A COMPARATIVE EVALUATION OF THE LARYNGEAL MASK AIRWAY- CLASSIC AND TRACHEAL INTUBATION FOR LAPAROSCOPIC CHOLECYSTECTOMY

Dissertation Submitted in partial fulfillment of the requirements for the degree of

M.D. (anaesthesiology)
Branch X

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY
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CERTIFICATE

This is to certify that the Dissertation "**A COMPARATIVE EVALUATION OF THE LARYNGEAL MASK AIRWAY- CLASSIC AND TRACHEAL INTUBATION FOR LAPAROSCOPIC CHOLECYSTECTOMY**" presented herein by **Dr.G.G.JAYAKAR** is an original work done in the Department of Anaesthesiology, Madras Medical College and Government General Hospital, Chennai for the award of Degree of M.D. (Branch X) Anesthesiology under my guidance and supervision during the academic period of 2003-2006.

Place:

Date:

Prof.Dr.Kalavathy Ponniraivan, M.D
DEAN
Madras Medical College & Hospital,
Chennai**.**

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CONTENTS

INTRODUCTION

Between 1981 & 1987, Dr. Archie Brain developed a new way of linking the artificial and anatomical airways. This new concept, known as the laryngeal mask airway was different from other forms of airway management.[1]

Combining the advantages of a noninvasive face mask and the more invasive tracheal tube, the laryngeal mask airway was created to fill an important functional gap that existed between the standard methods of airway control that were in use then.

Being the latest in a succession of attempts to fill the gap between the face mask and the tracheal tube, the LMA was initially received with skepticism in the anaesthesia community. Some considered that the facemask and the tracheal tube was all that was necessary for the practice of good anaesthesia whereas for some the LMA was a device exclusively meant for the management of the difficult airway.

Originally the device was recommended as a better alternative to the facemask. But ever since its development the LMA has challenged the assumption that tracheal intubation is the only acceptable way to maintain a clear airway and provide positive pressure ventilation. Infact the first clinical series of Dr. Brain included 16 cases of gynaecologic laparoscopy with positive pressure ventilation.

Use of the laryngeal mask airway (LMA) during surgery has exploded. Since its commercial introduction in 1988, the LMA is available in 80 countries and has been used in an estimated 150 million surgical procedures. There are now over

2,000 publications pertaining to the LMA. This family of airway devices has proven to be safe for patients not requiring endotracheal intubation, who are not at increased risk of gastric regurgitation and occasionally life-saving in the management of airways of patients who are unexpectedly difficult to ventilate and/or intubate. Though the LMA has provided the convenience of "hands-free" anaesthesia, for some anaesthesiologists the combination of LMA and positive pressure ventilation evokes fear of gastric distension, pulmonary aspiration of gastric contents and inadequate ventilation. Early publications strongly emphasized careful patient selection, and avoidance of agents or settings that may place the patient at greater risk of regurgitation.

In 1995, Brimacombe summarized the advantages and disadvantages of the LMA compared with tracheal intubation as derived from yet another meta-analysis[4]. The advantages included: hemodynamic stability at induction compared with intubation[2], and during emergence compared with extubation; minimal increase in intraocular pressure after insertion; reduced anaesthetic requirements for airway tolerance; lower frequency of coughing during emergence; improved oxygen saturation during emergence; and a lower incidence of sore throat in adults.

The main complications of using a LMA relate to the airway seal pressure of its cuff. The LMA cuff seal pressure is the inflation pressure above which gas can escape around the cuff. This is lower than with a tracheal tube, so there is a greater risk of gastric insufflation, gastro-oesophageal reflux and aspiration of regurgitated gastric contents when using an LMA[4].

Despite this .the LMA has gained widespread popularity for gynaecologic laparoscopic procedures in the UK[5,8]**.** Nearly ten years ago, Verghese and Brimacombe surveyed anesthesiologists in Reading, UK. Over a two-year period 11,910 of 39,824 (29.9%) consecutive general anaesthetics administered involved the use of a LMA. Of these, 18.7% were in "unconventional" settings including 1,469 gynaecologic laparoscopies usually employing controlled ventilation. But there were no cases of pulmonary aspiration[5]**.** Malins and Cooper had no cases of pulmonary aspiration in 3000 patients by 1994[6]. A subsequent report from Reading, UK indicated that the LMA is used in 99% of patients undergoing laparoscopic surgery[8]. Indeed, over the past decade, case reports, surveys and small series have described the elective use of the LMA in settings that heretofore would have been considered at best ill-advised [9,10].

Hence a prospective randomized study was designed to compare the clinical performance of LMA- Classic and Endotracheal tube regarding gastric distension and positive pressure ventilation during laparoscopic cholecystectomy.

AIM OF THE STUDY

The aim of the study was to evaluate the effectiveness of LMA- Classic compared to Endo tracheal tube during laparoscopic cholecystectomy based on the:

- Ventilation parameters: oxygen saturation
  End tidal carbon dioxide
  Minute ventilation
  Airway pressure
- Gastric distension

LARYNGEAL MASK AIRWAY

The LMA was designed by ARCHIE.I.J.BRAIN between 1981-85. Original purpose was to reduce the need for more invasive means of airway management while offering a more reliable alternative to the facemask, at the same time less stressful compared to the endotracheal tube.

Any device that forms an end-to-end seal surrounding the laryngeal orifice is by definition a LMA.

The standard LMA consists of a curved tube (shaft) to match the oropharyngeal anatomy connected to an elliptical mask at an angle of 30°. The airway tube is semi rigid to facilitate atraumatic insertion and semitransparent so that condensation and regurgitation are visible. The mask is oval shaped and consists of a cuff which is inflatable through an inflation tube and a self-sealing pilot balloon. The inner aspect of the mask is called the bowl. There are two vertical bars at the junction of the tube and the mask, the mask aperture bars, which are designed to prevent the epiglottis from falling back into the aperture of the tube. A black line runs longitudinally along the posterior aspect of the tube to orient it after placement. A standard 15mm connector is present at the machine end of the tube.

It is manufactured from medical grade silicon rubber and is reusable.

Initially the LMA was introduced in four sizes. The design of the mask is based on the shape of the hypopharynx and not on the larynx.

Available LMA sizes:

Size	Cm	Inflation volume	Patient size
1	8	4 ml	Neonates/infants unto 5 kg
1.5	10	7 ml	Infants between 5-10 kg
2	11	10 ml	Children between 10-20 kg
2.5	12.5	14 ml	Children between 20-30 kg
3	16	20 ml	Children and small adults between 30-50 kg
4	16	30 ml	Normal adults between 50-70 kg
5	18	40 ml	Large adults between 70-100 kg
6		50 ml	Extra large adults > 100 kg

Various types:

- Standard / classic LMA
- Flexible LMA
- LMA unique
- Intubating LMA / Fastrach
- LMA C Trach
- PROSEAL LMA

Preparation:

The cuff is fully deflated by pressing the hollow side down onto a clean surface, with two fingers pressing the tip flat. The deflated cuff should be free from wrinkles and its rim should face away from the mask aperture. This imparts rigidity to the cuff. A lubricant is applied to the posterior surface of the cuff.

Placement:

Standard technique: [11]

The LMA can be placed with or without muscle relaxants. The patient is placed in the sniffing position. The head is held in slight extension by having the nonintubating hand stabilizing the occiput. The jaw is allowed to fall open or is held open by an assistant. The device is held between the thumb and index finger as close as possible to the junction of the tube and the mask. The distal tip of the deflated cuff is pressed against the hard palate and the LMA is advanced using the index finger to guide the tube over the back of the tongue. The tube is advanced until a characteristic resistance is felt as the upper oesophageal sphincter is engaged. The hand is taken out. Without holding the tube the cuff is inflated with the appropriate amount of air to achieve a proper seal. The longitudinal black line on the shaft of the tube should lie in the midline against the upper lip.

Modified techniques of insertion: [11]

- Back to front (Guedel)
- Rotation

- Lateral approach
- Partially / fully inflated
- Introducing devices
- Laryngoscope assisted
- Anterior traction on tongue

The ideal final anatomic position occupied by the classic-LMA when inflated is as follows:

The distal cuff lies in the hypopharynx with the tip against the upper oesophageal sphincter, the sides lie facing the pyriform fossa, and the upper part of the cuff lies facing the base of the tongue with the epiglottis pointing upwards. The aperture of the correctly placed LMA aligns itself anatomically with the laryngeal inlet.

Signs of correct LMA placement:

- Slight outward movement of the tube on inflation
- Presence of a small oval swelling in the neck around the thyroid and cricoid area
- No cuff visible in the oral cavity
- Expansion of chest wall on bag compression

LMA removal:

The LMA is tolerated well even in lighter planes of anesthesia and can be left in place during emergence. The LMA should not be removed in lighter planes. It should ideally be removed after full return of airway reflexes.[12,13,14]

Uses of LMA: [15]

- Airway device in patients with difficult airway
- Conduit for ventilation during anaesthesia
- Device for emergency ventilation during anaesthesia
- Tracheal intubation assist device
- Emergency airway during resuscitation

Advantages of LMA over endotracheal tube:[4]

- More rapid placement
- Avoids laryngoscopy
- Less invasion of the respiratory tract
- Decreased cardiovascular response
- Less rise in intra ocular pressure
- Decreased anaesthetic requirements
- Decreased incidence of post-op sore throat
- Decreased need for administration of muscle relaxants
- Decreased incidence of coughing during emergence
- Better tolerated

Disadvantages of LMA over endotracheal tube: [4]

- Risk of aspiration
- Airway not as secure
- Unsuitable for collapsible airways

Advantages of LMA over facemask: [4]

- Hands free
- Positive pressure ventilation
- Monitoring
- Fewer episodes of hypoxia
- Avoids compression of eyes and nerves
- Placement independent of facial anatomy
- Better access to head and neck

Disadvantages of LMA over facemask: [4]

- Risk of pharyngo laryngeal trauma
- Reflux is more likely

LMA and gastric insufflation:

Incidence of clinically detectable gastric distension is low (0%-0. 3%)[16]. The incidence increases with increasing airway pressure and tidal volume[17, 18]. It also depends on the precise position of the LMA and the way it is secured. The mean airway pressure at which air can be detected entering the stomach is approximately 30 cm H20[18,19]. Gastric insufflation is unlikely at airway pressure below 20 cm

H_2O[19] and tidal volumes of below 8 ml/kg[18]. If the gastric leak is sufficiently large or prolonged then significant gastric distension can occur leading to impaired respiratory function, increasing the risk of regurgitation. Epigastric auscultation should be done in all patients to ensure that gastric insufflation is not occurring. If gastric distension does occur passing a Ryles tube behind the partially deflated LMA can deflate the stomach.

LMA and gastrointestinal responses- Reflux and Aspiration:

The major limiting factor with the use of LMA is the lack of airway protection from regurgitated stomach contents. Physiologically inappropriate stimulation of pharyngeal receptors can produce abnormal oesophageal motility and relaxation of the lower oesophageal sphincter. However the incidence of clinically detectable reflux is much lower at approximately 0.1%[20, 21]. One factor preventing aspiration may be the persistent function of the upper oesophageal sphincter[22,23]. The overall incidence of pulmonary aspiration with LMA is 2/10,000[24]. There appears to be no increased risk of aspiration with controlled vs. spontaneous ventilation or in the paediatric population[24].

Positive pressure ventilation:

The low-pressure seal formed by LMA with the periglottic tissues makes the LMA only partially suitable for positive pressure ventilation because it may predispose to gastric insufflation, inadequate ventilation or both. However a large number of clinical trails have shown that patients with normal lung compliance may be mechanically ventilated through the LMA to airway pressures of 20 cm H_20 with minimal risk of gastric insufflation. However the tidal volumes should be 8-10 ml/kg. A meta analysis of 547 LMA publications failed to show any link between LMA and positive pressure ventilation and aspiration[24].

LAPAROSCOPIC SURGERY-ANAESTHETIC IMPLICATIONS

Physiological changes during laparoscopy: [25]

Three major forces that uniquely alter the patient's physiology during Laparoscopy:

- Increase in intra-abdominal pressure
- Effects of patient positioning
- Carbon dioxide

EFFECTS OF PNEUMOPERITONEUM: [26]

Cardiovascular changes:

- Increase in heart rate
- Increase in mean arterial pressure
- Increase in systemic vascular resistance
- Increase in myocardial filling pressures
- Increase in central venous pressure
- Increase in pulmonary capillary wedge pressure
- Decrease in cardiac output

Regional circulatory changes:

- **Cerebral-** Increased intra cranial pressure

(Due to decreased venous drainage of lumbar plexus due to inferior vena cava compression)

- **Hepatoportal-** Decreased portal & hepatic blood flow
- **Gastrointestinal tract-** Intramural acidosis
  Splanchnic ischemia
- **Renal-** Decreased renal blood flow
  Decreased Glomerular filtration rate
- **Lower limb-** Decreased femoral vein blood flow

Respiratory changes:

- Decreased functional residual capacity
- Decreased vital capacity
- Restricted diaphragmatic excursion
- Decreased compliance
- Ventilation perfusion abnormality
- Raised airway pressure
- Endobronchial intubation
- Cephalad displacement of mediastinum

EFFECTS OF HYPERCARBIA: [27]

Cardiovascular system:

Local effects:

- Direct depression of myocardial contractility & rate of contraction

- Direct stimulation of myocardial irritability and arrythmogenicity

Systemic effects:

- Stimulation of CNS & sympatho adrenal system
- Increase in cardiac output
- Increase in heart rate
- Increase in blood pressure
- Increase in central venous pressure

Respiratory system:

- Increase in minute ventilation
- Bronchodilatation
- Pulmonary vasoconstriction

Central nervous system:

- ↑ PCO_2- Direct cortical depression

  Increase in seizure threshold
- ↑↑ PCO_2- Stimulate sub cortical hypothalamic areas

  Increase in cortical excitability & seizures
- ↑↑↑ PCO_2- Cortical & sub cortical suppression
- Increase in cerebral blood flow
- Increase in intra cranial pressure

Neuro-endocrine system:

- Increased epinephrine & nor-epinephrine

- Increased cortisol
- Increased renin / aldosterone
- Increased anti diuretic hormone
- Increased atrial natriuretic peptide

Renal system:

Sympathetic stimulation

↓

Catecholamine release

↓

Decreased renal cortical blood flow

Afferent arterial constriction ← Intra-abdominal pressure >15 mmhg

↓

Decreased G F R

↓

Decreased urine output

Gastro intestinal system:

Diffusion of CO_2 into bowel

↓

Post-operative nausea & vomiting

EFFECTS OF POSITIONING: [26]

Reverse Trendelenberg:

- Decreased right atrial pressure
- Decreased venous return
- Decreased pulmonary capillary wedge pressure
- Decreased mean arterial pressure
- Decreased cardiac output

Trendelenberg position:

- Decreased vital capacity
- Decreased functional residual capacity
- Decreased lung compliance
- Increase in cerebral blood flow
- Increase in cardiac output

COMPLICATIONS: [26]

Injuries from instruments:

- Bleeding
- Organ perforation
- Injury to blood vessels
- Subcutaneous emphysema
- Peritonitis
- Wound infection

Due to pneumo peritoneum:

- Bowel ischemia

- Gastric regurgitation
- Compression of inferior vena cava
- Decreased venous return
- Decreased cardiac output
- Increase in intra thoracic pressure
- Pneumothorax
- Barotrauma
- Atelectasis
- Nausea & vomiting
- Vagal reflexes

Due to hypercarbia:

- Acidosis
- Arrhythmias
- Hypertension
- Increase in heart rate
- Increase in intracranial pressure
- CO_2 Embolism

Trendelenberg position:

- Venous congestion of head & neck
- Increase in venous pressure
- Increase in intracranial pressure

- Retinal hemorrhages & detachment
- Increase in intraocular pressure
- Endobronchial intubation
- Ventilation perfusion mismatch
- Hypoxia
- Neuropathy & Nerve injuries
- Corneal & conjunctival edema

Advantages of laparoscopy: [26]

- Minimally invasive
- Decreased blood loss
- Decreased postop pain
- Decreased postop ileus
- Early ambulation
- Decreased wound related complications
- Decreased hospital stay
- Cost-effective
- Quick return of respiratory functions

CAPNOGRAPHY

Capnography:

Study of shapes or designs of the changing concentrations of CO_2 in respired gases.

Capnograph:

Machine that generates waveform called capnogram.

Capnometry:

Numerical display of maximum inspiratory and expiratory CO_2 concentrations during a respiratory cycle.

Capnometer:

Device that performs and displays the reading.

Methods of measuring CO_2 levels:

- Infrared spectrography
- Mass spectrography
- Photo acoustic spectrography
- Chemical colorimetric analysis

Principle of capnography: [28]

Gases with two dissimilar atoms absorb infrared radiation. Infrared rays have a wavelength of 1 μm. CO_2 shows absorption at 4.3 μm. Intensity of infrared radiation projected through a gas mixture containing CO_2 is diminished by absorption. This allows the CO_2 band to be identified and it is proportional to CO_2 in the mixture.

Components of infrared analyzer:

- Infrared source
- Analyzer cell
- Reference cell
- Detector cell

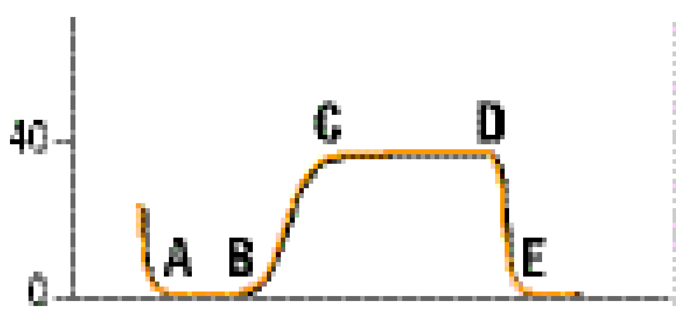
Types of CO_2 analyzer:

- Main-stream (aspiration through)
- Side-stream (flow-through)

Types of capnogram:

- Time capnogram
- Volume capnogram

Time capnogram: [29]



Four phases:

A-B: PHASE I- dead space gas with no CO_2

B-C: PHASE II- mixed dead space and alveolar gas

C-D: PHASE III alveolar gas rich in CO_2

D-E: PHASE 0- Inspiratory segment, CO_2 reaches zero/baseline

Two angles:

ALPHA: Between phase II-III.normal-100°-110°.

Indirect indication of V/Q status of the lung

Airway obstruction increases the slope

BETA: 90° between phase III- phase 0.

Assess extent of rebreathing

Volume capnogram:

CO_2 concentration plotted against the expired volume in a respiratory cycle. Only the expiratory segment is present.

CLINICAL APPLICATIONS OF CAPNOGRAPHY:

PETCO2 as an estimate of paco2: [30]

Normal $ETCO_2$= 35-45 mmhg

Normal (a – ET) pCO_2 = 2-5 mmhg

Increased: Elderly

Pulmonary disease- Emphysema, Embolism

Decreased cardiac output

Hypovolemia

Anaesthesia

Decreased: Large tidal volumes

Low frequency ventilation

Pregnancy

Infants

Apparatus:

Integrity of anaesthetic apparatus:

- Exhausted CO_2 absorbent
- Leaks in circuits
- Disconnections within the system
- Valve malfunction
- Partial / total occlusion of endo tracheal tube
- Accidental extubation

Adjustments of fresh gas flows in rebreathing systems:

Intubation:

- Detect oesophageal intubation
- Blind nasal intubation
- Proper positioning of double lumen tubes
- Detection of endobronchial intubation

Respiration:

Apnea & hypoventilation:

- Adequacy of spontaneous ventilation during general anaesthesia & recovery

Depth of anaesthesia:

- In spontaneously breathing patients

Brochospasm:

- Prolongation of expiratory upstroke

Hyperventilation:

Circulation:

Cardiac output:

- Decrease in cardiac output shows a fall in $ETCO_2$

Cardiopulmonary resuscitation: [31]

- Effectiveness of resuscitative attempts
- Prognostic significance

Air embolism:

- Rapid decrease in $ETCO_2$

Venous CO_2 embolism:

- Transient but rapid rise in $ETCO_2$ –early sign
- Large embolus- Decrease in $ETCO_2$

Metabolism:

Increase in $ETCO_2$:

- Malignant hyperthermia, Thyrotoxic crisis

- Shivering, convulsions
- Laparoscopy
- Administration of blood or bicarbonate

Decrease in $ETCO_2$:

- Hypothermia
- Increased depth of anaesthesia
- Increased muscle relaxation

Special situations:

LMA & capnography: [29,32]

- $ETCO_2$ measured via LMA/ETT correlate well with $PaCO_2$ both during mechanical ventilation and spontaneous ventilation in children as well as in adults.

Laparoscopy & capnography: [33,34]

- Non-invasive monitor of $PaCO_2$ during CO_2 insufflation
- Detection of accidental intravascular CO_2 insufflation
- Detection of complications - Pneumothorax

Thoracic anaesthesia:

- **Biphasic capnogram**: Lateral decubitus position
  Single lung transplantation
  Some patients with COPD
- **Reverse phase III:** Emphysema

- **Dual lung capnography:** used with double lumen tubes (DLT)

  CO_2 assessed from each limb of the DLT

Capnography in infants & children: [29, 35]

- Interaction between physical & physiological factors lead to normal variants in capnogram
- Mainstream capnometers are more accurate
- Distal $PETCO_2$ measurements used if the child is <12 kg

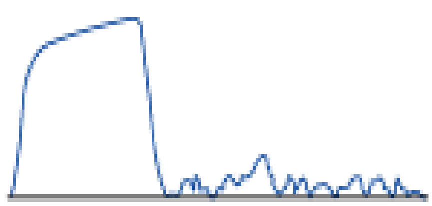
Intensive care unit:

- **To choose the best PEEP**: Best PEEP produces smallest

  a-ET PCO_2 gradient
- **Weaning:** useful noninvasive monitor to assess weaning
- **To monitor changes in dead space**
- **Percutaneous tracheostomy**
- **To confirm correct feeding tube placement**

Abnormal capnograms:

Sudden loss of $EtCO_2$ to zero or near zero:



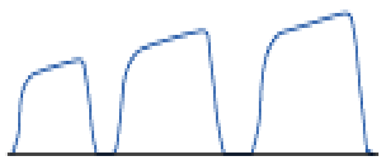
Possible causes:

Airway disconnection

Dislodged ET tube/oesophageal intubation

Totally obstructed/kinked ET tube

Gradually increasing $EtCO_2$:



Possible causes:

Hypoventilation

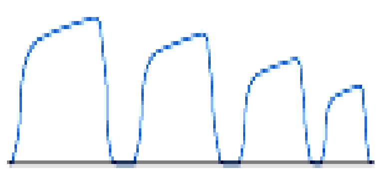
Rising body temperature/malignant hyperthermia

Increased metabolism

Partial airway obstruction

Absorption of CO_2 from exogenous source

Exponential decrease in $EtCO_2$:



Possible causes:

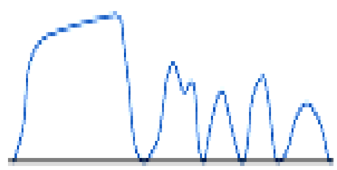
Cardiopulmonary arrest

Pulmonary embolism

Sudden hypotension; massive blood loss

Cardiopulmonary bypass

Sudden decrease in $EtCO_2$ to low non-zero value:



Possible Causes:

Leak in the airway system

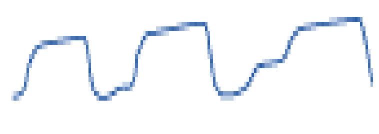
ET tube in hypo pharynx

Poorly fitting anaesthetic mask

Partial airway obstruction

Partial disconnect from ventilator circuit

Rise in Baseline and $EtCO_2$:



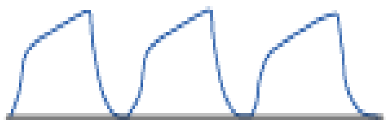
Possible causes:

Defective exhalation valve

Rebreathing of previously exhaled CO_2

Exhausted CO_2 absorber

Sustained low $EtCO_2$ without alveolar plateau:



Possible causes:

Incomplete exhalation

Partially kinked ET tube

Brochospasm

Mucous plugging

Poor sampling techniques

REVIEW OF LITERATURE

Dr.A.I.J. Brain originally described the LMA primarily as an alternative to facemask and endotracheal tube**.** But ever since its development the LMA has challenged the assumption that tracheal intubation is the only acceptable way to maintain a clear airway and provide positive pressure ventilation.

The main complications of using a LMA relate to the airway seal pressure of its cuff. The LMA cuff seal pressure is the inflation pressure above which gas can escape around the cuff. This is lower than with a tracheal tube, so there is a greater risk of gastric insufflation, gastro-oesophageal reflux and aspiration of regurgitated gastric contents when using an LMA. For the same reason for many anesthesiologists the combination of LMA and positive pressure ventilation evokes fear of gastric distension, pulmonary aspiration of gastric contents and inadequate ventilation.

Despite this, the LMA has gained widespread popularity for gynaecologic laparoscopic procedures in the UK**.** Over the past decade, case reports, surveys and small series have described the elective use of the LMA in settings that heretofore would have been considered at best ill advised.

1. Nyarwaya JB, **Mazoit JX**, **Samii K**; **Anaesthesia; 1994** [33]

Cardio respiratory changes induced by pneumoperitoneum and head-up tilt may generate alveolar ventilation to perfusion ratio changes and increased systemic vascular resistances. The reliability of end-tidal carbon dioxide tension and pulse oximetry in predicting arterial carbon dioxide partial pressure and arterial oxygen saturation may therefore be affected. So a study was designed to find if pulse oximetry and end-tidal carbon dioxide tension monitoring were reliable during laparoscopic surgery. They concluded that end-tidal carbon dioxide partial pressure and pulse oximetric saturation allow reliable monitoring of arterial carbon dioxide partial pressure and arterial oxygen saturation in the absence of pre-existing cardiopulmonary disease and/or acute perioperative disturbance.

2. Devitt JH, Wenstone R, Noel AG, O'Donnell MP; Anaesthesia;1995[17]

Since the utility of the laryngeal mask airway during positive-pressure ventilation was yet to be determined they designed a study to assess whether significant leaks occurred with positive-pressure ventilation and if leaks were associated with gastro oesophageal insufflation. They concluded that ventilation using the laryngeal mask was safe and adequate if airway resistance and pulmonary compliance are normal. They also came to a conclusion that gastro oesophageal insufflation of air will become a problem in the presence of increased airway pressure.

3. Brimacombe JR; Can J Anaesth; 1995 [4]

A meta-analysis was performed on randomized prospective trials comparing the laryngeal mask airway with other forms of airway management to determine if the laryngeal mask airway offered any advantages over the tracheal tube or facemask. Advantages over the tracheal tube included: increased speed and ease of placement by inexperienced personnel; increased speed of placement by anaesthetists; improved hemodynamic stability at induction and during emergence; minimal increase in intraocular pressure following insertion; reduced anaesthetic requirements for airway tolerance; lower frequency of coughing during emergence; improved oxygen saturation during emergence; and lower incidence of sore throat in adults. Disadvantages over the tracheal tube were lower seal pressures and a higher frequency of gastric insufflation.

4. Wurst H, Schulte-Steinberg H, Finsterer U; Anaesthetist; 1995[56]

Two groups of 22 patients each were studied in a prospective, randomized fashion during laparoscopic cholecystectomy and carbon dioxide pneumoperitoneum with regard to end-tidal and arterial PCO_2 and pulmonary elimination of carbon dioxide. They found that if during laparoscopic cholecystectomy with carbondioxide - pneumoperitoneum patients were ventilated with constant minute ventilation, a moderate increase in $paCO_2$ of about 10 mm Hg occurred. They concluded that if $paCO_2$ is to be held constant during pneumoperitoneum, minute ventilation has to be increased by about 40%.

5. Verghese C, Brimacombe JR; Anesth Analg; 1996. [5]

A survey of laryngeal mask airway usage was conducted by them to provide information about safety and efficacy with special emphasis on controversial issues such as positive pressure ventilation, prolonged anesthesia, and laparoscopic and nonlaparoscopic intraabdominal surgery. They came to a conclusion that laryngeal mask airway technique is safe and effective for both spontaneous and controlled ventilation. They also concluded that the use of the laryngeal mask airway for gynaecologic laparoscopy, and procedures > 2 hours was safe.

6. Voyagis GS, Papakalou EP; Acta Anaesthesiol Belg ; 1996[52]

The use of laryngeal mask airway size 3 or 4, and endotracheal tube 8.0 mm was studied comparatively to determine the adequacy of respiratory function during positive pressure ventilation by applying a series of given peak inspiratory pressures of 10.0, 12.5, 15.0, 17.5, 20.0 and 30.0 cm H_2O. They found that higher values of tidal volumes were expired via the laryngeal mask airway compared with endotracheal tube when a given peak inspiratory pressures of less than 20 cmH_2O was applied. They also found that laryngeal mask airway as opposed to endotracheal tube secured normocapnia during positive pressure ventilation with low peak inspiratory pressures.

7. Chhibber AK, Kolano JW, Roberts WA; Anaes Analg ;1996[32]

The study was done to study the relationship between end-tidal and arterial carbon dioxide with laryngeal mask airways and endotracheal tubes in children. They concluded that in infants and children weighing more than 10 kg who are mechanically ventilated via the laryngeal mask airway end tidal carbon dioxide value is as accurate an indicator of $PaCO_2$ as when ventilated via endotracheal tube.

8. Bures E, Fusciardi J, Lanquetot H; Acta Anaesthesiol scand ;1996[55]

During laparoscopic cholecystectomy the arterial-end-tidal CO_2 gradient (Pa-$ETCO_2$) has been variously shown to be unchanged, increased, decreased or even negative. The goal of this study was to evaluate Pa-$ETCO_2$, and to determine the proper contribution of Ventilatory adequacy in regard to the increase of $PETCO_2$. They concluded that only exogenous CO_2 loading, and not ventilatory adequacy, could explain such increase in $PETCO_2$ and $PaCO_2$, in cases of limited CO_2 insufflating pressure in ASA 1-2 patients.

9. Buniattian AA, Dolbneva EL; 1997[43]

This study was aimed at assessing the air tightness of the airways during the use of a laryngeal mask under muscle paralysis and positive pressure ventilation of the lungs with carboperitoneum during laparoscopic cholecystectomy. They concluded that though pneumoperitoneum caused increases in ETCO2, PCO2, inspiratory pressures and decreases in breathing volume and lung compliance the combination of laryngeal mask, neuromuscular blockers and positive pressure ventilation may be successfully and safely used in clinical practice.

10. Ho BY, Skinner HJ, Mahajan RP; Anaesthesia; 1998[44]

This study aimed to evaluate whether or not the use of intermittent positive pressure ventilation via the laryngeal mask airway is associated with a higher risk of gastro-oesophageal reflux when compared with intermittent positive pressure ventilation via a tracheal tube in patients undergoing day case gynaecological laparoscopy. They found no evidence to suggest that the use of intermittent positive pressure ventilation via the laryngeal mask increases the risk of gastro-oesophageal reflux in patients undergoing elective day case gynaecological laparoscopy.

11.Latorre F, Eberle B, Weiler N, Mienert R; Anaes Analg ;1998[50]

Since a potential risk of the laryngeal mask airway is an incomplete mask seal causing gastric insufflation or oropharyngeal air leakage, the objective of the study was to assess the incidence of laryngeal mask airway malpositions by fiberoptic laryngoscopy, and to determine their influence on gastric insufflation and oropharyngeal air leakage. Fiberoptic verification of mask position revealed sub optimal placement of laryngeal mask airway in 40% of cases. They concluded that such malpositioning considerably increased the risk of gastric air insufflation when laryngeal mask airway is used combined with positive pressure ventilation.

12.Fassoulaki A, Paraskeva A, Karabinis G; Acta Anaesthesiol Belg; 1999[51]

They studied the ventilatory adequacy and respiratory mechanics during positive pressure ventilation via the laryngeal mask airway as compared with the respiratory mechanics via the tracheal tube. They concluded that, in patients with normal airway pressure and compliance, positive pressure ventilation using the laryngeal mask airway is comparatively effective with the use of endotracheal tube.

13. Hirvonen EA, Poikolainen EO, Paakkonen ME; surg endosc;2000[54]

The increased intra-abdominal pressure during pneumoperitoneum, together with the head-up tilt used in upper abdominal laparoscopies, would be expected to decrease venous return to the heart. The goal of this study was to determine whether laparoscopy impairs cardiac performance when preventive measures to improve venous return are taken, and to analyze the effects of positioning, anesthesia, and increased intra-abdominal pressure. With the passive head-up tilt in awake and anesthetized patients, the cardiac index, central venous pressure, and pulmonary capillary wedge pressure decreased, and systemic vascular resistance increased. They concluded that the head-up positioning accounts for many of the adverse effects in hemodynamics during laparoscopic cholecystectomy. .

14. Roger Maltby, Michael T, Beriault, Neil. C. Watson; CJA; 2000[42]

They studied gastric distension and ventilation during laparoscopic cholecystectomy comparing LMA-Classic vs. tracheal intubation. They concluded that positive pressure ventilation with a correctly placed LMA-Classic of appropriate size permits adequate pulmonary ventilation and that gastric distension occurred with equal frequency with either airway device.

15. Lu PP, Brimacombe J, Yang C, Shyr M; Br J Anaesthesia ;2002[40]

They did the study to test the hypothesis that the ProSeal laryngeal mask airway is a more effective ventilatory device than the Classic laryngeal mask airway for laparoscopic cholecystectomy. They concluded that the ProSeal laryngeal mask airway is a more effective ventilatory device for laparoscopic cholecystectomy than the Classic laryngeal mask airway. Further they recommended against the use of the Classic laryngeal mask airway for laparoscopic cholecystectomy.

16. Maltby JR, Beriault MT, Watson NC, Liepert DJ; Can J Anaesth.2002[49]

The study was done to compare LMA-ProSeal with endotracheal tube with respect to pulmonary ventilation and gastric distension during laparoscopic cholecystectomy. They concluded that a correctly seated LMA-ProSeal or endotracheal tube provided equally effective pulmonary ventilation without clinically significant gastric distension in all non-obese patients.

17. Natalini G, Lanza G, Rosano A, Dell'Agnolo P; J clin anesthesia; 2003[46]

They compared the airway seal and frequency of sore throat with the LMA-ProSeal and the standard laryngeal mask airway during laparoscopic surgery. They concluded that The LMA-ProSeal and the laryngeal mask airway show similar airtight efficiency during laparoscopy.

18. Maltby JR, Beriault MT, Watson NC, Liepert DJ, Fick GH; 2003[47]

They conducted a study to compare the laryngeal mask airways, LMA-Classic and LMA-ProSeal with the endotracheal tube with respect to pulmonary ventilation and gastric distension during gynaecologic laparoscopy. They came to a conclusion that correctly placed LMA-Classic or LMA-ProSeal is as effective as an endotracheal tube for positive pressure ventilation without clinically important gastric distension in non-obese and obese patients.

19. Viira D, Myles PS; Anaesth Intensive Care; 2004.[45]

They did a literature search and found limited evidence to support or refute the use of the laryngeal mask airway in the setting of gynaecologic laparoscopy. They however found that the reported incidence of aspiration or more serious morbidity associated with the use of the laryngeal mask airway in laparoscopic surgery is very low.

20. Piper SN, Triem JG, Rohm KD, Maleck WH, Schollhorn TA; 2004[48]

The aim of this study was to assess the practicality of the ProSeal laryngeal mask airway during laparoscopic surgery with capnoperitoneum compared to endotracheal intubation. They concluded that the ProSeal laryngeal mask airway is a convenient and practicable approach for anaesthesia in patients undergoing laparoscopic surgery.

21. Chmielewski C, Snyder-Clickett S; AANA J; 2004[53]

The purpose of this article was to discuss the benefits, safety, and efficacy of the laryngeal mask airway and identify the risks and misconceptions associated with laryngeal mask airways when used with positive pressure ventilation. They concluded that when compared to other airway adjuncts, however, the laryngeal mask airway is a safe, effective means of delivering ventilation under anesthesia.

MATERIALS AND METHODS

Study design:

This study was a randomized prospective comparative study.

Study setting and population:

After obtaining institutional ethical committee clearance, the study was carried out in the General Surgery OT, Department of Anaesthesiology, Madras Medical College, Chennai, from October 2005 to March 2006.

The study was conducted in 40 adult patients of either sex between the age group of 18- 50 years belonging to ASA status I-II posted for elective laparoscopic cholecystectomy at the Government General Hospital-Chennai.

Inclusion criteria:

- Adults of either sex
- 18-50 years
- ASA physical status I – II
- Mallampatti class I-II

Exclusion criteria: [36]

- H/O hiatus hernia
- Reflux oesophagitis
- BMI (body mass index) >30 kg/m^2
- Diabetes mellitus
- MPC (Mallampatti classification) > II
- Symptoms related to laryngopharyngeal morbidity

- Musculoskeletal abnormalities affecting the cervical vertebrae

Study method:

Patients were randomized into 2 groups:

- Study group (**Group L):** LMA for airway management
- Control group (**GroupE**): ETT for airway management

Patients fasted overnight. They were given aspiration prophylaxis with Tab. Ranitidine 150 mg on the night before and Inj. Ranitidine 50 mg i.v & Inj. Metoclopramide 10 mg i.v 1 hr before surgery[37,38]. Patients were premedicated with Inj. Glycopyrrolate 0.2 mg i.m 1 hr before surgery. Ryle's tube was put and the stomach contents aspirated before induction. After placement of routine monitoring devices and preoxygenation, patients were induced with Inj. Propofol 2-3 mg/kg i.v, Inj. Pentazocine lactate 0.5 mg/kg i.v, Inj. Lignocaine 1 mg/kg i.v and Inj. Vecuronium 0.1mg/kg i.v. Anaesthesia was in the supine position with the patient's head on a standard pillow 8 cm in height.

Group L (LMA):

For women a size # 3 LMA inflated with 20 ml of air was used and for men size # 4 LMA inflated with 30 ml of air was used**.** A clear, water-based gel was used for lubrication. Ryles tube was removed before LMA insertion. Positive pressure was not applied until LMA insertion. The correct placement of LMA was confirmed by the absence of leak on auscultation over the epigastrium and neck and adequate chest expansion at airway pressure 20 cm water during manual ventilation and a square-wave capnograph trace[39]. Fixation was by taping the tube over the chin. A rolled gauze swab was used as a bite block with the LMA. Failed insertion attempt was defined as removal of the device from the mouth. Three attempts were allowed before insertion was considered a failure[40].

Group E (ETT):

For women ETT size 7.0/7.5 mm and for males size 8.0/8.5 mm was used. Cuff inflated to provide an airtight seal. Position was confirmed clinically and with capnography. After placement of ETT Ryle's tube was aspirated and removed.

For both groups anesthesia was maintained with isoflurane in O_2 & N_2O mixture at a FIO_2 of 0.5% administered through a circle system with CO_2 absorption. Fresh gas flows were kept at 4 L/min. Neuromuscular blockade was maintained with vecuronium. Residual blockade was reversed with Inj. Glycopyrrolate 0.01 mg/kg and Inj Neostigmine 0.05 mg/kg i.v at the end of the procedure.

Ventilation parameters were initially set at a tidal volume of 10 ml/kg at a rate of 15 breaths/min. Intraoperatively the minute ventilation was adjusted to maintain an ETCO2 between 35-40. Abdominal insufflation pressures were limited to 15 mm/hg[41].

Oxygenation was considered as a failure if SPO2 fell between 95%-90%. It was considered as a failure if SPO2 fell < 90%[40]. Ventilation was considered sub optimal if ETCO2 was > 45 mmhg and a failure if ETCO2 was >55 mmhg.[40]

The surgeon scored gastric distension on a visual analog scale of 0-10, where 0=empty stomach and 10=distension that interfered with surgical exposure at the entry of the laparoscope following peritoneal insufflation and immediately before removal of the laparoscope at the end of the surgical procedure[42].

RESCUE MANOUVRES:

- **Failure of oxygenation or ventilation with LMA:**[40]
  - Gas released from abdominal cavity
  - Patient preoxygenated and intubated
- **Significant gastric distension (interfering with surgery) with LMA**:[36]
  - Passage of Ryle's tube behind partially deflated LMA and emptying of the stomach
  - Alternatively tracheal intubation
- **Suspected aspiration with LMA:** [36]
  - LMA left in place and head down positioning of the patient
  - Plane deepened with Propofol
  - Ventilation with 100% oxygen and with small tidal volumes
  - Suctioning of the LMA and bronchial tree
  - Intubation if clinical deterioration present

Patients were shifted to PACU and monitored post-operatively.

PARAMETERS OBSERVED:

Vitals: SPO_2, Non-invasive blood pressure, ECG, Pulse rate

Ventilation parameters: $ETCO_2$, minute ventilation, airway pressure, FIO_2, fresh gas flow.

Gastric distension:

Intra-op problems: Inadequate ventilation, hemodynamic instability, arrhythmias,

Insufflation time:

Anaesthesia time:

Post-extubation problems: cough/laryngospasm/nausea/vomiting

OBSERVATION AND RESULTS

The laryngeal mask airway (LMA) and the endotracheal tube (ETT) were compared based on the following parameters:

- Ventilation parameters: Minute ventilation
  End tidal carbon dioxide (EtCO2)
  Oxygen saturation
  Airway pressure
- Gastric distension:
- Post-extubation problems: Coughing
  Vomiting
  Breath-holding
  Laryngospasm
  Brochospasm
- Duration: Insufflation time
  Anaesthesia time

The groups were:

Study group (**GROUP L**): LMA

Control group (**GROUP E):** ETT

The patients in both the groups were compared using students t test (for measured variables) and fischer's exact test (for discrete variables). Chi square test was used to compare sex differences.

Demographic variables

	Group	N	Mean	Std. Deviation	Student t-test
Age	Case	20	33.85	8.002	t=0.28 p=0.78 (NS)
	Control	20	31.55	7.942	
Weight	Case	20	51.95	5.434	t=0.18 p=0.86 (NS)
	Control	20	50.45	6.893	
BMI	Case	20	22.25	1.410	t=1.34 p=0.19 (NS)
	Control	20	21.50	2.065	

BMI-Body mass index NS- Not significant

The average age of the patients in the study group was 34 ± 8 years, whereas in the control group it was 32 ± 8 years. There was no statistically significant difference between the two groups. ($p>0.05$)

The average weight of the patient in the study group was 52 ± 5 kg compared to the control group where the average weight was 50 ± 7 kg. There was no statistically significant difference between the two groups. ($p>0.05$)

The average body mass index of the patients in the study group was 22 ± 1, whereas in the control group it was 21 ± 2.There was no statistically significant difference between the two groups. ($p>0.05$)

Sex

		Group		Total
		Case	Control	
Sex	Male	4	6	10
	Female	16	14	30
Total		20	20	40

There was no statistically significant difference between the two groups based on the distribution of sex characteristics. **$\chi 2$=0.53 P=0.46** (not significant)

Saturation percentage of oxygen (SPO2)

	Group	N	Mean	Std. Deviation	Student t-test
SPO_2-B	Case	20	99.00	.000	t=0.00 p=1.00 (NS)
	Control	20	99.00	.000	
SPO_2-P	Case	20	99.00	.000	t=0.00 p=1.00 (NS)
	Control	20	99.00	.000	

B- Baseline P- Pneumoperitoneum NS- Not significant

In both the study and control groups the oxygen saturation was 99 % at baseline as well as during insufflation showing no significant difference. ($p > 0.05$)

End tidal carbon dioxide (ETCO2)

	Group	N	Mean	Std. Deviation	Student t-test
$PETCO_2$-B	Case	20	32.25	0.933	t =0.30 p=0.77 (NS)
	Control	20	31.50	1.164	
$PETCO_2$-P	Case	20	37.10	1.814	t=0.29 p=0.77 (NS)
	Control	20	36.50	1.357	
$PETCO_2$- I	Case	20	5.000	1.777	t=0.44 p=0.66 (NS)
	Control	20	4.750	1.802	

B- Baseline I- Increase NS- Not significant
P- Pneumoperitoneum

The average baseline $ETCO_2$ values were 32 ± 1 mmhg in the study group whereas in the control group it was 31 ± 1 mmhg, showing no significant difference. ($p > 0.05$)

The average $ETCO_2$ values during pneumoperitoneum were 37 ± 2 mmhg in the study group whereas in the control group it was 36 ± 1 mmhg, showing no significant difference. ($p > 0.05$)

The average increase in $ETCO_2$ values from baseline to pneumoperitoneum was 5 ± 2 mmhg in both the study group and the control group, showing no significant difference. ($p > 0.05$)

Minute ventilation (Vmin)

	Group	N	Mean	Std. Deviation	Student t-test
VMIN-B	Case	20	6.363	.625	t=0.05 p=0.96 (NS)
	Control	20	6.375	.837	
VMIN-P	Case	20	9.600	1.113	t=0.31 p=0.76 (NS)
	Control	20	9.475	1.422	
VMIN- I	Case	20	3.237	.954	t=0.48 p=0.64 (NS)
	Control	20	3.100	.859	

B- Baseline I- Increase NS- Not significant
P- Pneumoperitoneum

The average baseline minute ventilation was 6 ± 0.5 liters in the study group whereas in the control group it was 6 ± 1 liters, showing no significant difference. ($p > 0.05$)

The average minute ventilation during pneumoperitoneum was 10 ± 1 liters in the study group whereas in the control group it was 9 ± 1 liters, showing no significant difference. ($p > 0.05$)

The average increase in minute ventilation values from baseline to pneumoperitoneum was 3 ± 1 liters in both the study group and the control group, showing no significant difference. ($p > 0.05$)

Airway pressure (AWP)

	Group	N	Mean	Std. Deviation	Student t-test
AWP- B	Case	20	16.65	1.694	t=1.44 p=0.15 (NS)
	Control	20	17.50	2.283	
AWP- P	Case	20	20.70	1.750	t=1.5 p=0.14 (NS)
	Control	20	21.60	2.037	
AWP- I	Case	20	4.05	1.538	t=0.44 p=0.66 (NS)
	Control	20	4.10	2.268	

	Group	N	Mean	Std. Deviation	Student t-test
Case	AWP- B	20	16.65	1.69	t=7.49 p=0.001 (S)
	AWP- P	20	20.20	1.75	
Control	AWP- B	20	17.5	2.20	t=6.01 p=0.001 (S)
	AWP- P	20	21.6	2.23	

B- Baseline I- Increase S- Significant NS- Not significant
P- Pneumoperitoneum

The average baseline airway pressure was 17 ± 2 cmH_20 in the study group whereas in the control group it was 18 ± 2 cmH_20, showing no significant difference. ($p > 0.05$)

The average airway pressure during pneumoperitoneum was 21 ± 2 cmH_20 in the study group whereas in the control group it was 22 ± 2 cmH_20, showing no significant difference. ($p > 0.05$)

Within the study group and the control group there was a significant increase in the airway pressure from baseline to pneumoperitoneum. ($p < 0.05$)

The average increase in airway pressure values from baseline to pneumoperitoneum was 4 ± 2 cmH_20 in both the study group and the control group, showing no significant difference. ($p > 0.05$)

Gastric distension (GD)

	Group	N	Mean	Std. Deviation	Student t-test
GD-INC	Case	20	1.95	0.826	t=2.63 p=0.01 (S)
	Control	20	1.30	0.733	

INC – Increase S- Significant

Two cases in the control group had no increase in gastric distension score during the procedure compared to one such case in the study group.

The maximum gastric distension-increase score was 3, which occurred in five cases in the study group compared to one such case in the control group.

The average increase in the gastric distension score was 2 ± 1 in the study group whereas in the control group it was 1 ± 1, showing a statistically significant difference between the two groups. ($p < 0.05$)

Duration

	Group	N	Mean	Std. Deviation	Student t-test
I- TIME	Case	20	74.25	19.485	t=0.19 p=0.84 (NS)
	Control	20	75.50	20.449	
A- TIME	Case	20	81.45	20.621	t=1.28 p=0.21 (NS)
	Control	20	90.50	23.836	

A- Anaesthesia I-Insufflation (pneumoperitoneum)
NS- Not significant

The average insufflation time was 74 ± 19 mins in the study group compared to 75 ± 20 mins in the control group, showing no significant difference. ($p > 0.05$)

The average anaesthesia time was 81 ± 21 mins in the study group compared to 90 ± 24 in the control group, showing no significant difference. ($p > 0.05$)

Events related to extubation

Events	Case N=20	Control N=20	x^2 Fischer exact t test
Cough	2	4	p = 0.66 (NS)
Laryngospasm/ Bronchospasm	Nil	Nil	
Nausea & Vomiting	2	1	p = 1.00 (NS)
O_2 desaturation	Nil	Nil	
Blood on airway device	2	Nil	p = 0.48 (NS)

NS- Not significant

There was no significant difference between the two groups based on events related to extubation. ($p>0.05$)

Coughing was more common in the ETT group.(2O%)

The incidence of sore throat or dysphagia could not be determined on the first postoperative day because of the presence of Ryles tube

DISCUSSION

The LMA was designed by ARCHIE.I.J.BRAIN between 1981-85. Original purpose was to reduce the need for more invasive means of airway management while offering a more reliable alternative to the facemask, at the same time less stressful compared to the tracheal tube.

The major limiting factor with the use of LMA is the lack of airway protection from regurgitated stomach contents. Physiologically inappropriate stimulation of pharyngeal receptors can produce abnormal oesophageal motility and relaxation of the lower oesophageal sphincter. However the incidence of clinically detectable reflux is much lower at approximately 0.1%[20,21]. One factor preventing aspiration may be the persistent function of the upper oesophageal sphincter. The overall incidence of pulmonary aspiration with LMA is 2/10,000[22,23].

Incidence of clinically detectable gastric distension is low (0%-0. 3%)[16]. The incidence increases with increasing airway pressure and tidal volume. It also depends on the precise position of LMA and the way it is secured. If the gastric leak is sufficiently large or prolonged then significant gastric distension can occur leading to impaired respiratory function and increasing the risk of regurgitation.

The low-pressure seal formed by LMA with the periglottic tissues makes the LMA only partially suitable for positive pressure ventilation because it may predispose to gastric insufflation, inadequate ventilation or both. However a large number of clinical trials have shown that patients with normal lung compliance may be mechanically ventilated through the LMA to airway pressures of 20 cm H_20 with minimal risk of gastric insufflation. However the tidal volumes should be 8-10 ml/kg.

Doyle et al[57] stated that the increase in abdominal pressure during laparoscopy may result in an increase in gastro-oesophageal reflux. However **Lind et al**[58] suggested that the increase in abdominal pressure during laparoscopy causes a reflex increase in tone of lower oesophageal sphincter. This increases the normal barrier pressure of 30 cm H_2O and provides further protection from passive reflux.

In this study the baseline SPO2 values were 99% in both the study (LMA) and the control group (ETT), showing no significant difference (p=1.00). During carbon dioxide insufflation, ventilation was adequate to maintain a saturation of 99% in both the groups showing no significant difference (p=1.00), which was in concordance with the studies done by **Maltby et al**[42], **Buniattian et al**[43] and **Natalini et al**[46]. These authors have shown that maintenance of adequate oxygen saturation is possible with LMA during laparoscopic procedures.

The baseline ETCO2 values were 31 ± 1 mmhg in the study group (LMA) and 32 ± 1 mmhg in the control group (ETT) in this study showing no significant difference (p=0.77). During carbon dioxide pneumoperitoneum the average $ETCO_2$ values were 37 ± 2 mmhg in the study group (LMA) whereas in the control group (ETT) it was 36 ± 1 mmhg, showing no significant difference (p=0.77). The average increases in the $ETCO_2$ values were 5 ± 2 mmhg in both the groups showing no significant difference (p=0.66), which was in concordance with the studies done by **Maltby et al**[42], **Buniattian et al**[43] and **Natalini et al**[46]. In these studies the authors have clearly shown that maintenance of $ETCO_2$ values within the normal values was possible with the laryngeal mask airway during laparoscopic cholecystectomy.

The average minute ventilation required during pneumoperitoneum for the effective elimination of carbon dioxide and maintenance of adequate oxygen saturation in this study was 10 ± 1 liters in the study group (LMA) whereas in the control group (ETT) it was 9 ± 1 liters, showing no significant difference (p = 0.76). The average increase in minute ventilation from baseline to pneumoperitoneum required for the effective elimination of carbon dioxide and maintenance of adequate oxygen saturation in this study was 3 ± 1 liters in both the study group and the control group, showing no significant difference (p = 0.64). This was in concordance with the studies done by **Maltby et al**[42] and **Buniattian et al**[43]**.**

In this study the average baseline airway pressures were 17 ± 2 cmH20 in the study group whereas in the control group it was 18 ± 2 cmH20, showing no significant difference (p = 0.14). During pneumoperitoneum the average airway pressure was 21 ± 2 cmH20 and 22 ± 2 cmH_20, in the study and control groups respectively, showing no significant difference (p = 0.15). In this study the airway pressure showed a significant increase during insufflation within both the groups (p=0.001), in concordance with **Brimacombe et al**[40]**.** The average increase in airway pressure from baseline to pneumoperitoneum was 4 ± 1 cmH_20, (21 cm H_20) in the study group whereas it was 4 ± 2 cmH_20, (22 cm H_20) in the control group, showing no significant difference (p = 0.60) between the two groups which was in concordance with **Maltby et al**[42], **Natalini et al**[46] and **Brimacombe et al**[40]**.** In these studies the authors have shown that though the increase in airway pressure slightly exceeds the recommended values in the LMA group there is no significant difference in the airway pressures between the LMA and endotracheal tube during laparoscopic cholecystectomy.

In this study no increase in the gastric distension during the procedure occurred in two cases in the control group (ETT) compared to one such case in the (LMA) group. The maximum increase in the gastric distension score was 3, which was seen in 5 cases in the (LMA) group compared to 1 case in the (ETT) group. In the (ETT) group > 50% of the cases had a gastric distension increase score of <2, while in the (LMA) group > 50% of the cases had a gastric distension increase score of ≥ 2. The average increase in the gastric distension score from baseline to carbon dioxide pneumoperitoneum was 2 ± 1 in the study group (LMA) whereas in the control group (ETT) it was 1 ± 1,showing a statistically significant difference between the two groups (p =0.01). This was in concordance with the study done by **Brimacombe et al**[40] who showed that significant gastric distension occurred during laparoscopic cholecystectomy when LMA was used. However this finding was in contrast to **Maltby et al**[42] who showed that gastric distension occurred with equal frequency when either the LMA or endotracheal tube was used during laparoscopic cholecystectomy and that this distension was not significant. This might be due to the fact that **Maltby et al**[42] used a larger size LMA (# 4 for females and # 5 for males) in their study as suggested by **Brimacombe et al**[18]. This was not followed in our study because the patients in our study were smaller with an average weight of 50 ± 5 kg compared to the study by **Maltby et al**[42] where the average patient weight was 72 ± 10 kg. The reason for significant gastric distension occurring with the LMA might be because, the LMA is sub optimally placed in 40% of the cases as shown by **Weiler et al**[50]. Using fiber optic confirmation **Weiler et al**[50] showed that in spite of signs of correct clinical placement, the LMA is suboptimally placed in 40% of the patients. Such sub optimal placement might cause the LMA seal to become increasingly leaky in the face of increasing airway pressure during laparoscopy.

The LMA was correctly placed in the first attempt in 17 cases while for 3 cases two attempts were required. Endotracheal intubation was successful in the first attempt in 19 cases while for one case two attempts were required.

In this study we used fresh gas flows of 4 liters. There was no necessity to increase fresh gas flows to compensate for leaks around the LMA cuff. **Maltby et al**[42] have shown that low flow anaesthesia can be safely used with LMA during laparoscopic cholecystectomy.

The incidence of events related to extubation did not show a significant difference between the two groups. Coughing was more common in the ETT group but this was not statistically significant (p=0.69) in concordance with **Maltby et al**[42]. There were no cases of laryngospasm or bronchospasm in both the groups. The incidence of post-operative sore throat or dysphagia could not be determined because all the patients had nasogastric tube introduced in the post-operative period.

No untoward complications were noted in both the groups during the perioperative period.

One case in the study group (LMA) was converted to open procedure due to surgical reasons.

SUMMARY

- The comparative evaluation of the LMA- classic with tracheal intubation for laparoscopic cholecystectomy showed no significant difference between the two groups based on the demographic variables.
- The LMA group maintained effective oxygen saturation similar to the ETT group during pneumoperitoneum showing no significant difference.
- The $ETCO_2$ values were within normal limits in both the groups during pneumoperitoneum and baseline, showing no significant difference.
- The changes in minute ventilation required for effective pulmonary ventilation during pneumoperitoneum were similar between both the groups.
- Similar increases in the airway pressures were seen during pneumoperitoneum in both the groups showing no significant difference.
- Significant increase in the gastric distension occurred in the LMA group during pneumoperitoneum.
- There were no significant differences between the two groups based on the duration of the procedure.
- Regarding events related to extubation/ LMA removal there were no significant differences between the two groups.

CONCLUSION

In spite of the increase in airway pressure during laparoscopy, laryngeal mask airway provides adequate pulmonary ventilation maintaining oxygen saturation and effective elimination of carbon dioxide similar to endotracheal tube. However in the face of an increased airway pressure and increased minute volume requirements, significant gastric distension occurs with the laryngeal mask airway during laparoscopy. Hence the laryngeal mask airway may not be a safe alternative to tracheal intubation for laparoscopic cholecystectomy.

GASTRIC DISTENSION AND VENTILATION DURING LAPAROSCOPIC CHOLECYSTECTOMY: LMA-CLASSIC VS ETT

NAME: AGE/SEX:

IP NO:

WEIGHT: HEIGHT:

BMI:

MPC: LMA/ETT:

ASPIRATION PROPHYLAXIS:

Tab. Ranitidine 150 mg per oral night before procedure.

Inj. Ranitidine-50 mg i.v 1 hr before procedure

Inj.Metoclopramide-10 mg i.v 1 hr before procedure

PREMEDICATION:

Inj. Glycopyrrolate- 0.2 mg i.m 1 hr before procedure

Ryle's tube put and stomach contents emptied before induction

INDUCTION: Inj. Propofol 2-3 mg/kg i.v

Inj. Pentazocine 0.6 mg/kg i.v

MUSCLE RELAXANT: Inj. Vecuronium 0.1 mg/kg i.v

MAINTENANCE OF ANAESTHESIA: 0_2 + N_2O (FiO_2- 0.5 %) + Isoflurane

ABDOMINAL INSUFFLATION PRESSURE: Limited to 15 mmhg

		SPO2 %	PR(ECG /min	NIBP mmhg	$P_{ET}CO_2$	FiO_2	TV Ml	RR/ min	Vmin L	Awp cmH_2O	FGF L
BASELINE											
INSUFFLATION	0										
	5										
	10										
	15										
	20										
	25										
	30										
	35										
	40										
	45										
	50										
	55										
	60										
	65										
	70										
	75										
	80										
	85										
	90										
	95										
	100										
	105										
	110										
	115										
	120										
	125										
	130										
	135										
	140										
	145										
	150										
	155										
	160										
	165										
	170										
	175										
	180										
	185										

INTRA-OP PROBLEMS: Inadequate ventilation

Malposition

Hemodynamic instability

Arrhythmias

LMA replaced with ETT

GASTRIC DISTENSION: Entry score Exit score

(0 – 10) (0 – 10)

ANAESTHESIA TIME:

INSUFFLATION TIME:

EMERGENCE OUTCOMES:

None / Cough / Laryngospasm / Re-intubation

MASTER CHART –ETT

S.NO	NAME	AGE	SEX	HEIGHT	WEIGHT	BMI	SPO2	PR-B	PR-P	NIBP-B	NIBP-P	PETCO2-B	PETCO2-P	TV-B	RR-B	VMIN-B	TV-P	RR-P	VMIN-P	AWP-B	AWP-P	FIO2	FGF	GD ENTRY	GD EXIT	GD-INC	INS TIME	ANS-TIME	ATTEMPTS
1	SOMASUNDARI	28	F	150	45	20	99	102	78	124\94	146/98	32	37	350	15	5.5	350	25	8.75	15	20	0.5	4	2	3	1	45	80	1
2	SELVI	30	F	150	52	23	99	83	66	121/85	154/84	30	39	400	15	6	400	25	10	18	25	0.5	4	1	3	2	80	100	1
3	CHITRA	24	F	155	55	23	99	73	68	122/90	130/90	32	38	450	15	6.75	450	25	11.25	20	20	0.5	4	1	4	3	85	95	1
4	SAROJA	33	F	160	50	20	99	98	72	130/50	152/98	33	40	400	15	6	400	23	9	25	23	0.5	4	1	2	1	60	70	1
5	SARANYA	21	F	155	50	21	99	88	66	112/68	136/82	31	36	400	15	6	400	20	8	18	20	0.5	4	1	2	1	60	80	1
6	VIJI	31	F	150	40	18	99	72	68	115/72	138/98	31	37	350	15	5.5	350	25	8.75	18	22	0.5	4	1	3	2	105	140	1
7	FATHIMA	24	F	150	40	18	99	74	65	123/98	145/95	32	35	350	15	5.5	300	25	7.5	15	22	0.5	4	1	3	2	125	150	1
8	SETTU	45	M	165	55	20	99	88	60	116/74	132/78	30	37	450	15	6.75	500	20	10	18	25	0.5 .	4	1	2	1	30	45	1
9	MANI	45	M	155	55	22	99	66	62	126/82	148/96	35	36	450	15	6.75	450	20	9	18	23	0.5	4	1	2	1	60	70	2
10	THANGARAJ	45	M	160	60	23	99	78	60	129/71	148/98	33	37	500	15	7.5	450	25	11.25	20	25	0.5	4	1	3	2	70	75	1
11	KANIAMMAL	35	F	145	45	21	99	88	78	136/72	146/98	32	36	350	15	5.5	400	20	8	18	20	0.5	4	2	3	1	75	85	1
12	PRIYA	28	F	150	45	20	99	92	76	142/80	154/84	31	35	350	15	5.5	400	20	8	17	21	0.5	4	1	2	1	80	90	1
13	SRIDEVI	32	F	150	50	21	99	78	68	134/76	130/90	32	36	400	15	6	400	23	9	16	21	0.5	4	2	2	0	90	100	1
14	LAVANYA	25	F	155	50	21	99	80	68	142/76	145/95	33	36	400	15	6	400	22	9	18	22	0.5	4	2	3	1	85	95	1
15	MALAR	26	F	155	55	22	99	76	64	138/78	132/78	32	35	450	15	6.75	450	25	9	18	23	0.5	4	1	2	1	75	85	1
16	DURAI	46	M	165	60	23	99	88	72	136/76	148/96	31	37	500	15	7.5	500	25	12.5	21	27	0.5	4	1	3	2	65	70	1
17	PALANI	40	M	160	65	25	99	90	70	122/76	152/98	31	37	550	15	8.25	500	25	12.5	20	24	0.5	4	2	3	1	70	75	1
18	RAMADOSS	40	M	155	60	26	99	80	66	124/68	136/82	31	35	500	15	7.5	500	20	10	21	25	0.5	4	2	2	0	90	110	1
19	VIDHYA	30	F	150	55	23	99	87	70	130/80	138/98	32	36	450	15	6.75	450	20	9	17	22	0.5	4	2	3	1	85	100	1
20	RANI	35	F	150	45	20	99	88	68	128/80	145/95	31	35	350	15	5.5	350	25	9	19	22	0.5	4	1	3	2	75	95	1

BMI- Body mass index PETCO2- End tidal CO_2 RR- Respiratory rate

SPO2- Saturation percentage of oxygen PR- Pulse rate NIBP- Noninvasive blood pressure

TV-Tidal volume FIO2-Inspired oxygen concentration INS-Insufflation

VMIN- Minute ventila B- Baseline ANS- Anesthesia

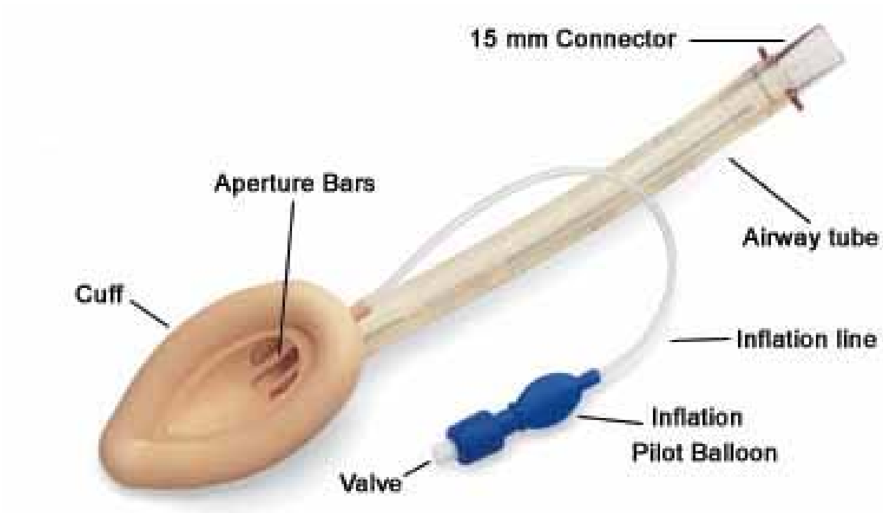
AWP- Airway pressure P- Pneumoperitoneum INC-Increase

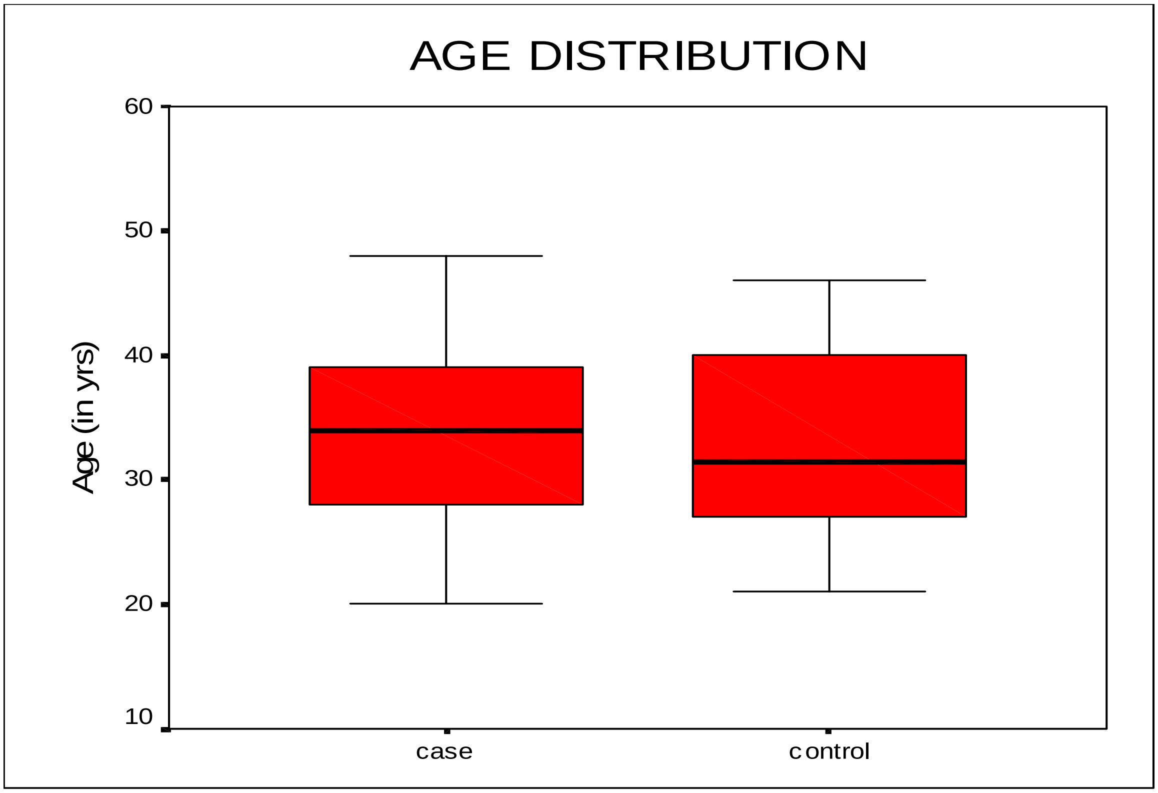
FGF-Fresh gas flow GD- Gastric distension

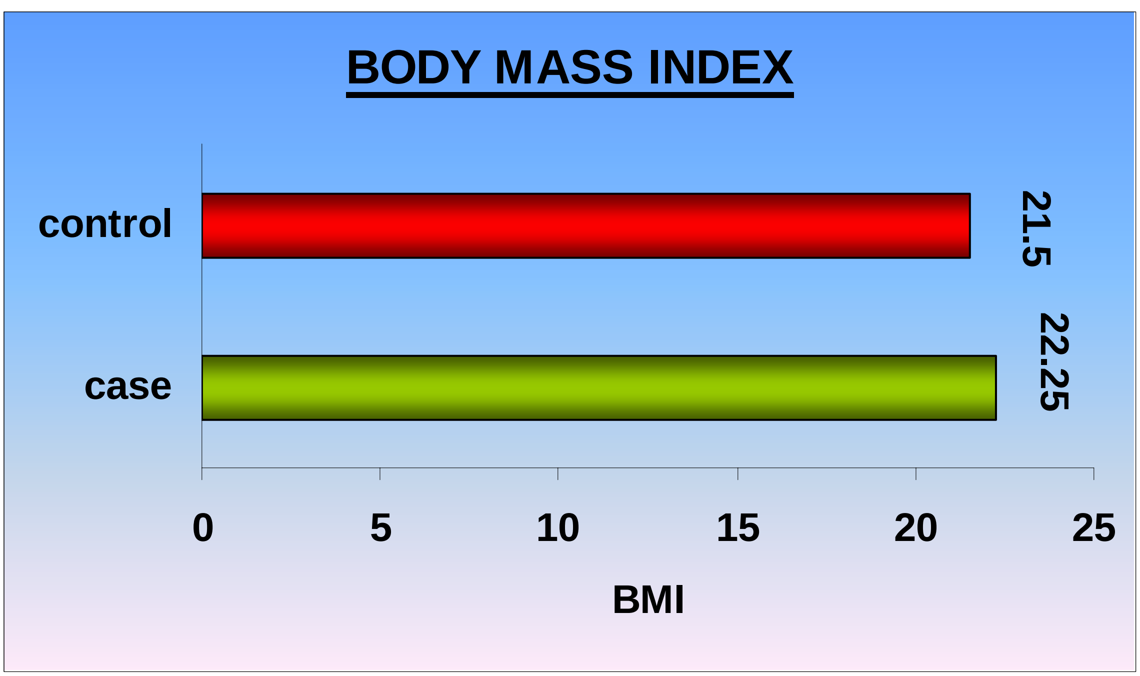
MASTER CHART –LMA

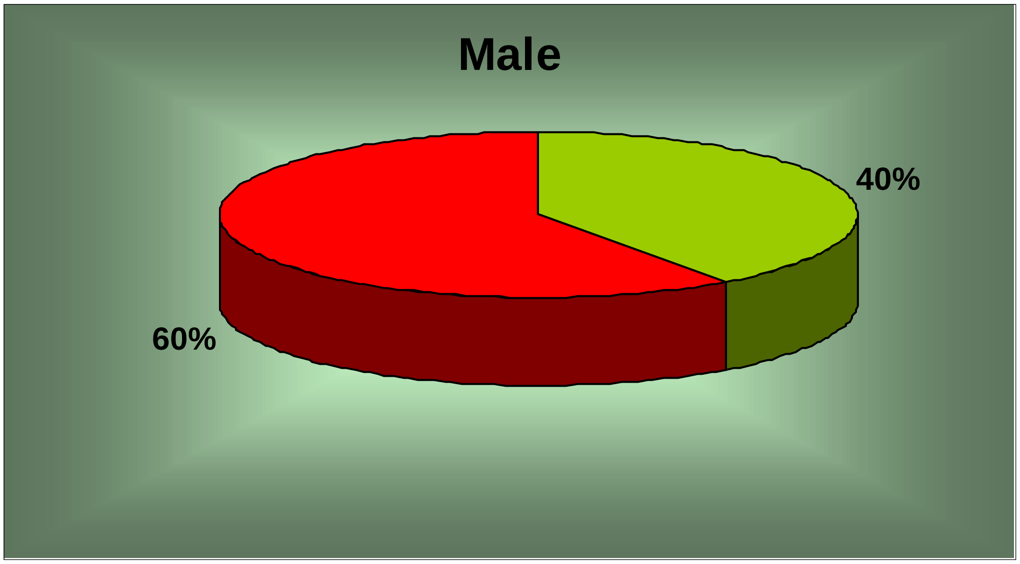
S.NO	NAME	AGE	SEX	HEIGHT	WEIGHT	BMI	SPO2	PR-B	PR-P	NIBP-B	NIBP-P	PETCO2-B	PETCO2-P	TV-B	RR-B	VMIN-B	TV-P	RR-P	VMIN-P	AWP-B	AWP-P	FIO2	FGF	GD-ENTRY	GD-EXIT	GD-INC	I-TIME	A-TIME	ATTEMPTS
1	NAGALAKSHMI	28	F	155	65	26	99	78	72	122/76	136/76	32	40	500	15	7.5	500	25	12.5	18	23	0.5	4	3	6	3	45	69	1
2	MANOJ	21	M	170	65	21	99	83	68	128/78	138/88	33	39	500	15	7.5	450	25	11.25	20	22	0.5	4	1	3	2	35	40	1
3	SHOBA	28	F	155	55	23	99	84	76	118/86	124/78	32	40	450	15	6.75	400	25	10	18	25	0.5	4	1	4	3	85	105	1
4	SARADHA	38	F	150	48	21	99	88	80	132/88	140/96	30	38	400	15	6	350	25	8.75	18	20	0.5	4	3	5	2	75	80	1
5	RENUKA	34	F	155	50	22	99	70	76	122/84	136/98	30	38	500	15	7.5	400	25	10	20	23	0.5	4	1	2	1	115	130	2
6	CHANDRA	48	F	159	55	24	99	62	58	124/84	136/70	34	40	450	15	6.75	400	25	10	16	18	0.5	4	2	4	2	75	85	1
7	MURUGANANDHAN	33	M	160	55	24	99	75	72	116/84	120/90	32	36	450	15	6.75	400	20	8	14	19	0.5	4	2	2	0	110	120	2
8	RAMADOSS	42	M	160	55	24	99	88	70	122/88	112/78	32	35	450	15	6.75	400	22	9	15	20	0.5	4	2	5	3	55	65	1
9	POONGODI	37	F	148	50	22	99	90	70	136/78	122/78	31	36	400	15	6	400	25	10	16	22	0.5	4	1	3	2	70	75	1
10	MAHESHWARI	34	F	145	45	21	99	80	76	132/68	120/80	32	36	350	15	5.5	350	25	10	18	22	0.5	4	1	4	3	75	80	1
11	SUSHEELA	45	F	150	45	20	99	78	72	122/78	116/78	31	35	350	15	5.5	350	20	7.5	15	19	0.5	4	1	3	2	80	85	1
12	PARVEEN BANU	35	F	146	50	21	99	88	68	130/90	120/78	32	35	400	15	6	400	24	9.5	16	20	0.5	4	2	4	2	75	75	1
13	KANDHIMATHY	40	F	148	50	22	99	82	70	120/80	110/70	31	36	400	15	6	400	25	10	15	20	0.5	4	2	4	2	90	90	1
14	SHEEBA	25	F	150	48	22	99	86	68	116/76	120/80	32	36	400	15	6	400	20	8	17	20	0.5	4	2	5	3	90	90	1
15	NESAN	38	M	155	55	23	99	78	66	120/68	112/78	32	35	450	15	6.75	450	20	9	16	19	0.5	4	1	3	2	80	90	1
16	CHITRA	20	F	145	48	22	99	90	68	110/68	114/68	31	36	400	15	6	400	23	9.5	18	21	0.5	4	1	3	2	80	85	2
17	KRISHNAVENI	45	F	150	50	22	99	78	70	110/70	122/60	32	36	400	15	6	400	24	9.5	15	22	0.5	4	2	4	2	75	80	1
18	INDRANI	25	F	150	50	22	99	90	60	122/78	120/78	31	36	400	15	6	400	25	10	16	19	0.5	4	2	3	1	60	65	1
19	SHANTHI	28	F	145	50	21	99	80	62	130/90	114/70	32	35	400	15	6	400	23	9.5	17	20	0.5	4	1	2	1	55	60	1
20	KALAVATHY	33	F	150	50	22	99	72	65	118/78	112/78	31	35	400	15	6	400	25	10	15	20	0.5	4	2	3	1	60	60	1

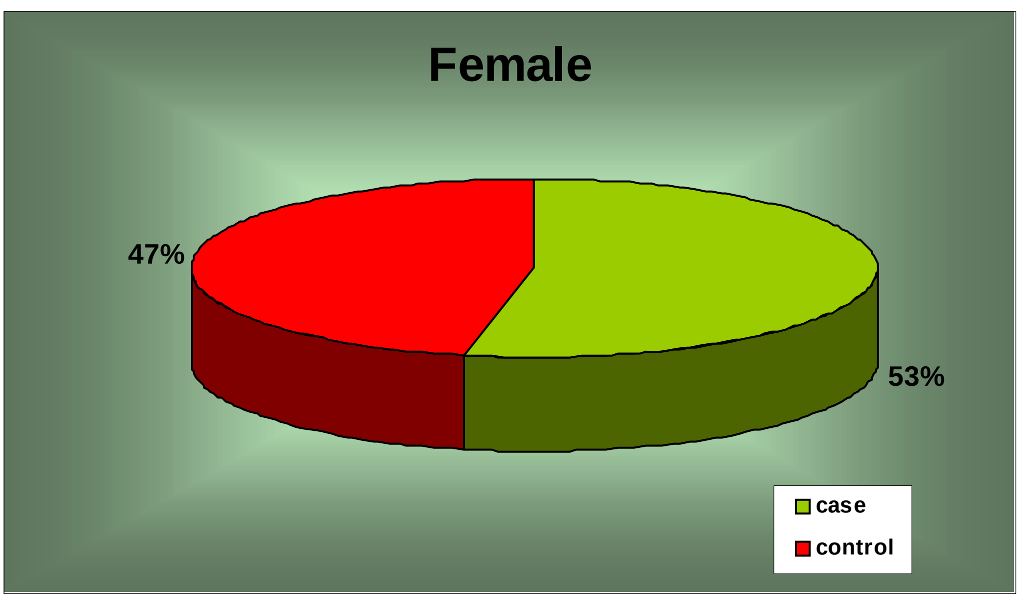
BMI- Body mass index
$PETCO_2$- End tidal CO_2
RR- Respiratory rate
SPO2- Saturation percentage of oxygen
PR- Pulse rate
NIBP- Noninvasive blood pressure
TV-Tidal volume
FIO_2-Inspired oxygen concentration
INS-Insufflation
VMIN- Minute ventila
B- Baseline
ANS- Anesthesia
AWP- Airway pressure
P- Pneumoperitoneum
INC-Increase
FGF-Fresh gas flow
GD- Gastric distension

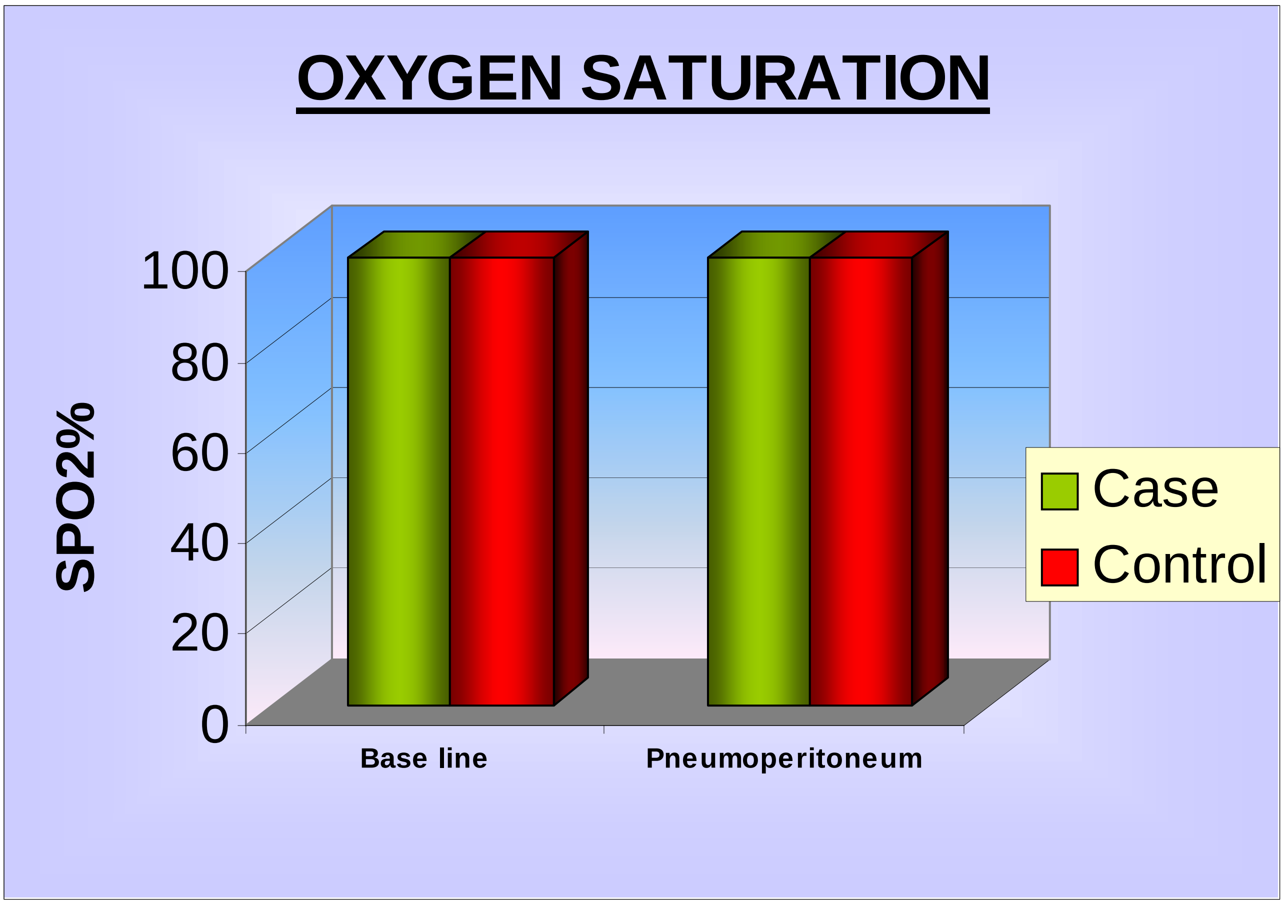

15 mm Connector
Aperture Bars
Airway tube
Cuff
Inflation line
Inflation
Pilot Balloon
Valve

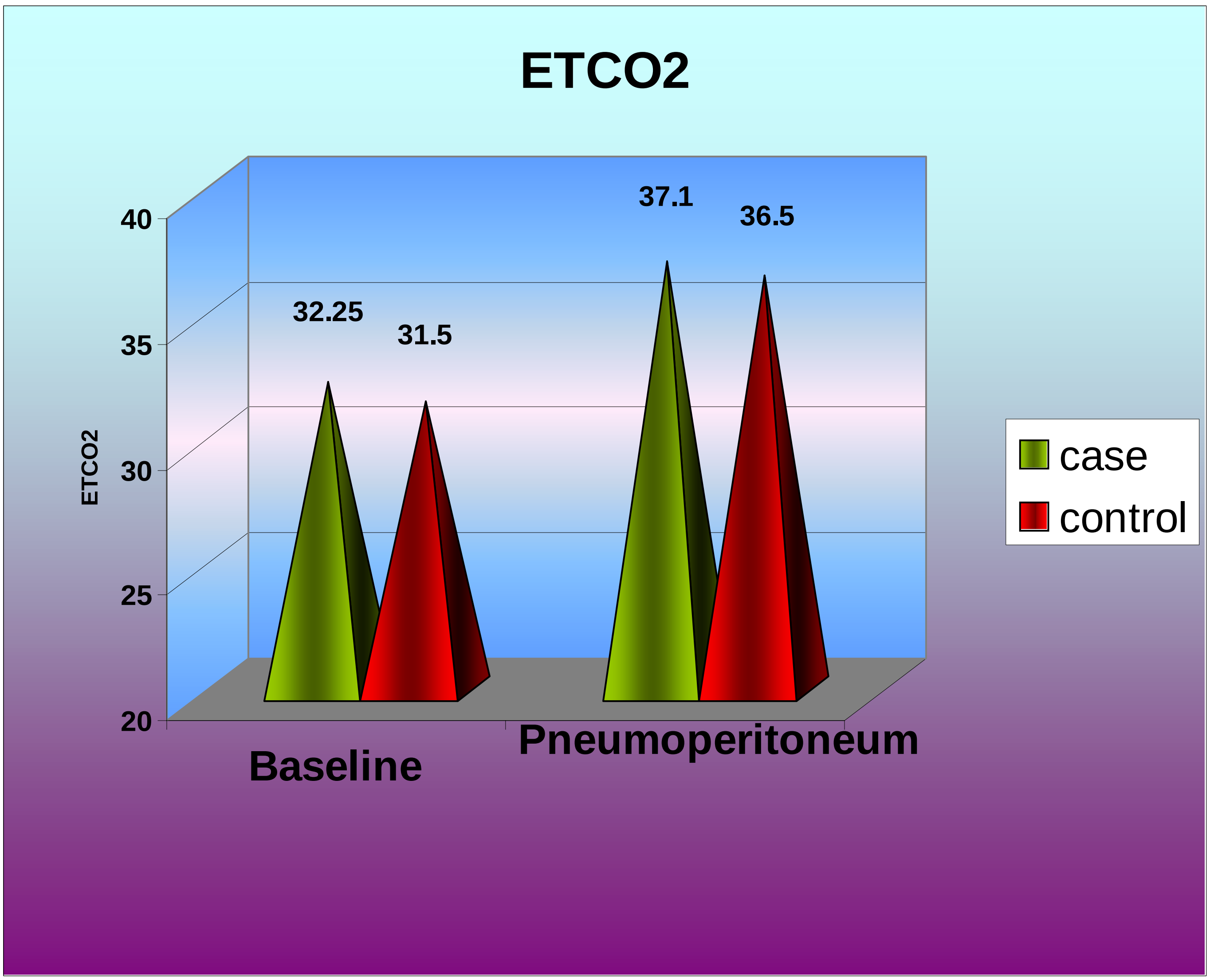

AGE DISTRIBUTION
60
50
40
30
20
10
Age (in yrs)
case
control

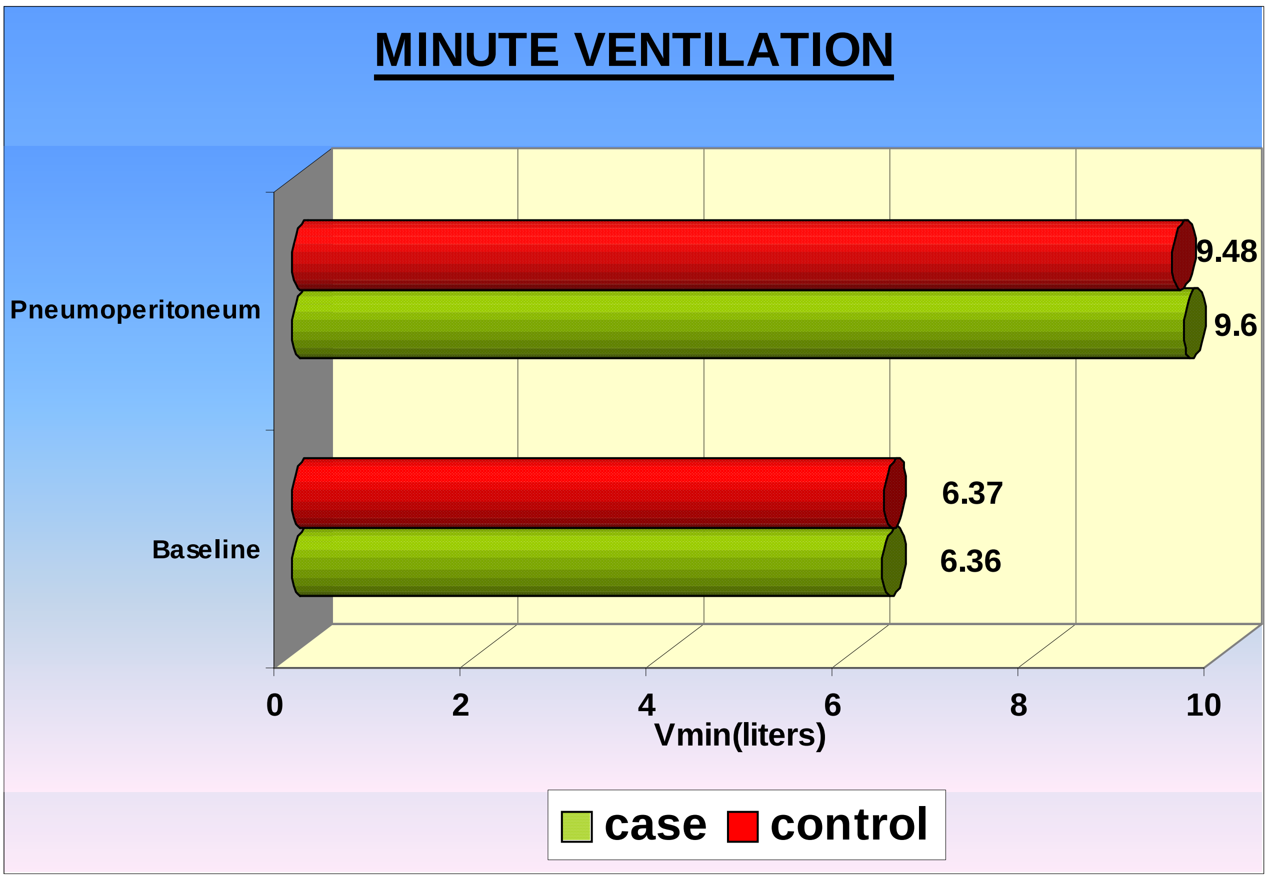

BODY MASS INDEX
control
case
21.5
22.25
0
5
10
15
20
25
BMI

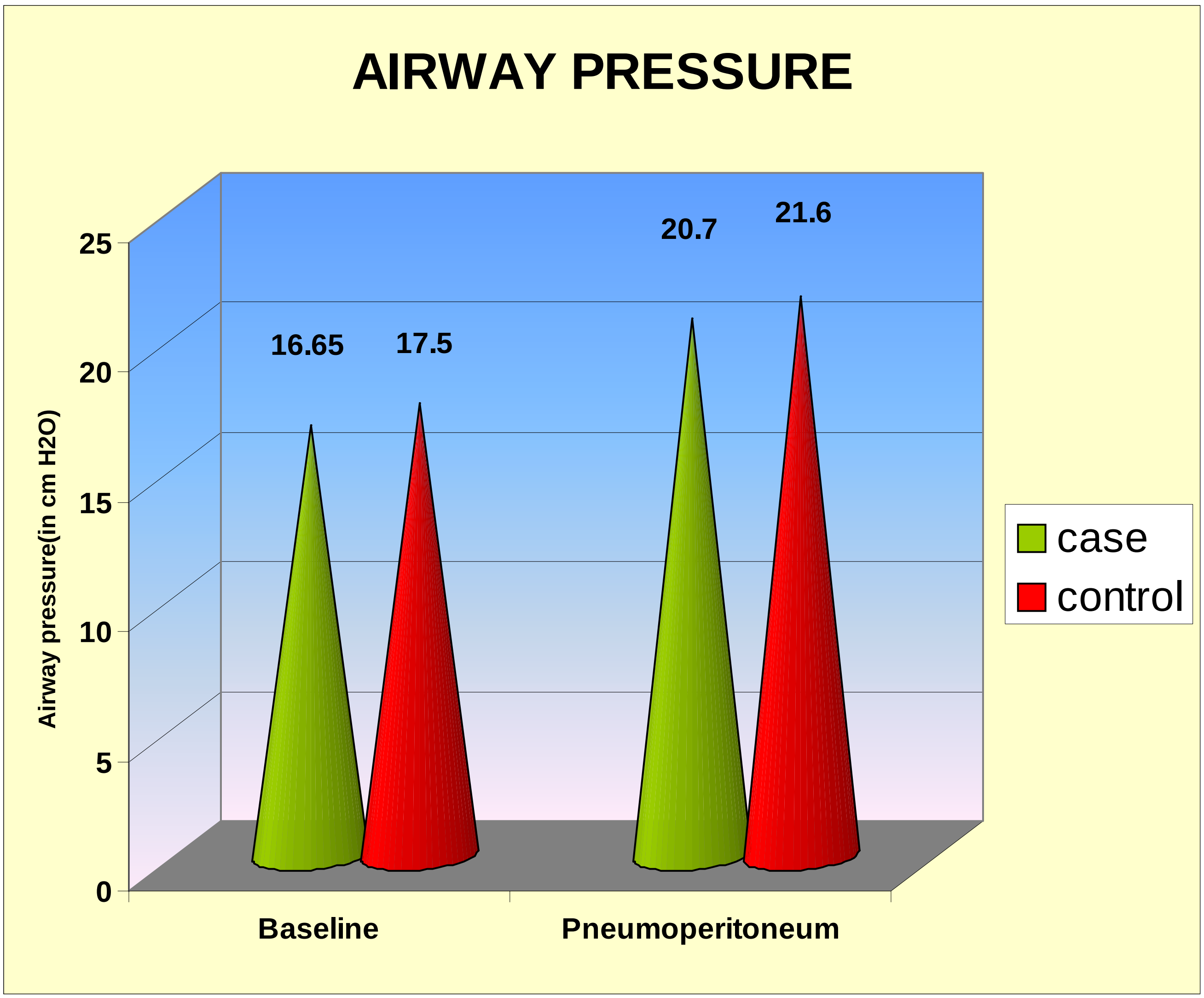

Male
40%
60%


Female
47%
53%
case
control

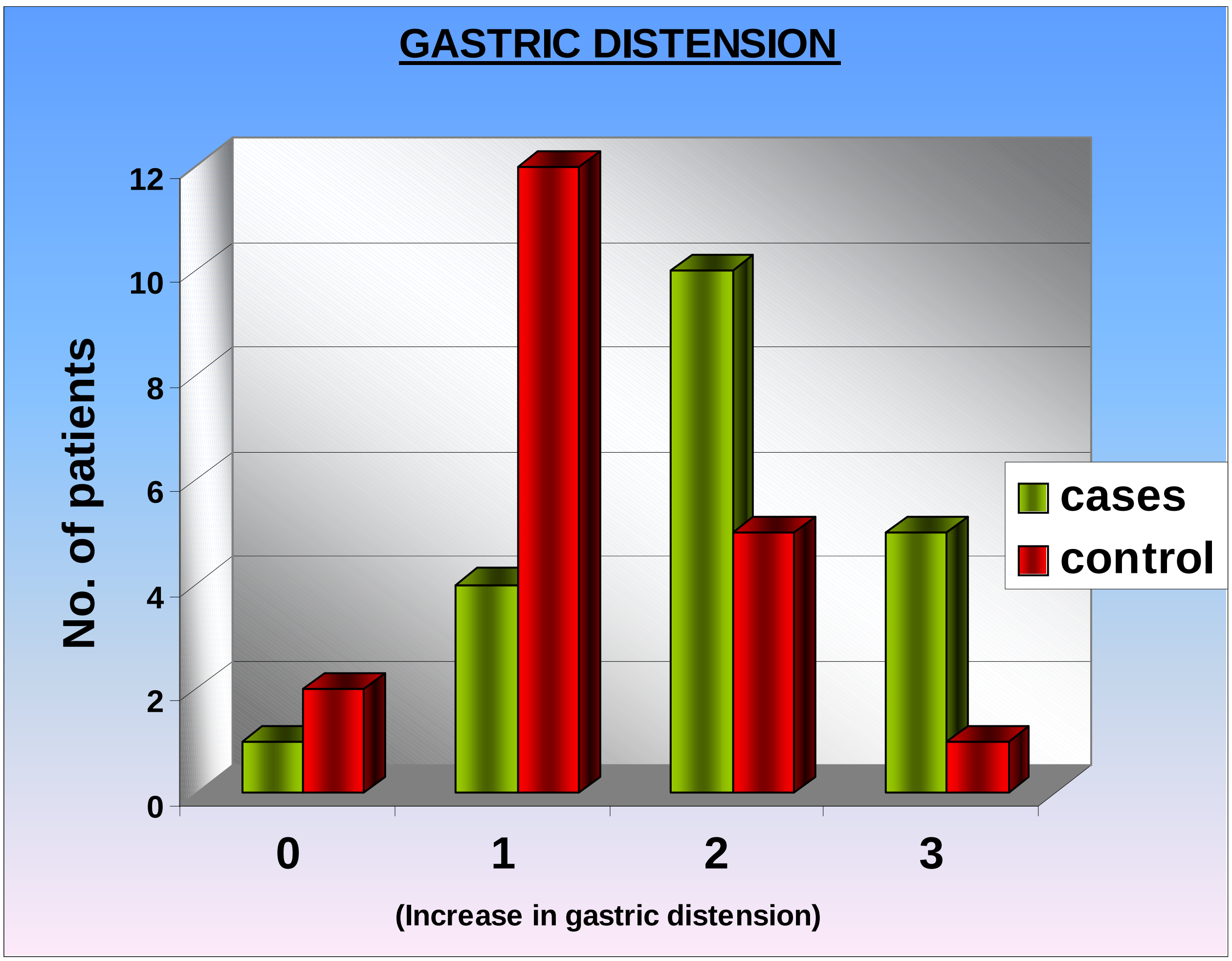

OXYGEN SATURATION
SPO2%
100
80
60
40
20
0
Base line
Pneumoperitoneum
Case
Control

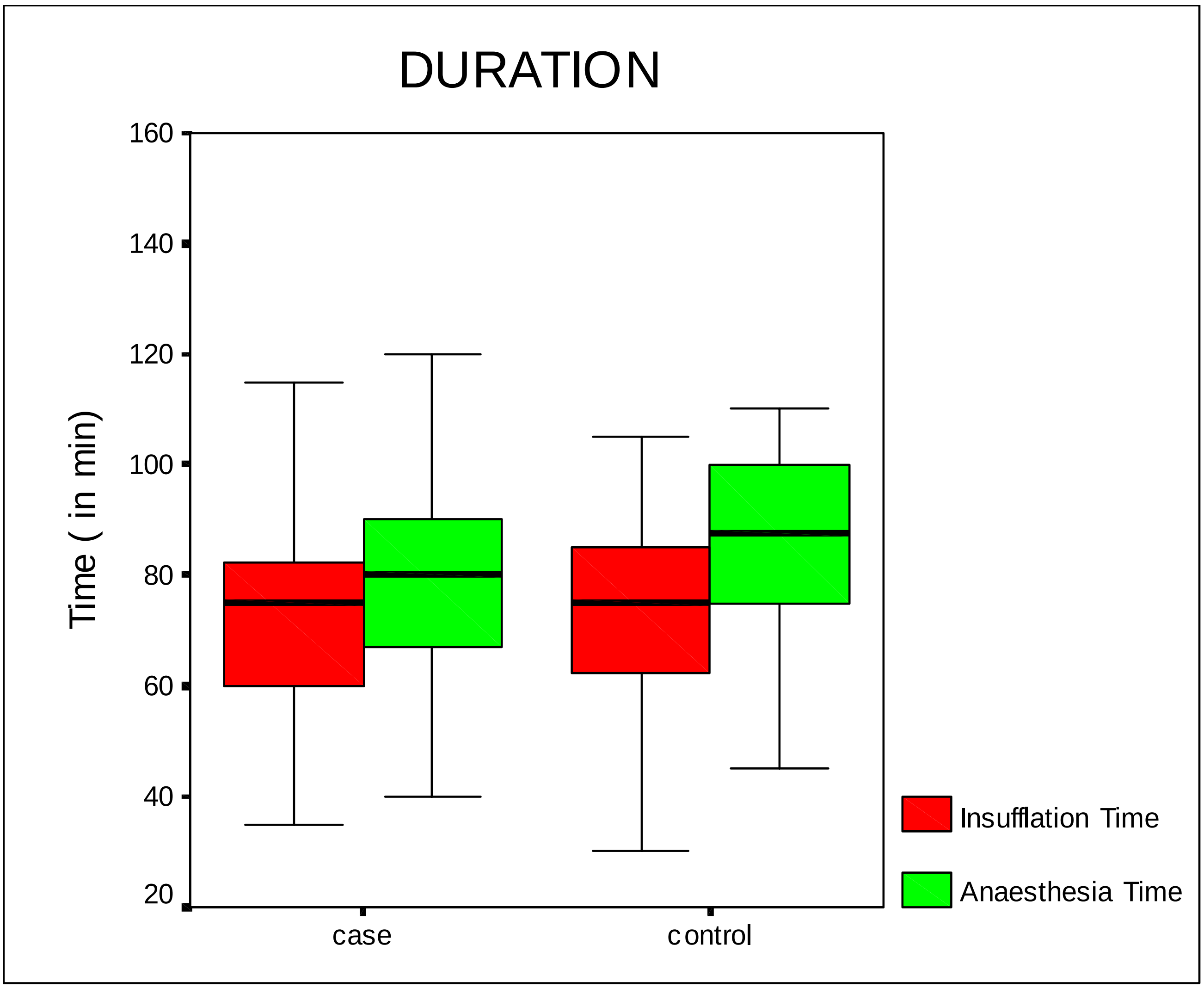

ETCO2
40
35
30
25
20
ETCO2
32.25
31.5
37.1
36.5
Baseline
Pneumoperitoneum
case
control

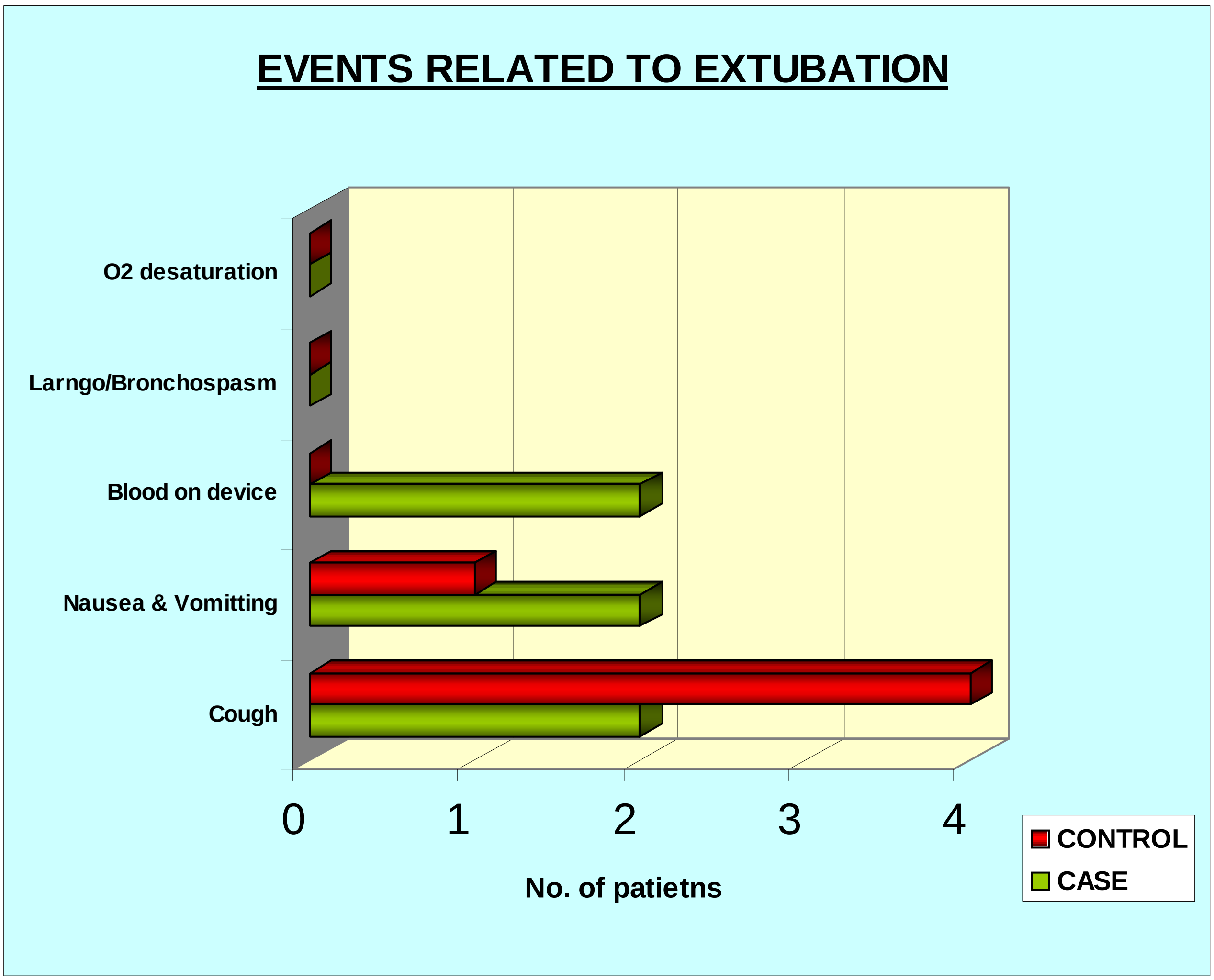

MINUTE VENTILATION
Pneumoperitoneum
Baseline
9.48
9.6
6.37
6.36
0
2
4
6
8
10
Vmin(liters)
case
control



AIRWAY PRESSURE
Airway pressure(in cm H2O)
25
20
15
10
5
0
16.65
17.5
20.7
21.6
Baseline
Pneumoperitoneum
case
control


GASTRIC DISTENSION
No. of patients
0
2
4
6
8
10
12
0
1
2
3
(Increase in gastric distension)
cases
control


DURATION
160
140
120
100
80
60
40
20
Time (in min)
case
control
Insufflation Time
Anaesthesia Time


EVENTS RELATED TO EXTUBATION
O2 desaturation
Larngo/Bronchospasm
Blood on device
Nausea & Vomitting
Cough
0
1
2
3
4
No. of patietns
CONTROL
CASE

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