alprazolam 0.5 mg on the previous night of surgery . and T.Ranitidine 150 mg , T. Perinorm 10 mg on the morning of surgery .
- All the patients were premedicated with inj Glycopyrrolate 10 Mcgs /kg i.m. 45 minutes before surgery.
- After shifting to the theatre right cephalic vein was cannulated with 18 G iv cannula and ringer lactate was started.
- After attaching the monitors for electro cardiogram , oxygen saturation probe , and non invasive blood pressure basal parameters were recorded .

DRUGS TO BE KEPT READY FOR ANAESTHESIA:

- inj .glycopyrrolate 0.2 mg ampoules ,
- inj. Fentanyl 50 Mcgs /ml ampoules ,
- inj.propofol vials 1% ,
- inj.succinyl choline hydrochloride vial ,
- inj .atracurium vials,
- inj. Neostigmine ampoules ,
- sevoflurane
- appropriate size endotracheal tube.

- Patients were given inj fentanyl 2 Mcgs /kg for analgesia and induced with inj propofol 2 mg /kg and paralysed with inj.succinyl choline 1.5 mg /kg.
- After adequate relaxation the patients were intubated with appropriate size endotracheal tube and connected to GE ventilator with the tidal volume 10 ml/kg and respiratory rate adjusted between 12 to 14 /min and maintained with oxygen and nitrous oxide at 1.5 L/min and 3 L/min, and sevoflurane 1% -2%.
- Patient's left radial artery was cannulated with 20 G IV cannula and connected to a three way adaptor and flushed with heparin saline to maintain the patency. An arterial sample was collected and sent for analysis.
- Arterial blood gas analysis was sent 15 minute after insufflation .
- Throughout surgery intra abdominal pressure was maintained at 10 – 12 mmHg.
- Heart rate , systolic blood pressure , diastolic blood pressure ,mean arterial pressure , peak airway pressure , ETCO2 were measured for obtaining baseline values. And 15 minutes after insufflation. After the surgery is over and adequate respiratory attempts were present. the patient was reversed with inj.neostigmine 50 mcgs/kg and inj.glycopyrrolate 10 mcgs/kg dose. After the return of adequate muscle power and return of reflexes the patient was extubated after adequate oral suctioning.

OBSERVATION AND RESULTS

MAIN OBJECTIVES

To determine and compare the relationship of arterial carbondioxide and end tidal carbondioxide pressure gradient before and after CO_2 pneumoperitoneum.

OTHER OBJECTIVES

- TO determine the correlation between $PaCO_2$ and $ETCO_2$ during laparoscopic surgery
- To determine the hemodynamic changes (pulse rate , systolic , diastolic blood pressure , mean arterial blood pressure) during laparoscopy.
- To determine the peak airway pressure changes and acid base changes (pH , hco3) during laparoscopy .

Normal values:

$EtCO_2$ 35-45mmHg

$PaCO_2$ 35-45mmHg

pH 7.35-7.45

HCO_3:22-24 mmhg

$PaCO_2$-$etCO_2$ gradient 2-5 mmHg

- The study was conducted in Madras Medical College Hospital General surgery operation theatres.

DEMOGRAPHIC PROFILE

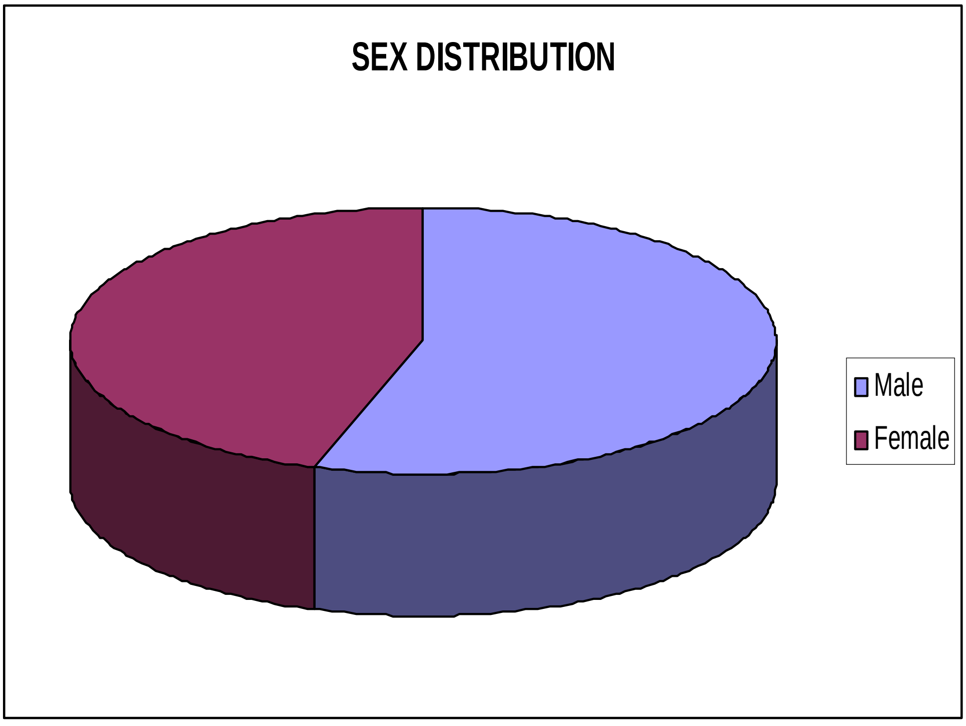
- The sample of 60 patients was taken for the study .data was expressed as mean ± SD . statistical analysis was with student's t test .A p value < 0.05 was considered significant.

DESCRIPTIVE STATISTICS (mean and standard deviation)					
	N	**Minimum**	**Maximum**	**Mean**	**Std.Deviation**
AGE	60	20	46	30.25	6.398
Valid N (listwise)	60				

The age distribution is between 20 and 46 years . the mean is 30.25 and the standard devition is 6.398 . p value is 0.06 , which is insignificant.

SEX					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	**Male**	33	55.0	55.0	55.0
	Female	27	45.0	45.0	100.0
	Total	60	100.0	100.0	

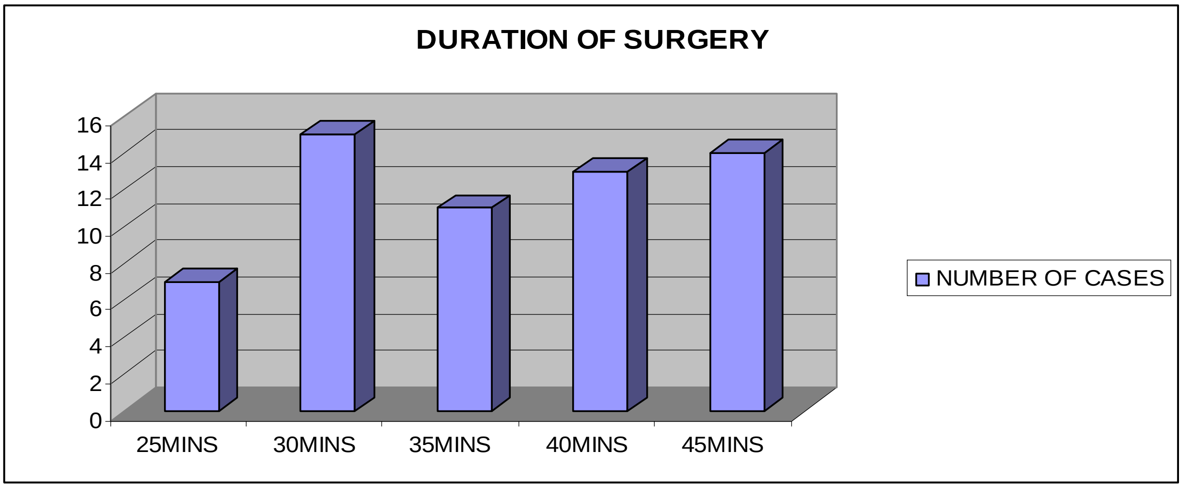
Sex distribution shows out 60 patients 55% (33) patients were males and the remaining 45% (27) were females.



Statistics		
DURATION OF_SURGERY		
N	Valid	60
	Missing	0
Mean		36
Median		35
Mode		30
Std. Deviation		6.815
Range		20
Minimum		25
Maximum		45

The mean duration of surgery for 60 patients is 36 minutes and the standard deviation is 6.815.the minimum duration is 25 minutes and maximum is 45 minutes.

DURATION_OF_SURGERY					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	25	7	11.7	11.7	11.7
	30	15	25	25	36.7
	35	11	18.3	18.3	55
	40	13	21.7	21.7	76.7
	45	14	23.3	23.3	100
	Total	60	100	100	



SYSTOLIC BP BEFORE INSUFFLATION

N	Valid	60
	Missing	0
Mean		124.17
Std. Deviation		7.567

SYSTOLIC BP 15 MINS AFTER CO_2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		117.6
Std. Deviation		8.447

ANALYSIS (STUDENT t TEST)

Systolic BP before & after CO2 Insufflation:

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
Sys_BP	1	60	117.63		
	2	60	124.17	7.567	.977

Independent Samples Test

		Levene's Test for Equality of Variances	t-test for Equality of Means						
		Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Sys_BP	Equal variances assumed	1.000		118	0.130.	-6.533		.	.
	Equal variances not assumed		.	.	.	-6.533	.	.	.

P value > 0.05 ..which is statistically insignificant.

DIASTOLIC BP BEFORE CO2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		70.80
Std. Deviation		5.339

DIASTOLIC BP 15MINS AFTER CO2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		77.13
Std. Deviation		5.583

DIASTOLIC BP BEFORE & AFTER CO2 INSUFFLATION

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Dias_BP	1	60	70.80	5.339	.689
	2	60	77.13	5.583	.721

Independent Samples Test										
		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
dias_bp	Equal variances assumed	.055	.860	-6.351	118	.000	-6.333	.997	-8.308	-4.359
	Equal variances not assumed			-6.351	117.765	.000	-6.333	.997	-8.308	-4.358

p value is 0.000, less than 0.05 . **SIGNIFICANT**

MEAN BLOOD PRESSURE BEFORE CO2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		86
Std. deviation		5.00

MEAN BLOOD PRESSURE BEFORE CO2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		92.790
Std. Deviation		4.9463

Mean BP
Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
meanBP	Equal variances assumed	.014	.906	-7.074	118	.000	-6.4166667	.9070769	-8.2129259	-4.6204074
	Equal variances not assumed			-7.074	117.991	.000	-6.4166667	.9070769	-8.2129273	-4.6204060

p value is 0.00 which is < .05, statistically **significant.**

DESCRIPTIVE STATISTICS

	N	Mean	Std.Deviation
PULSE_RATE_BEFORE_INSUFFLATION	60	77.83	11.218
PR_AFTER_INSUFFLATION	60	81.78	11.213
Valid N (listwise)	60		

INDEPENDENT SAMPLE TEST FOR HEART RATE

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
HR	Equal variances assumed	4.385	.038	1.9290	118	.000	-3.9500	2.048	-8.0049	0.10493
	Equal variances not assumed			1.9290	118	.000	-3.9500	2.048	-8.0049	0.10493

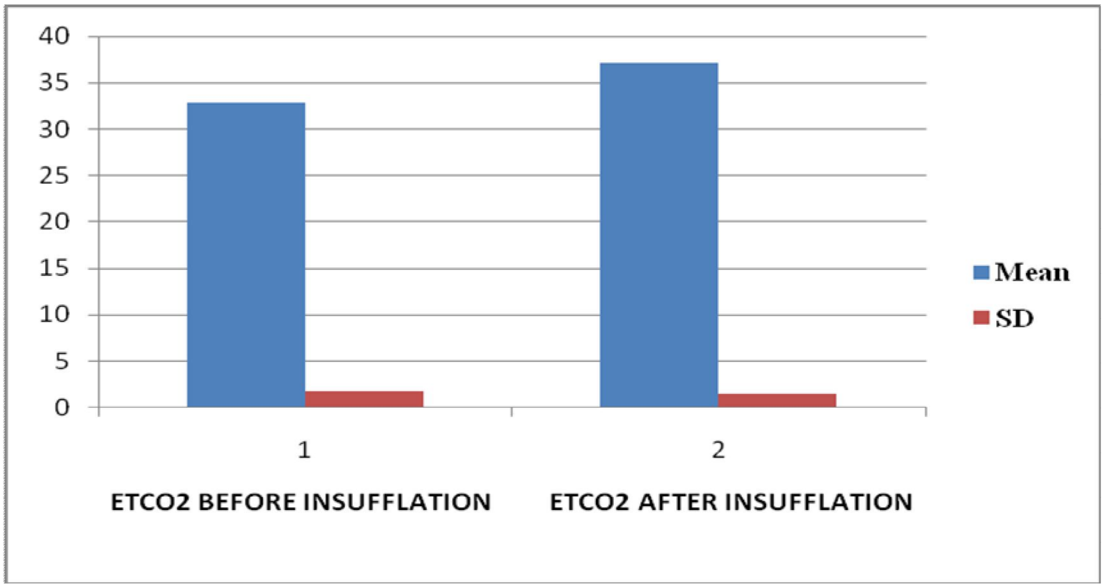
p value is 0.00 , statistically **significant**

$ETCO_2$ BEFORE CO_2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		32.77
Std. Deviation		1.835

$ETCO_2$ AFTER CO_2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		37.08
Std. Deviation		1.499



ETCO2 BEFORE & AFTER C02 INSUFFLATION

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Etco2	1	60	32.77	1.835	.237
	2	60	37.08	1.499	.194

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
etco	Equal variances assumed	4.342	.039	-14.110	118	.000	-4.317	.306	-4.922	-3.711
	Equal variances not assumed			-14.110	113.476	.000	-4.317	.306	-4.923	-3.711

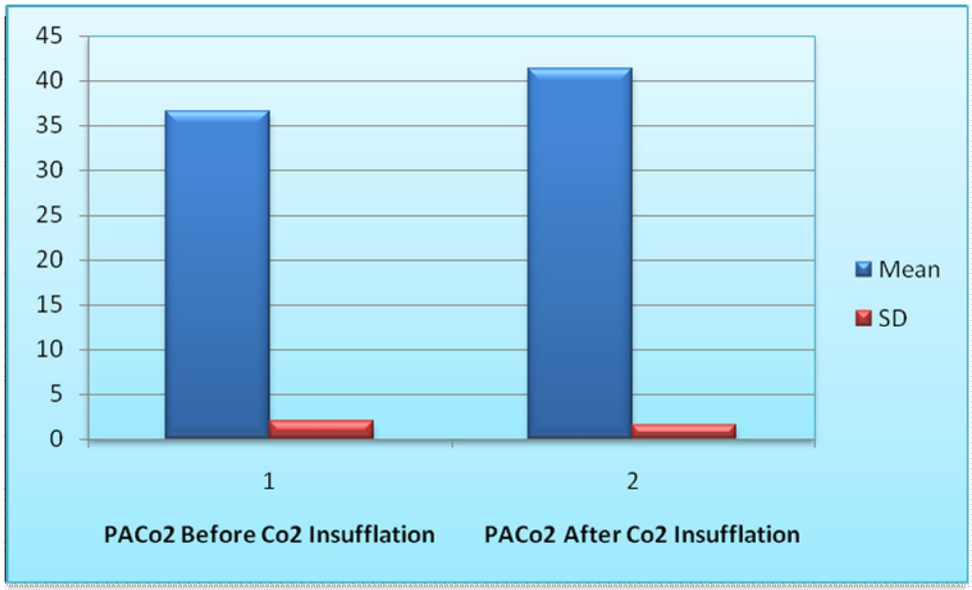
p value is 0.001, which is less than .05, thus it is **significant.**

PaC02 BEFORE CO2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		36.52
Std. Deviation		2.077

PaCO2 AFTER CO2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		41.36
Std. Deviation		1.562



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
PaCO2	Equal variances assumed	4.385	.038	-14.424	118	.000	-4.838	.335	-5.503	-4.174
	Equal variances not assumed			-14.424	109.557	.000	-4.838	.335	-5.503	-4.174

p value is less than 0.05, which is statisticallysignificant

PACO2 – ETCO2 PRESSURE GRADIENT

N	Valid	60
	Missing	0
Mean		3.75
Std. Deviation		1.146

PaCO2 – ETCO2GRADIENT AFTER CO2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		4.27
Std. Deviation		.935

PACO2- ETCO2

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
PaCO2-EtCO2 diff	Equal variances assumed	.118	.732	-2.732	118	.007	-.5216667	.1909771	-.8998534	-.1434799
	Equal variances not assumed			-2.732	113.432	.007	-.5216667	.1909771	-.9000112	-.1433221

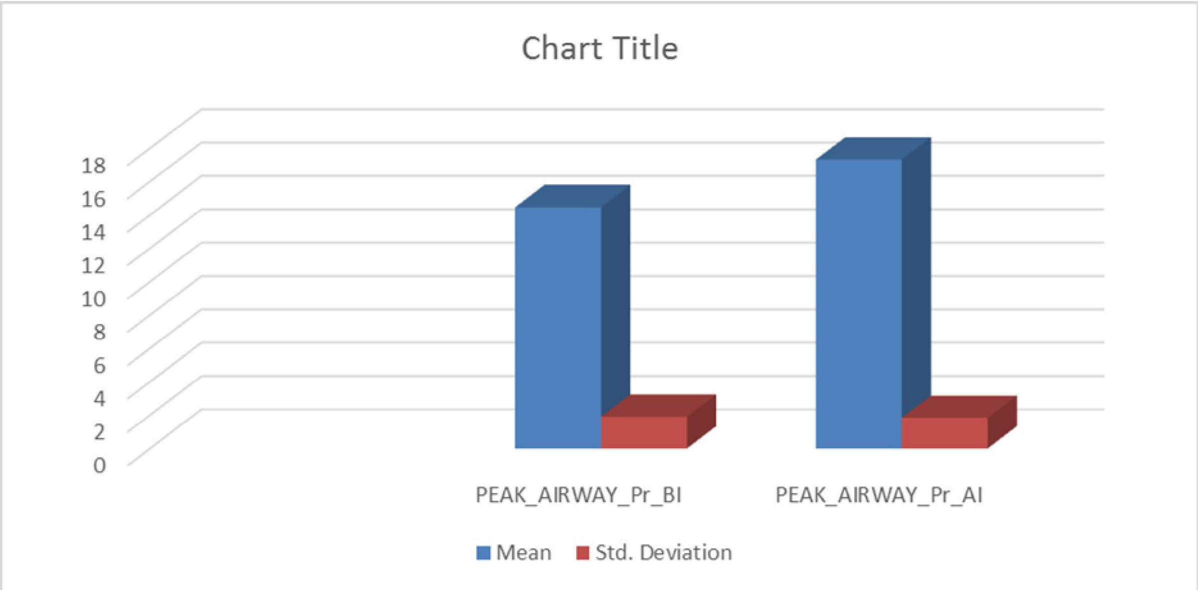
p value is 0.007, less than 0.05, statistically **significant**

PEAKAIRWAY PRESSURE BEFORE C02 INSUFFLATION

N	Valid	60
	Missing	0
Mean		14.47
Std. Deviation		1.90

PEAKAIRWAY PRESSURE AFTER CO2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		17.32
Std. Deviation		1.836



PEAKAIRWAY PRESSURE BEFORE AND AFTER INSUFFLATION.

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
peakairway_PR	1	60	14.47	1.900	.245
	2	60	17.32	1.836	.237

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
peakairway_PR	Equal variances assumed	.170	.681	-8.355	118	.000	-2.850	.341	-3.526	-2.174
	Equal variances not assumed			-8.355	117.865	.000	-2.850	.341	-3.526	-2.174

p value is 0.00 , statistically **significant.**

pH BEFORE CO_2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		7.40
Std. Deviation		.022

pH AFTER CO_2 INSUFFLATION

N	Valid	60
	Missing	0
Mean		7.360
Std. Deviation		.012

pH before & after CO_2 insufflation

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
pH	Equal variances assumed	31.027	.000	11.374	118	.000	.037	.003	.030	.043
	Equal variances not assumed			11.374	90.663	.000	.037	.003	.030	.043

p value s 0..000 , less than .05 , statistically **significant.**

BICARBONATE BEFORE AND AFTER CO2 INSUFFLATION:

	N	Minimum	Maximum	Mean	Std. Deviation
HCO3_BI	60	24	26	25.05	516
HCO3_AI	60	24	26	24.52	.372
Valid N (listwise)	60				

Independent Samples Test

		Levene's Test for Equality of Variances	t-test for Equality of Means						
		Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
HCO	Equal variances assumed	1.000		118	0.30.	.527		.	.
	Equal variances not assumed		.	.	.	.527	.	.	.

p value is 0.30 , > 0.05 statistically insignificant.

DISCUSSION

During laparoscopic surgery, carbon dioxide pneumoperitoneum is created resulting in hypercarbia which has complex effects on various system of our body.

HEMODYNAMIC EFFECTS

Our study demonstrates that the intra abdominal pressure of 12 mmHg maintained for laparoscopic surgery induces hemodynamic changes characterised by increase in heart rate, mean arterial blood pressure , peripheral vascular resistance.

These extreme changes are seen in cardiopulmonary insufficiency patient.

Similarly ,[14] JORIS et al demonstrated during laparoscopic surgery, both mechanical and humoral factors contribute to increase in systemic vascular resistance. He also explained that decrease in the cardiac output is caused by a reduction in venous return or increased systemic vascular resistance.

Cardiac output was decreased to a maximum of 28% at an insufflation pressure of 15 mmHg. The cardiac output further reduced when the intra abdominal pressure exceeds 20 mmHg.

It seems that the normal heart , which tolerates an increase of after load very easily, becomes sensitive to changes in afterload like a compensated heart, when this normal heart is subjected to pneumoperitoneum .

These results indicate the need for caution in patients with impaired cardiac function , anemia or hypovolemia scheduled for laparoscopic surgery.

These data suggest that it is prudent to reduce the rate of insufflation and limit abdominal inflating pressures to minimum

Also [23]V.MURALIDHAR studied physiology of pneumoperitoneum and anaesthesia in laparoscopic surgery. He postulated increased systemic vascular resistance, increased mean arterial pressure, minimal increase in heart rate during pneumoperitoneum.

HEART RATE

Statistical significance: The mean heart rate pre insufflation was 77.83 , and 15 minutes after insufflation was 81.78 .and

p value is less than 0.05 , thus statistically significant.

Clinical significance; Caused by CO_2 pneumoperitonum, which was in accordance to [14]JORIS et al and [23]MURALIDHAR et al.

SYSTOLIC BLOOD PRESSURE

The mean systolic blood pressure before insufflation is 117.63 mmHg and during insufflation is 124.17 mmHg . and the p value is 0.130, statistically insignificant. Similarly ,

[7] GUPTA SHOBHANA et al studied the changes in vital parameters during laparoscopic surgery. The systolic blood pressure varied from 126.56±6.45 mm Hg preoperatively to 129.55±8.65 mm Hg post operatively , where the p value is 0.1345, that is insignificant. This result was in accordance with our study .

DIASTOLIC BLOOD PRESSURE

The mean diastolic blood pressure is 70.80 mmHg before CO2 pneumperitoneum and 77.13 mmHg during the insufflation. And p value of 0.00, statistically significant .

[7] GUPTA SHOBHANA et al also studied diastolic blood pressure changes, which was 77.48 ± 3.44mmHg preoperatively and 80.08±3.466 mmHg postoperatively, the p value was 0.004 statistically significant, this result was similar to our study have the p value was 0.00 , highly significant. But it was clinically normal range.

MEAN ARTERIAL BLOOD PRESSURE

There is statistically significant (p value 0.00) increase in mean arterial blood pressure during pneumoperitoneum. The mean preinsufflation mean arterial blood pressure was 86 mmHg and 15 minutes after insufflation was 92.790 mmHg., which is in accordance with [14]JORIS et al, [18]MAKWANA et al.

Alterations in cardiac rhythm may also be seen during laparoscopy and are related to increased intra abdominal pressure , hypercarbia and surgical stimulation. As we maintained the intra abdominal pressure between 10-12 mmHg, none of the patients developed intra operative arrhythmias.

[30]D.B. SCOTT and D.G. JULIAN stated that the incidence of cardiac arrhythmias was more in patients who received carbondioxide to inflate the abdomen compared to nitrous oxide.

[35]WITTGEN et al studied that patients with preoperative cardiopulmonary disease showed significant increase in arterial blood pressure and decrease in pH during CO_2 pneumoperitoneum compared with patients without underlying disease. So we included patients with stable cardiac status and excluded patients with compromised cardiopulmonary function.

RESPIRATORY SYSTEM

[32]TAN and[10] HIROVEN et al , proposed an increase in tidal volume rather than respiratory rate controls hypercarbia efficiently . Also [32]P.L.TAN , T.L.LEE, et al demonstrated an increase in tidal volume is sufficient to eliminate excess CO_2 and maintain normal pulmonary oxygenation. Therefore, in our study we maintained tidal volume 10 ml /kg.and respiratory rate 12-14 /min.

ETCO2 AND PaCO2

ETCO2 increased from 32.77 to 37.08 mmHg, and PaCO2 increased from 36.52 to 41.36 mmhg respectively during the procedure, and the p value was < 0.05 for both. Thus it is statistically significant, but the ETCO2 and the PaCO2 were under clinically normal range . According to[22] MULLET et al rapid rise in PaCO2 and ETCO2 occurs within 10 minutes of insufflation. So we took data after 15 minute CO2 insufflation.

Similar to the findings of [22]MULLET et al ,[19] MEININGER et al, [11]ISHIKAWA et al and [21] MONAGLE et al, there was a progressive increase in ETCO2 and PaCO2 during CO2 insufflation in our study. The maximum rate of increase in CO2 occurred in the first 15 minutes, there after increase in carbon dioxide reached plateau and remain the same for 15- 45 minutes.

A correlation between PaCO2 and ETCO2 was observed in our study , this is similar to findings of [25]NYARWAYA et al and[2] BARAKA et al who also noted a correlation between the PaCO2 and ETCO2.

[27]P.PELOSI et al found that abdominal insufflation during laparoscopic surgery causes markedly reduced static compliance of the respiratory system ,lung and chest wall and to a lesser amount lung volume. However during laparoscopy PaCO2 increases, which closely correlates with PETCO2 . Consequently P(a-et)co2 gradient did not change . Oxygen saturation did not significantly alter during abdominal insufflation,

P(a-ET) GRADIENT

The mean difference of PaCO2 and ETCO2 pressure gradient was 3.75 mmHg , before insufflation and the mean difference of PaCO2 and ETCO2 pressure gradient after pneumoperitoneum was 4.27mmHg. In healthy patients with normal ventilation –perfusion ratio, the pressure gradient is 2-5 mmHg. The p value for PaCO2 and ETCO2 gradient was 0.007 , statistically significant . Although the p value is statistically significant, it remains within normal physiological range and similar with [2]BARAKA et al , [25]NYARWAYA et al,[3] BHAVANI SHANKAR et al studies.

pH AND BICARBONATE

The mean pH before pneumoperitoneum was 7.40 and the mean pH after pneumoperitoneum was 7.36. pH significantly decreases after 15 minutes, and the p value is 0.00 , less than 0.05. statistically significant. Our study is similar to[33] D.T.T.TRAN et al that showed CO_2 insufflation lowered the p H to 7.31 from 7.40 which was statistically highly significant with p value <0.001.

The mean bicarbonate before and during CO2 insufflation is 25.05 mmHg and 24.52 mmHg .and the p value is 0.30 , statistically insignificant. [31] Se-yuan Liu et al demonstrated that ETCO2 and PaCO2 increased from 31.4 ±0.7 mmhg to 42.1±1.6 mmhg and 33.3 ±0.7 mmhg to 43.7±1.2 mmhg respectively, during the course of the procedure. Arterial p H decreased from 7.43±0.01 mmhg to 7.34±0.01 mmHg, while bicarbonate concentration remain same, similar to our study.

PEAK AIRWAY PRESSURE

The mean peak airway pressure before insufflation was 14.47 cmH20 and the mean of peak airway pressure after pneumoperitoneum was 17.32 cmH2O. The p value is 0.00 (<o.05) statistically significant.

SUMMARY

- We studied the effects of pneumoperitoneum on P(a-et)co_2 gradient during laparoscopic surgery.
- There is no significant difference in the age and sex of the patients.
- There is no significant difference in duration of surgery.
- There is no significant increase in systolic blood pressure but there is significant increase in diastolic blood pressure.
- There is significant increase in mean arterial blood pressure.
- There is significant increase in heart rate.
- There is significant increase in end tidal carbon dioxide after co_2 insufflation, but it is clinically within normal range.
- There is significant increase in $PaCO_2$ after CO_2 insufflation and the increase is less than 45 mmHg.
- There is significant increase in $PaCO_2$-$ETCO_2$ gradient after CO_2 insufflation. But the pressure gradients was within normal range.
- There is significant decrease in pH , but bicarbonate measurements remain unchanged.
- There is significant increase in peak airway pressure after CO_2 insufflation.

CONCLUSION

We have demonstrated that during laparoscopic cholecystectomy or, appendicectomy , abdominal carbondioxide insufflation causes increase in ETCO2 and PaCO 2 signifcantly higher than preinsufflation value but within physiological range. A correlation was observed between the PaCO2 and ETCO2 throughout duration of insufflation.ETCO2 can be used an index of PaCO2 with the provision that the clinician be aware that an increased P(a-ET)CO2 gradient which reflects reduced cardiac output. The arterial and end tidal carbon dioxide pressure gradients are under the normal limits even after CO2 pneumoperitoneum in ASA 1 and 2 patients. The normal pressure P(a-ET)CO2 gradient implies adequate ventilation to alveoli and perfusion ;(blood flow to pulmonary capillaries).

This results suggest that endtidal capnography and pulse oximetry can be used as non invasive techniques for monitoring CO2 elimination and arterial oxygenation during laparoscopic surgery in ASA1 and 2 patients.

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PROFORMA

Date: Roll no:

Name:

Age: Ht:Wt: Sex: IP No:

Diagnosis:

Surgical procedure:

PRE OP ASSESSMENT:

HISTORY: Any Co-morbid illness

H/O Documented Difficult Airway

H/O previous surgeries

EXAMINATION : CVS :

RS :

INVESTIGATIONS :Complete blood count

Blood urea and serum ,creatinine.

Blood group and typing,

CXR

ECG

MODIFIED ALLEN TEST

MEASURES OF STUDY OUTCOME:

MEASUREMENTS WERE PERFORMED AT STEADY STATE, BEFORE PNEUMOPERITONEUM AND 15 MIN LATER

- HEART RATE,SYSTOLIC AND DIASTOLIC ARTERIAL PRESSURE mmHg
- PEAK AIRWAY PRESSURE cmH2O
- PaCO2 mmHg
- PEt CO2 mmHg
- P(a-ET)CO2 GRADIENT mmHg
- $_{P}$H
- Bicarbonate. mmHg

INFORMATION TO PARTICIPANTS

Investigator: Dr. P.UMA MAHESWARI

Name of the Participant:

Title:

"A Prospective, randomized study to assess the effect of pneumoperitoneum on arterial and end-tidal carbon dioxide pressure gradient during laparoscopic surgery in adult."

You are invited to take part in this research study.We have got approval from the IEC. Your are asked to participate because you satisfy the eligibility criteria.We want to assess the effect of pneumoperitoneum on arterial and end-tidal carbon dioxide pressure gradient during laparoscopic surgery in adult."

What is the Purpose of the Research:

To assess the difference between the arterial and end –tidal carbon dioxide pressures during laparoscopic surgery .

- HEART RATE BEATS PER MINUTE, SYSTOLIC AND DIASTOLIC ARTERIAL PRESSURE mmHg

- PEAK AIRWAY PRESSURE cmH2O
- $PaCO_2$ mmHg
- PEt CO_2 mmHg
- P(a-ET)CO_2 GRADIENT mmHg
- pH
- BICARBONATE mmHg

The Study Design:

60 patients scheduled for laparoscopic cholecystectomy Or appendicectomy

1. MEASUREMENT AT STEADY STATE (BEFORE PNEUMOPERITONEUM)
2. MEASUREMENT AFTER 15 MINUTES OF PNEUMOPERITONEUM

Benefits

Etco2 which is non-invasive continuous monitor compare to invasive arterial blood gas analysis.

Discomforts and risks

Nil

This intervention has been shown to be well tolerated as shown by previous studies. And if you do not want to participate you will have alternative of setting the standard treatment and your safety is our prime concern.All tests, medicine and medical services concerned with this research will be provided free of cost to the patient.

Time :

Date :

Place :

Signature / Thumb Impression of Patient

Patient Name:

Signature of the Investigator : ______________________________

Name of the Investigator : ______________________________

PATIENT CONSENT FORM

Study title :

“A Prospective, randomized study to assess the effect of pneumoperitoneum on arterial and end-tidal carbon dioxide pressure gradient during laparoscopic surgery in adult.**’’**

Study center:

Institute of Anaesthesiology and Critical Care,

Madras Medical College,

Chennai- 600003.

Participant Name : Age: Sex:

I.P.No:

I confirm that I have understood the purpose of the above study . I have the opportunity to ask the question and all my questions and doubts have been answered to my satisfaction.

I have been explained about the safety,advantage and disadvantage of the drugs.

I understand that my participation in the study is voluntary and that I am free to withdraw at anytime without giving any reason.

I understand that my identity will not be revealed in any information released to third parties or published , unless as required under the law . I agree not to restrict the use of any data or results that arise from the study.

Time:

Date: Signature / thumb impression of patient

Place: Patient name:

Signature of the investigator: Name of the investigator

ஆராய்ச்சி தகவல் தாள்

ஆராய்ச்சியாளர் பெயர் :

பங்கேற்பாளர் பெயர் :

ஆராய்ச்சி தலைப்பு :

லேப்பரோஸ்கோப்பி அறுவை சிகிச்சையின் போது கார்பன்டைஆக்சைடு காற்று ஏற்றத்தால் ஏற்படும் தமனியின் மற்றும் என்டைடல் கார்பன்டைஆக்சைடு அழுத்தச் சரிவை ஆய்வு செய்தல்.

ஆராய்ச்சியின் நோக்கம் :

இவ்வாராய்ச்சியின் மூலமாக நான் ஆய்வு செய்ய இருப்பவை

1. இதய துடிப்பு

2. இரத்த அழுத்தம்

3. காற்று குழாயின் அழுத்தம்

4. தமனி கார்பன்டைஆக்சைடு பகுதி அழுத்தம்

5. என்டைடல் கார்பன்டைஆக்சைடு பகுதி அழுத்தம்

6. தமனி மற்றும் என்டைடல் கார்பன்டைஆக்சைடு பகுதி அழுத்த சரிவு

ஆய்வு முறை :

லேப்பரோஸ்கோப்பி சிகிச்சைக்கு உட்படுத்தப்படும் 60 நோயாளிகள்

1. காற்று ஏற்றத்திற்கு 15 நிமிடங்கள் முன்பு அளவீடு

2. காற்று ஏற்றத்திற்கு 15 நிமிடங்கள் பின்பு அளவீடு

நன்மைகள்

என்டைடல் கார்பன்டைஆக்சைடு துளையில்லா மற்றும் தொடர்ந்து பதிவு செய்யும் முறை பக்க விளைவுகள் இல்லை.

இந்த முறையான ஆய்வு ஏற்கனவே பல இடங்களில் நடத்தப்பட்டுள்ளது. மேலும் இதன் பாதுகாப்பு உறுதி செய்யப்பட்டுள்ளது. நீங்கள் இந்த ஆய்வில் பங்கு கொள்ள விருப்பம் இல்லை என்றால் எப்போதும் உபயோகிக்கப்படும் மருந்தே உபயோகிக்கலாம்.

இந்த ஆய்வு சம்மந்தமான எல்லா புள்ளி விவரங்களும் மற்றும் நோயாளிகளின் விவரங்கள் ரகசியமாக வைக்கப்படும். இந்த ஆய்வு சம்மந்தப்பட்ட எல்லாப் பரிசோதனைகள் மருந்துகள், மற்றும் மருத்துவ சேவைகள் அனைத்தும் நோயாளிகளுக்கு இலவசமாக வழங்கப்படும்.

ஆய்வாளரின் பெயர் :

பங்கேற்பவரின் பெயர் :

ஆய்வாளரின் கையொப்பம் :

பங்கேற்பவரின் கையொப்பம் :

ஆராய்ச்சி ஒப்புதல் படிவம்

தலைப்பு :

லேப்பரோஸ்கோப்பி அறுவை சிகிச்சையின் போது கார்பன்டைஆக்சைடு காற்று ஏற்றத்தால் ஏற்படும் தமனியின் மற்றும் என்டைடல் கார்பன்டைஆக்சைடு அழுத்தச் சரிவை ஆய்வு செய்தல்.

ஆய்வு நிலையம் : மயக்கவியல் துறை, சென்னை மருத்துவக் கல்லூரி, சென்னை-3.

பங்குபெறுபவரின் பெயர் :

பங்குபெறுபவரின் எண் :

பங்குபெறுபவர் இதனை ☑ குறிக்கவும் :

மேலே குறிப்பிட்டுள்ள மருத்துவ ஆய்வின் விவரங்கள் எனக்கு விளக்கப்பட்டது. என்னுடைய சந்தேகங்களை கேட்கவும், அதற்கான தகுந்த விளக்கங்களை பெறவும் வாய்ப்பளிக்கப்பட்டது. ☐

நான் இவ்வாய்வில் தன்னிச்சையாகத்தான பங்கேற்கிறேன். எந்த காரணத்தினாலோ, எந்தக் கட்டத்திலும், எந்த சட்ட சிக்கலுக்கும் உட்படாமல் நான் இவ்வாய்வில் இருந்து விலகிக் கொள்ளலாம் என்றும் அறிந்து கொண்டேன். ☐

இந்த ஆய்வு சம்மந்தமாகவோ, இதை சார்ந்த மேலும் ஆய்வு மேற்கொள்ளும் போதும் இந்த ஆய்வில் பங்கு பெறும் மருத்துவர் என்னுடைய மருத்துவ அறிக்கைகளை பார்ப்பதற்கு என் அனுமதி தேவையில்லை என அறிந்து கொள்கிறேன். நான் ஆய்வில் இருந்து விலகிக் கொண்டாலும் இது பொருந்தும் என அறிகிறேன். ☐

இந்த ஆய்வில் மூலம் கிடைக்கும் தகவல்களையும் பரிசோதனையின் முடிவுகளையும் மற்றும் சிகிச்சை தொடர்பான தகவல்களையும் மருத்துவர் மேற்கொள்ளும் ஆய்வில் பயன்படுத்திக் கொள்ளவும் அதை பிரசுரிக்கவும் என் முழு மனதுடன் சம்மதிக்கின்றேன். ☐

இந்த ஆய்வில் பங்குக் கொள்ள ஒப்புக் கொள்கிறேன். எனக்கு கொடுக்கப்பட்ட அறிவுரைகளின் படி நடந்து கொள்வதுடன் இந்த ஆய்வை மேற்கொள்ளும் மருத்துவ அணிக்கு உண்மையுடன் இருப்பேன் என்று உறுதி அளிக்கிறேன். ☐

பங்கேற்பவரின் கையொப்பம் :

கட்டை விரல் ரேகை :

பங்கேற்பவரின் பெயர் மற்றும் விலாசம்

இடம் :

தேதி :

ஆய்வாளரின் கையொப்பம் :

ஆய்வாளரின் பெயர் :

இடம் :

தேதி :

S.NO	NAME	AGE	IP NO	SEX	PROCEDURE	DURATION OF SURGERY	PULSE RATE BEFORE INSUFFLATION	15 MINS AFTER INSUFFLATION	SYSTOLIC BP BEFORE INSUFFLATION	DIASTOLIC BP BEFORE INSUFFLATION	MEAN BP BEFORE INSUFFLATION	SYSTOLIC BP 15 MINS AFTER INSUFFLATION	DIASTOLIC BP 15 MINS AFTER INSUFFLATION	MEAN BP 15 MINS AFTER INSUFFLATION	ETCO2 BEFORE INSUFFLATION
1	Ilangovan	22	46960	M	Appendicectomy	35	79	84	134	63	86.67	136	70	92.00	32
2	yeliya	24	51128	M	Appendicectomy	30	93	92	120	73	88.67	128	80	96.00	34
3	Arunachalam	38	48316	M	Appendicectomy	30	76	79	117	65	82.33	123	74	90.33	30
4	Venu	35	57142	M	Appendicectomy	30	87	89	126	68	87.33	130	69	89.33	35
5	Bharathi	34	54281	M	Cholecystectomy	45	75	78	127	78	94.33	134	86	102.00	35
6	Kalaiselvann	22	55167	M	Cholecystectomy	45	82	86	118	69	85.33	124	73	90.00	32
7	Soundary	35	60102	F	Cholecystectomy	45	72	77	120	72	88.00	126	80	95.33	35
8	Saranya	20	54108	F	Appendicectomy	30	67	69	118	80	92.67	125	86	99.00	31
9	gomathi	25	50207	F	Appendicectomy	30	75	78	118	70	86.00	124	78	93.33	31
10	Akilandam	35	55160	M	Cholecystectomy	45	88	85	114	75	88.00	122	80	94.00	32
11	stella mary	30	59849	F	Cholecystectomy	45	105	100	125	67	86.33	130	72	91.33	33
12	abdhul	22	54087	M	Appendicectomy	30	60	62	114	74	87.33	120	80	93.33	32
13	Bhargavi	25	63801	F	Appendicectomy	30	86	90	125	69	87.67	128	74	92.00	29
14	vijyan	27	64084	M	Appendicectomy	30	75	78	124	64	84.00	128	70	89.33	36
15	Alamelu	35	65515	F	Cholecystectomy	45	78	79	117	67	83.67	125	75	91.67	29
16	srinivasan	25	65332	M	Appendicectomy	30	83	87	123	80	94.33	128	86	100.00	32
17	Lavanya	26	48854	F	Cholecystectomy	45	78	98	112	75	87.33	130	80	96.67	32
18	Saroja	23	48169	F	Appendicectomy	30	70	74	110	63	78.67	120	72	88.00	34
19	Usha	38	46445	F	Cholecystectomy	45	68	77	108	63	78.00	118	70	86.00	34
20	Mala	35	43903	F	Cholecystectomy	45	99	102	127	77	93.67	133	84	100.33	33
21	Stella	30	42191	F	Appendicectomy	30	74	77	113	76	88.33	117	83	94.33	33
22	shanmugam	36	44719	M	Cholecystectomy	45	62	66	130	70	90.00	134	75	94.67	33
23	prasanth	23	42942	M	Appendicectomy	30	69	68	114	69	84.00	118	73	88.00	33
24	mallika	25	46954	F	Appendicectomy	30	83	87	118	62	80.67	124	69	87.33	31
25	Sivakumar	26	46454	M	Appendicectomy	30	67	73	128	73	91.33	133	78	96.33	34
26	Lakshmi	29	49608	F	Appendicectomy	30	70	74	132	82	98.67	138	90	106.00	33
27	Karthik	20	48832	M	Cholecystectomy	45	66	73	122	73	89.33	127	79	95.00	34
28	Rajesh	30	42032	M	Cholecystectomy	40	77	72	107	63	77.67	113	66	81.67	32
29	Selvarani	38	42481	F	Cholecystectomy	40	75	77	109	67	81.00	118	78	91.33	35

S.NO	NAME	AGE	IP NO	SEX	PROCEDURE	DURATION OF SURGERY	PULSE RATE BEFORE INSUFFLATION	15 MINS AFTER INSUFFLATION	SYSTOLIC BP BEFORE INSUFFLATION	DIASTOLIC BP BEFORE INSUFFLATION	MEAN BP BEFORE INSUFFLATION	SYSTOLIC BP 15 MINS AFTER INSUFFLATION	DIASTOLIC BP 15 MINS AFTER INSUFFLATION	MEAN BP 15 MINS AFTER INSUFFLATION	ETCO2 BEFORE INSUFFLATION
30	Rajesh	32	40070	M	Appendicectomy	25	63	66	110	70	83.33	118	78	91.33	30
31	Lakshmi	28	43374	F	Cholecystectomy	40	87	95	128	60	82.67	130	65	86.67	30
32	Santhanmary	26	49738	F	Appendicectomy	25	59	60	110	70	83.33	114	78	90.00	30
33	Jeyaraman	35	45505	M	Appendicectomy	25	85	86	100	73	82.00	108	77	87.33	34
34	Rajendaran	37	45180	M	Cholecystectomy	40	75	84	126	75	92.00	130	80	96.67	30
35	Shanthi	40	48134	F	Cholecystectomy	40	75	83	117	80	92.33	127	85	99.00	35
36	Vasanthi	27	47340	F	Appendicectomy	25	69	68	104	65	78.00	118	72	87.33	31
37	Hari	32	46430	M	Appendicectomy	25	60	68	124	75	91.33	130	78	95.33	32
38	Dhasarathan	31	46340	M	Appendicectomy	40	98	99	115	70	85.00	125	82	96.33	36
39	Subasree	25	48590	F	Appendicectomy	40	88	92	107	67	80.33	112	73	86.00	35
40	Sulochana	43	43621	F	Cholecystectomy	40	90	94	120	70	86.67	128	74	92.00	32
41	Jeganathan	42	47821	M	Cholecystectomy	40	83	87	124	75	91.33	136	77	96.67	33
42	hemala	29	46326	F	Appendicectomy	40	67	69	105	62	76.33	110	69	82.67	32
43	Abu saleem	28	45074	M	Appendicectomy	25	87	93	112	72	85.33	114	79	90.67	35
44	Mallika	28	42001	F	Appendicectomy	25	87	90	120	74	89.33	125	79	94.33	32
45	Babuu	24	45132	M	Appendicectomy	35	83	88	132	70	90.67	133	74	93.67	37
46	Thirumalai	34	45102	M	Appendicectomy	35	89	94	103	68	79.67	114	79	90.67	32
47	Krishnan	40	46321	M	Cholecystectomy	40	73	77	128	64	85.33	130	70	90.00	35
48	Raji	28	47174	M	Appendicectomy	35	100	105	100	76	84.00	110	80	90.00	34
49	Loganathan	25	47163	M	Appendicectomy	35	102	107	104	64	77.33	110	73	85.33	30
50	Senthilpandi	38	47638	M	Cholecystectomy	40	70	75	117	77	90.33	121	82	95.00	34
51	Sundaramoorthy	42	41853	M	Cholecystectomy	40	82	87	126	77	93.33	130	87	101.33	32
52	Subramani	33	46043	M	Appendicectomy	35	62	67	112	72	85.33	118	75	89.33	34
53	Kavitha	21	46075	F	Appendicectomy	35	71	76	120	75	90.00	127	82	97.00	31
54	Maheswari	26	48902	F	Cholecystectomy	45	77	83	118	78	91.33	122	83	96.00	33
55	Banumathi	33	52176	F	Cholecystectomy	45	68	78	121	71	87.67	127	78	94.33	31
56	Sekar	32	51864	M	Appendicectomy	35	80	84	110	70	83.33	134	82	99.33	34
57	Gunajothi	46	43279	F	Cholecystectomy	45	86	89	120	72	88.00	124	77	92.67	32
58	Balraman	25	48764	M	Appendicectomy	35	65	73	108	68	81.33	112	75	87.33	33
59	Abirami	25	52765	F	Appendicectomy	35	87	95	127	76	93.00	132	85	100.67	34
60	Kariappan	27	47677	M	Appendicectomy	35	63	64	120	65	83.33	127	70	89.00	34

ETCO2 15 MINS AFTER INSUFFLATION	PaCO2 BI	Paco2 AI	Paco2-ETCO2 BI	Paco2-ETCO2 AI	PEAK AIRWAY Pr BI	PEAK AIRWAY Pr AI	PH BI	PH AI	HCO3 BI	HCO3 AI
35	36	39.5	4	4.5	14	17	7.39	7.37	25.9	25
39	36.5	42.3	2.5	3.3	17	20	7.4	7.37	25.9	25
38	34.2	41.5	4.2	3.5	12	15	7.39	7.37	25.9	25
36	39.2	42	4.2	6	18	21	7.38	7.36	25.8	24.7
39	37.3	43	2.3	4	18	21	7.4	7.37	25.8	24.7
36	36	40.7	4	4.7	13	16	7.39	7.37	25.8	24.7
38	40.1	43.2	5.1	5.2	12	16	7.39	7.36	25.7	25.6
37	33.7	39.4	2.7	2.4	16	20	7.4	7.37	25.7	25.6
37	34.2	42	3.2	5	16	19	7.39	7.36	25.7	25.6
38	35.7	41.2	3.7	3.2	16	19	7.39	7.36	25.6	24.7
37	35.8	41.5	2.8	4.5	14	16	7.4	7.37	25.6	24.7
36	37	40.5	5	4.5	13	16	7.39	7.36	25.6	24.7
34	32.5	38.5	3.5	4.5	15	17	7.38	7.36	25.6	24.7
37	40	42.8	4	5.8	12	15	7.39	7.35	25.5	24.5
35	32.5	39.5	3.5	4.5	16	20	7.37	7.35	25.5	24.5
35	34.1	40	2.1	5	15	17	7.37	7.35	25.5	24.5
35	35	40	3	5	12	16	7.42	7.38	25.4	24.8
38	37.7	42.3	3.7	4.3	15	18	7.42	7.38	25.4	24.8
38	37.8	42	3.8	4	14	17	7.42	7.37	25.4	24.8
37	36.2	42	3.2	5	17	18	7.42	7.37	25.4	24.8
38	36.5	42.2	3.5	4.2	13	15	7.4	7.39	25.4	24.8
39	38	41.7	5	2.7	17	20	7.39	7.35	25.3	24.5
36	35.6	40.4	2.6	4.4	16	18	7.38	7.36	25.3	24.5
37	34.2	40.5	3.2	3.5	12	16	7.4	7.37	25.2	24.6
37	39.2	42.5	5.2	5.5	17	19	7.39	7.35	25.2	24.6
36	35.2	40.2	2.2	4.2	19	21	7.43	7.37	25.2	24.6
38	37.8	43.4	3.8	5.4	12	16	7.4	7.37	25.2	24.6
35	36.8	39.6	4.8	4.6	15	17	7.42	7.37	25.2	24.6
40	38.8	43.5	3.8	3.5	16	19	7.42	7.37	25.1	24.5

ETCO2 15 MINS AFTER INSUFFLATION	PaCO2 BI	Paco2 AI	Paco2-ETC02 BI	Paco2-ETC02 AI	PEAK AIRWAY Pr BI	PEAK AIRWAY Pr AI	PH BI	PH AI	HCO3 BI	HCO3 AI
34	33.5	38.6	3.5	4.6	14	17	7.42	7.37	25.1	24.5
36	33.8	38.5	3.8	2.5	13	16	7.42	7.37	25	24.7
37	34.3	39.6	4.3	2.6	15	18	7.43	7.37	25	24.7
39	38.5	42.5	4.5	3.5	15	18	7.44	7.37	25	24.7
37	34.2	40.3	4.2	3.3	11	14	7.4	7.38	25	24.7
41	40.5	44.6	5.5	3.6	14	16	7.43	7.36	24.9	24.4
37	35	40	4	3	14	18	7.38	7.36	24.9	24.4
37	36.5	42.8	4.5	5.8	15	18	7.43	7.35	24.9	24.4
40	41.2	44.5	5.2	4.5	12	14	7.42	7.37	24.8	24.5
37	39.2	40.5	4.2	3.5	15	18	7.42	7.36	24.8	24.5
38	37.2	42	5.2	4	11	14	7.43	7.38	24.7	24.3
35	37.3	40.5	4.3	5.5	13	17	7.43	7.38	24.7	24.3
36	36.3	41.5	4.3	5.5	14	18	7.38	7.35	24.7	24.3
40	40	44	5	4	17	19	7.38	7.35	24.6	24.3
38	37.5	44	5.5	6	16	19	7.37	7.36	24.6	24.3
36	35.2	40	-1.8	4	14	18	7.37	7.34	24.6	24.3
36	36.2	40	4.2	4	12	15	7.37	7.35	24.6	24.3
39	38.5	42.8	3.5	3.8	12	14	7.37	7.35	24.6	24.3
38	37.3	41	3.3	3	16	20	7.37	7.35	24.5	24.1
37	34.2	40.2	4.2	3.2	14	17	7.44	7.38	24.5	24.1
37	37.5	41.8	3.5	4.8	12	15	7.44	7.39	24.5	24.1
38	36.5	42.5	4.5	4.5	14	17	7.43	7.37	24.4	24.1
38	38.3	43.5	4.3	5.5	13	16	7.38	7.35	24.4	24.1
36	34	41.5	3	5.5	15	16	7.4	7.37	24.4	24.1
37	35.7	41.7	2.7	4.7	16	19	7.37	7.35	24.4	24.1
35	33.5	37.8	2.5	2.8	14	17	7.42	7.39	24.4	24.1
37	38	42.5	4	5.5	14	17	7.43	7.36	24.3	24
36	35	40	3	4	17	18	7.42	7.38	24.3	24
38	38.5	41.8	5.5	3.8	16	18	7.4	7.37	24.2	24
37	36.8	41.7	2.8	4.7	15	18	7.38	7.35	24.2	24
37	37.2	40.7	3.2	3.7	13	15	7.38	7.35	24.2	24

INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE, CHENNAI 600 003

EC Reg.No.ECR/270/Inst./TN/2013
Telephone No.044 25305301
Fax: 011 25363970

CERTIFICATE OF APPROVAL

To
Dr.Uma Maheswari.P.
Post Graduate in MD (Anaesthesiology)
Madras Medical College
Chennai 600 003

Dear Dr.Uma Maheswari.P.

The Institutional Ethics Committee has considered your request and approved your study titled **" A PROSPECTIVE, RANDOMIZED STUDY TO ASSESS THE EFFECT OF PNEUMOPERITONEUM ON ARTERIAL AND END-TIDAL CARBON-DIOXIDE PRESSURE GRADIENT DURING LAPAROSCOPIC SURGERY IN ADULT "** NO.24042015.

The following members of Ethics Committee were present in the meeting hold on 07.04.2015 conducted at Madras Medical College, Chennai 3

1. Prof.C.Rajendran, MD	:Chairperson
2. Prof.R.Vimala,MD.,Dean,MMC,Ch-3	: Deputy Chairperson
3. Prof.B.Kalaiselvi,MD.,Vice Principal,MMC,Ch-3	: Member Secretary
4. Prof.B.Vasanthi,MD.,Prof.of Pharmacology,MMC	: Member
5. Prof.Raghumani,MS.,Prof.of Surgery,MMC	:Member
6. Prof.S.Baby Vasumathi, Director, Inst. of O&G,MMC	: Member
7. Prof.K.Ramadevi,MD., Director ,Inst.of Bio-Chem.MMC	: Member
8. Prof.Saraswathy,MD.,Director,Pathology, MMC	: Member
9.Prof.K.Srinivasagalu,MD.,Director, I.I.M , MMC	: Member
10.Thiru S.Rameshkumar, B.Com., MBA.	: Lay Person
11.Thiru S.Govindasamy, BA., BL.,	: Lawyer
12.Tmt.Arnold Saulina, MA., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

8/4/15

Member Secretary – Ethics Committee
MEMBER SECRETARY
INSTITUTIONAL ETHICS COMMITTEE
MADRAS MEDICAL COLLEGE
CHENNAI-600 003

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