EFFECTS OF CHANGING FROM SEVOFLURANE TO DESFLURANE ON THE RECOVERY PROFILE AFTER SEVOFLURANE INDUCTION: A RANDOMIZED CONTROL STUDY

A STUDY OF 70 CASES

DISSERTATION SUBMITTED FOR

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BRANCH X (ANAESTHESIOLOGY)

APRIL 2017

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

CHENNAI

TAMILNADU

BONAFIDE CERTIFICATE

This is to certify that this dissertation entitled **"EFFECTS OF CHANGING FROM SEVOFLURANE TO DESFLURANE ON THE RECOVERY PROFILE AFTER SEVOFLURANE INDUCTION"** submitted by **Dr. ANNE FENO A.** to the FACULTY OF ANAESTHESIOLOGY, THE TAMILNADU DR. M. G. R. MEDICAL UNIVERSITY, CHENNAI, in partial fulfilment of the requirement in the award of the degree of M. D. Degree X (ANAESTHESIOLOGY) for the April 2017 examination is a bonafide research work carried out by her under my direct supervision and guidance.

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I, **DR. ANNE FENO A.** declare that the dissertation titled **"EFFECTS OF CHANGING FROM SEVOFLURANE TO DESFLURANE ON THE RECOVERY PROFILE AFTER SEVOFLURANE INDUCTION"** has been prepared by me. This is submitted to the TAMILNADU DR. M. G. R. MEDICAL UNIVERSITY, CHENNAI, in partial fulfilment of the requirement for the award of M. D. Degree Branch X (ANAESTHESIOLOGY) Degree Examination to be held in April 2017. I also declare that this dissertation, in part or full was not submitted by me or any other to any other university or board, either in India or abroad for any award, degree or diploma.

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INTRODUCTION

General anaesthesia can be broadly defined as a drug-induced reversible depression of the CNS resulting in the loss of response to and perception of all external stimuli. The components of the anaesthetic state include unconsciousness, amnesia, analgesia, immobility and attenuation of autonomic responses to noxious stimulation. The conduct of general anaesthesia includes preparation, induction, maintenance, emergence and recovery.

Preparation is the complete assessment of the patient including the functional reserve of various organ systems and appropriate planning regarding urgency of the procedure, positioning of the patient and area of procedure.

Induction phase is the transition from awake state to full effect of anaesthesia on Central Nervous System, Cardio Vascular System, respiratory and muscular system. Magnitude of changes in various systems reflect physiological state of patient - age, stress level, physiological reserve, fluid balance, drug therapy.

Maintenance of anaesthesia is further adjustment of anaesthetic levels based on patient's response - Stage of surgery, trends of monitored variables. Maintenance phase is usually a stable period unless there is change in the level of surgical stress and impairment in the state of patient's fitness. Anaesthetic gases

and vapours form the major component with some IV narcotics and relaxants as background.

Emergence from anaesthesia is the slower version of induction phase in a reverse order, that is, a stage in recovery from general anaesthesia including return of spontaneous breathing, airway protection reflexes and consciousness. Central Nervous System wakes up in stages and in order - Brainstem or lower functions first (breathing, cough, shivering) return first followed by, cerebral cortex (purposeful movements, response to commands). This is facilitated by removal of anaesthetic agents in an orderly fashion. Excitement aspects including limb movement, restlessness, coughing are common. There is high likelihood for vomiting, laryngospasm, upper airway obstruction which are to be anticipated and managed if occur.

Successful general anaesthesia mandates the experience to be a pleasant one with lack of awareness. Inhalational induction using volatile agents is practiced widely as it is convenient and the therapeutic effects are predictable. This has become more popular with the advent of day care surgeries. The emergence is expected not only to be rapid, but also to be smooth, so that patients will be able to resume their routine day to day activities in the earliest possible time.

The speed of washout of inhalational anaesthetics follow an exponential decay with the speed inversely parallel to the solubility of anaesthetics in blood, that is, the washout is more rapid for anaesthetics that are less soluble.

Comparing desflurane and sevoflurane, desflurane being the least soluble and having a lower partition co-efficient, the washout is more rapid and the recovery profile is with ease and faster compared to other volatile anaesthetic agents. Substituting a less soluble anaesthetic for a more soluble one has been proposed as a technique to accelerate the washout of anaesthetics and recovery from anaesthesia.

Desflurane has got a lower lipid solubility and this allows for more rapid emergence and recovery than sevoflurane. Unfortunately, volatile induction using desflurane is limited because of airway irritation.

AIM OF THE STUDY

The aim of the study is to elucidate the effects on the recovery profile when changing from sevoflurane to desflurane during the early part of anaesthesia in patients undergoing elective laparoscopic surgeries under General Anaesthesia: A randomised controlled study.

HISTORICAL BACKGROUND

Inhalational induction dates back to 1842 when Crawford W. Long and William E. Clark used ether on patients for surgery and dental extractions, though the first publicized demonstration was done by William T.G. Morton on October 16, 1846 even before the invention of hypodermic syringes and needles.

Copper Kettle was the first temperature compensated accurate vaporizer. Later the TECOTA vaporizer was accepted into anaesthetic practice. The technology was used to create the fluotec, the first of a series of agent specific TEC-temperature compensated vaporizers for use in operating rooms.

Fluorinated hydrocarbons revolutionized inhalational anaesthesia. Fluorine substitution for other halogens lowered the boiling point, thereby increasing stability and decreasing the toxicity. Methoxy flurane though remained popular, faded off due to the dose related nephrotoxicity. Finally, desflurane was evolved and released in 1992 and sevoflurane in 1994.

Last of these is Xenon which never gained popularity because of the extreme costs associated with its removal from air. However, interest on it has been renewed as it is inert and the gas concentration can be accurately measured when administered at low flows and devices are available to scavenge and reuse the gas.

PHARMACOLOGY

BIOPHYSICAL PROPERTIES OF INHALED ANAESTHETICS

1. Partial pressure:

Partial pressure is the portion of total pressure contributed by one component of a gas mixture where each component contributes pressure to its molar fraction. The partial pressure of an anaesthetic gas is a measure of thermodynamic activity of the gas and determines its pharmacologic effect. The partial pressure of an anaesthetic is usually represented as percentage or fraction of the delivered gas mixture where atmospheric pressure is near 1 atmosphere.

Correcting these values to absolute partial pressure is important under conditions when local atmospheric pressure differs significantly from the standard – high altitude, underwater or in a hyperbaric chamber. The same inhaled concentration of an anaesthetic gas results in a reduced pharmacological effect at higher altitudes because the partial pressure of the anaesthetic is lower. Because partial pressure is the thermodynamic force for gas movement in a system, anaesthetics move from regions of high partial pressure to low partial pressure, unaffected by the other components of the gas mixture and equilibrium is achieved when the partial pressure of an anaesthetic is equal in the different compartments.

The maximal partial pressure of a volatile compound is its vapour pressure that is, the partial pressure of volatile anaesthetic within the drug reservoir of a vaporizer. Vapour pressure is unique to each anaesthetic and increases with increasing temperature. Volatile anaesthetics are defined by a vapour pressure < 1 atmosphere at 20ºC and the boiling point > 20ºC. Gaseous anaesthetics are defined by a vapour pressure > 1 atmosphere at 20ºC and a boiling point below 20ºC. Volatile anaesthetics typically account for a small fraction of the gas mixture delivered to patients.

In contrast, gaseous anaesthetics such as nitrous oxide and xenon, because of their relative lack of potency typically compose a large fraction of an inhaled gas mixture and thus produce additional effects such as concentration effect, second gas effect and air space expansion that are negligible with potent volatile anaesthetics.

2. Hydrophobicity:

It is a molecular property of certain chemicals including most general anaesthetics that do not readily form hydrogen bonds and therefore display low water solubility. Hydrophobic compounds are usually lipophilic demonstrating high solubility in low polarity solvents such as oils. Common measures of hydrophobicity are partition coefficients between water and olive oil which is mostly oleic acid, an 18 carbon fatty acid or between water and n-octanol.

3. Partition coefficient :

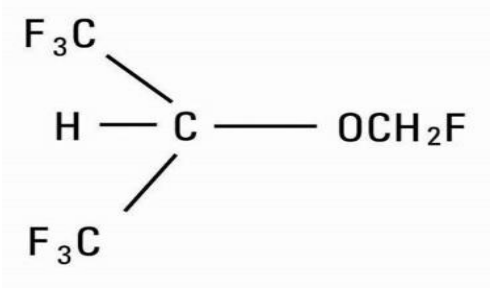
It is represented by the Greek letter λ. Partition coefficient is the ratio of two solute concentrations at equilibrium, that is, at equal partial pressures in two separate but adjacent solvents or compartments such that the solute moves freely between the compartments. Another useful way to conceptualize the partition coefficient is that it represents the relative volume of two compartments that contain equal concentrations of the solute at equilibrium.

Anaesthetic partition coefficient between blood and gas ($\lambda_{b/g}$) and between tissue and blood ($\lambda_{t/b}$) are important factors in uptake and distribution of inhaled anaesthetics as they move from pulmonary air space to pulmonary blood, then from blood to various tissues. Blood solubility of anaesthetic gases increases as temperature decreases. Because most anaesthetics are hydrophobic they tend to display high solubility in tissues with high lipid content and bind to many proteins that form hydrophobic or amphiphilic pockets.

Anaesthetic partitioning into blood, that is, solubility increases after ingestion of fatty foods and may decrease in anaemic or malnourished patients. Methoxyflurane and halothane are notable for high blood solubility. Nitrous oxide, sevoflurane and desflurane are characterized by low blood solubility.

SEVOFLURANE

Fluoromethyl 2,2,2,-trifluoro-1-(trifluoromethyl) ethyl ether



Introduced into clinical practice in the year 1981

Physical properties:

It is a colourless liquid with pleasant odour.

- Chemical nature – Halogenated ether
- Molecular weight – 200.1
- Boiling point – 58.6 ºC
- Density – 1.5 g/ml
- Vapour pressure – 157 mm of Hg
- Oil gas partition co-efficient at 37 ºC – 47.5
- Blood gas partition co-efficient at 37 ºC – 0.65
- MAC value - 1.8

Effect on organ systems:

A. Cardiovascular system:

Sevoflurane causes mild depression of myocardial contractility. It also causes a slight decrease in arterial blood pressure and systemic vascular resistance. It may prolong the QT interval.

B. Respiratory system:

Sevoflurane depresses respiration and reverses bronchospasm.

C. Cerebral system:

Sevoflurane causes slight increase in cerebral blood flow and intra cranial pressure at normocardia. High concentration of sevoflurane (> 1.5 MAC) may impair auto-regulation of cerebral blood flow. Cerebral metabolic oxygen requirements decrease. Seizure activity has not been reported.

D. Neuromuscular system:

Sevoflurane produces muscle relaxation adequate enough for intubation.

E. Renal system:

Sevoflurane slightly decreases renal blood flow.

F. Hepatic system:

Sevoflurane decreases portal vein blood flow but increases hepatic artery blood flow, thereby maintaining total hepatic blood flow and oxygen delivery. It is not associated with immune mediated anaesthetic hepato toxicity.

Biotransformation and toxicity:

About 5% of the absorbed sevoflurane is metabolised by the liver microsomal enzyme P450, the 2E1 isoform. Alkali such as Barium hydroxide lime or soda lime can degrade sevoflurane to produce a nephrotoxic end product called compound A (Flurомethyl 2, 2 difluro 1 trifluro methyl vinyl ether). Accumulation of compound A increases with low flow anaesthesia, high sevoflurane concentration, prolonged anaesthesia and increased respiratory gas temperature. Fresh gas flows of atleast 2 lit/min for anaesthesia lasting for more than few hours is recommended. Sevoflurane can also be degraded into Hydrogen fluoride by metal and environmental impurities present in the anaesthesia equipment, glass bottle packaging and manufacturing equipment. Hydrogen fluoride can produce an acid burn on contact with respiratory mucosa.

Contraindications:

- Severe hypovolemia
- Intracranial hypertension

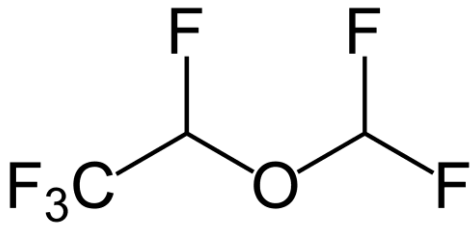
- Susceptibility to malignant hypothermia

Drug interactions:

Sevoflurane potentiates neuromuscular blocking agents. Heart is not sensitized to catecholamine induced arrhythmias like halothane.

DESFLURANE

2-(difluoromethoxy)-1, 1, 1, 2-tetrafluoroethane



Introduced into clinical practice in the year 1990

Physical properties:

- Chemical nature – Halogenated ether
- Molecular weight – 168
- Boiling point – 22.8 ºC
- Density – 1.45 g/ml
- Vapour pressure – 664 mm of Hg
- Oil gas partition co-efficient at 37 ºC – 19
- Blood gas partition co-efficient at 37 ºC – 0.45
- MAC value – 6.6

Effect on organ systems:

A. Cardiovascular system:

Desflurane causes minimal left ventricular depression. Fall in arterial blood pressure due to decline in systemic vascular resistance may occur with increase in the dose. At MAC value of 1-2, cardiac output either remains unchanged or depressed slightly. Central venous pressure, pulmonary artery pressure and heart rate may be moderately increased. Rapid increase in desflurane concentration leads to worrisome elevation in heart rate, blood pressure and catecholamine levels. These cardiovascular responses can be attenuated by fentanyl, esmolol or chlonidine.

B. Respiratory system:

Desflurane causes a decrease in tidal volume and an increase in respiratory rate. Alveolar ventilation decreases that leads to rise in resting $PaCO_2$. Desflurane induction may cause coughing, breath holding, laryngospasm, salivation due to its pungent nature as it irritates the airway. These problems make desflurane a poor choice for inhalational induction.

C. Cerebral system:

Desflurane directly vasodilates the cerebral vasculature increasing cerebral blood flow and intracranial pressure. Countering the decrease in cerebral vascular resistance is a marked decline in the cerebral metabolic rate of oxygen that tends

to cause cerebro vascular constriction. Cerebral oxygen consumption is decreased during desflurane anaesthesia. Thus during periods of desflurane induced hypotension, cerebral blood flow is adequate to maintain aerobic metabolism despite a low cerebral perfusion pressure. Initially, EEG frequency is increased but as anaesthetic depth increases, burst suppression occurs.

D. Neuromuscular system:

Desflurane is associated with dose dependent decrease with a response to train-of-four and tetanic peripheral nerve stimulation.

E. Renal system:

There is no evidence of any significant nephro toxic effects caused by exposure to desflurane.

F. Hepatic system:

Hepatic function tests are generally unaffected by desflurane. Desflurane undergoes minimal metabolism, therefore the risk of anaesthetic induced hepatitis is minimal.

Biotransformation and toxicity:

Desflurane more than other volatile anaesthetics is degraded by dessicated carbon dioxide absorbent into potentially, clinically significant levels of carbon monoxide. Carbon monoxide poisoning, though difficult to diagnose under

general anaesthesia, carboxy haemoglobin can be detected by arterial blood gas analysis. Disposing off dried out absorbent or use of calcium hydroxide can minimize the risk of carbon monoxide poisoning.

Contraindications:

- Severe hypovolemia
- Intracranial hypertension
- Susceptibility to malignant hypothermia

Drug interactions:

Desflurane potentiates neuromuscular blocking agents. It does not sensitize the heart to catecholamine induced arrhythmias and hence epinephrine can be safely administered in doses upto 4.5 mics/kg.

A high vapour pressure, an ultrashort duration of action, moderate potency and rapid emergence are the most characteristic features of desflurane.

PHARMACOKINETICS OF INHALATIONAL ANAESTHETICS

A. Factors affecting inspiratory concentration (F_I)

The actual composition of the inspired gas mixture depends mainly on:

1. Fresh gas flow rate
2. Volume of the breathing system
3. Circuit absorption

Higher the fresh gas flow rate, smaller the breathing system volume and lower the circuit absorption, the closer the inspired gas concentration will be to the fresh gas concentration.

B. Factors affecting alveolar concentration

1. Uptake
2. Ventilation
3. Concentration effect

Because anaesthetic agents are taken up by the pulmonary circulation during induction, alveolar concentration lag behind inspired concentrations (FA/FI < 1). The greater the uptake, slower the rise of alveolar concentration, lower the FA/FI ratio and slower the rate of induction.

Three factors affect anaesthetic uptake:

- Solubility in the blood
- Alveolar blood flow
- Difference in partial pressure between alveolar gas and venous blood

Co-efficient is the ratio of the concentrations of anaesthetic gas in each of two phases at steady state. Steady state is defined as equal partial pressures in the two phases. The higher the blood/gas co-efficient, the greater the anaesthetic's solubility and greater its uptake.

If the cardiac output drops to zero, so will anaesthetic uptake. As cardiac output increases, anaesthetic uptake increases, the rise in alveolar partial pressure slows and induction is delayed.

The partial pressure difference depends on tissue uptake, which in turn depend on tissue solubility of the agent, tissue blood flow and the difference in partial pressure.

The lowering of alveolar partial pressure can be countered by increasing alveolar ventilation, most obviously for soluble anaesthetics. Anaesthetics that depress spontaneous ventilation will decrease the rate of rise in alveolar concentration and create a negative feedback loop.

The slowing of induction due to uptake from alveolar gas can be reduced by increasing the inspired concentration. Increasing the inspired concentration, not only increases the alveolar concentration but also increases the rate of rise due to concentrating effect and augmented inflow effect. High concentration of one anaesthetic gas will augment not only its own uptake but theoretically that of a concurrently administered volatile anaesthetic. The concentration effect of one gas upon another is called the second gas effect, which is probably insignificant in the clinical practice of anaesthesiology.

C. Factors affecting arterial concentration

1. Venous admixture
2. Alveolar dead space
3. Non-uniform alveolar gas distribution

Ventilation perfusion mismatch will increase the alveolar arterial difference. Mismatch access a restriction to flow. It raises the pressure in front of the restriction, lowers the pressure beyond the restriction and reduces the flow through the restriction. The overall effect is increase in the alveolar partial pressure particularly for the highly soluble agents and decrease in the arterial partial pressure particularly for poorly soluble agents.

D. Factors affecting elimination

1. Biotransformation
2. Transcutaneous loss
3. Exhalation

The most important route for elimination of inhalational anaesthetics is the alveolus.

Many of the factors that speed induction also speed recovery:

- Elimination of rebreathing
- High fresh gas flow
- Low anaesthetic circuit volume
- Low absorption by the anaesthetic circuit
- Decreased solubility
- High cerebral blood flow
- Increased ventilation

The rate of recovery is usually faster than induction because tissues that have not reached equilibrium will continue to take up anaesthetic until the alveolar partial pressure falls below the tissue partial pressure.

RECOVERY FROM ANAESTHESIA

1. Similarities and differences to induction:

Clearance of inhaled anaesthetics from target tissue (brain and spinal cord) is primarily via the same pathways used for anaesthetic induction: anaesthetic gases flow from tissues into venous blood and then to the lungs, if $P_{ald} < P_{MV}$ then the net flow of anaesthetic will be out of the blood and into the alveoli where it is exhaled. To achieve the fastest clearance possible, P_{circ} must therefore be as low as possible and this must be achieved by high flow of non - anaesthetic carrier gases after discontinuing delivery of anaesthetic.

Increasing ventilation will accelerate clearance, whereas increased cardiac output slows clearance because more gas exchange volumes are required to remove anaesthetics from the larger blood flow. Highly blood soluble anaesthetics which increase the effective blood flow clear more slowly than insoluble anaesthetics. Return of consciousness usually occur after P_{CNS} drops below MAC_{AWAKE}. Nitrous oxide provides an even faster return of consciousness because of two additional advantages:

i. The concentration effect works in reverse during clearance for nitrous oxide, increase in alveolar ventilation and maintaining the gradient for flow from pulmonary blood to alveoli.

ii. MAC_{AWAKE} for nitrous oxide is near typical inhale concentration during general anaesthesia, therefore elimination of only a small fraction is associated with return of consciousness.

This is why, nitrous oxide has the sole hypnotic drug is associated with a high risk of intra operative awareness which can be prevented by using a balanced gas mixture of approximately 1 MAC_{AWAKE} of a second potent inhaled anaesthetic.

Body composition has an increasing effect as the length of anaesthetic exposure increases, especially for highly soluble anaesthetics. Patients with increased muscle or fat have larger volumes of anaesthetic drug distribution over time, resulting in slower clearance rates. One important difference between uptake and clearance is that although over pressure can be used to hasten uptake and induction of anaesthesia the vaporizer settings cannot be set to < 0. Thus, the most readily modifiable factors to affect the rate of anaesthetic clearance are fresh gas flow and minute ventilation.

2. Context sensitive recovery from anaesthesia:

After a short period of inhalation and uptake anaesthetic clearance from blood is rapid through both exhalation and distribution to muscle and other tissues. As a result, P_{ALV} decreases rapidly to a low value after discontinuing anaesthetic delivery. After prolonged period of inhalation and uptake the

anaesthetic partial pressure in muscle and other compartments increase closer to that in blood reducing the contribution of distributive clearance. Instead, clearance from the central blood compartment is slowed by the reverse flow of anaesthetic from the high capacity tissues. Thus in comparison with a short period of inhalation, prolonged inhaled anaesthesia is followed by a smaller initial decrease in P_{ALV} and a more pronounced slow clearance phase, resulting in slower recovery from anaesthesia. Context sensitivity is exaggerated in highly soluble anaesthetics and it has less impact with anaesthetics that display low blood and tissue solubility. The relative advantage of low blood solubility anaesthetics increases with the duration of anaesthesia.

3. Percutaneous and visceral anaesthetic loss:

Aside from pulmonary exchange some portion of inhaled anaesthetics is lost by diffusion through other large area interfaces between the body and the surrounding air. The skin surface of an average human is approximately 2 m^2 and blood flow through skin during general anaesthesia may be substantial because of inhibition of normal thermoregulatory vasoconstriction. However transcutaneous losses general anaesthetics probably contribute negligibly to their clearance. During open abdominal or thoracic surgery, visceral surfaces are also directly exposed to air and under these circumstances anaesthetic losses via direct transfer and air movements are larger than those via skin but are still a small fraction of total clearance.

4. Effect of the anaesthetic circuit:

Circuit components including tubing, connectors, manual ventilation bag and carbon dioxide material absorb the inhaled anaesthetics effectively creating another compartment that fills while anaesthetic is flowing and needs to be emptied during washout. Low level release of anaesthetic gases from these components can continue for a considerable time.

5. Clearance via metabolism of anaesthetics:

Metabolism of inhaled anaesthetics in tissues, particularly liver contributes to a variable degree of drug clearance. A high rate of metabolism will reduce the anaesthetic partial pressures in tissues, resulting in reduced P_{MV} and increased rates of overall anaesthetic clearance. Tissue dependent breakdown contributes less to clearance of newer inhaled anaesthetics.

6. Additional considerations and possibilities:

Modern inhaled anaesthetics such as sevoflurane and desflurane have low blood solubility and therefore provide a distinct advantage from both anaesthetic induction and recovery from anaesthesia. What if anaesthesia is induced with one drug followed by a switch to another drug of less solubility during the maintenance period and for a period preceding emergence? This might allow for a rapid induction and wake up. Although a fast wake up can be achieved by allowing sufficient time for near total washout of one drug and its replacement

with another drug, this type of cross over requires significant lead time and high fresh gas flows.

7. Diffusion hypoxia:

This is an additional sequelae of rapid outgassing from the tissues of patients anaesthetized with nitrous oxide. During the initial 5 – 10 mins after discontinuation of anaesthesia, the flow of nitrous oxide from blood into the alveoli can be several litres per minute resulting in dilution of alveolar oxygen. Another effect of rapid outgassing is dilution of alveolar PCO_2 which can also reduce respiratory drive. If the patient does not receive supplemental oxygen, during this period, then the combined effects of respiratory depression from anaesthesia reduced alveolar PCO_2 and reduced alveolar PO_2 can result in hypoventilation and oxyhaemoglobin desaturation. This outcome is routinely avoided by providing supplemental oxygen for the first 1- 10 mins of recovery together with vigilant attention to respiration.

PHARCODYNAMICS OF INHALATIONAL ANAESTHETICS

Theories of anaesthetic action:

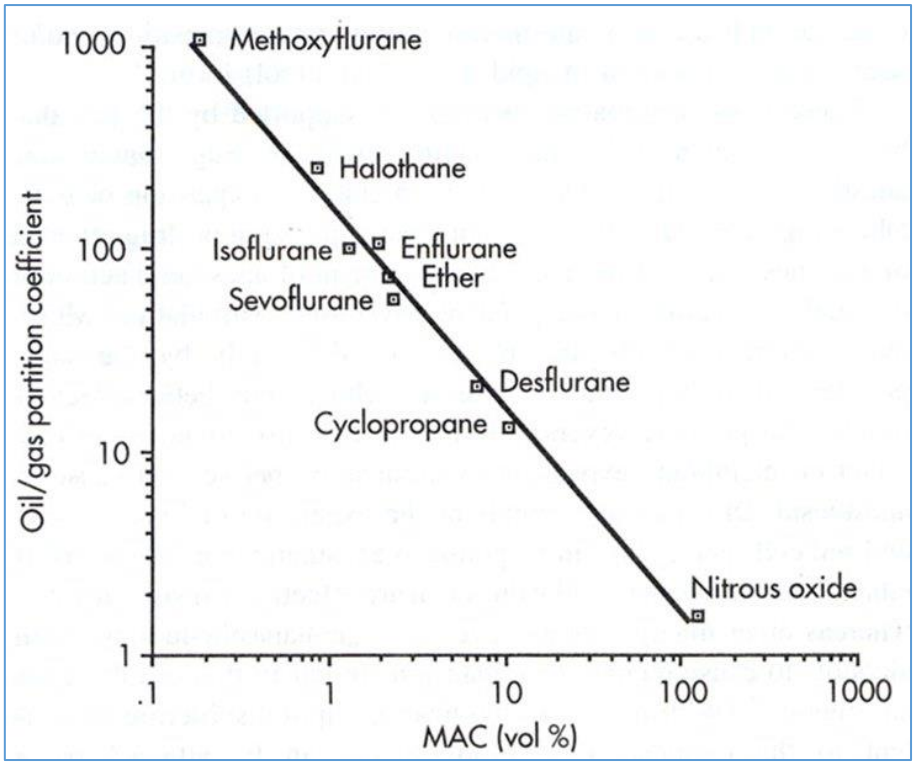
- Inhibition of NMDA receptors
- Enhancement of GABA activated chloride channel conductance
- Affecting the membrane bi-layer non-specifically

It is possible that inhalational anaesthetics act on multiple protein receptors that block excitatory channels and promote the activity of inhibitory channels affecting neuronal activity as well as by non - specific membrane effects.

Specific brain areas affected by various anaesthetics include the reticular activating system, the cerebral cortex, the cuneate nucleus, the olfactory cortex and the hippocampus. Anaesthetics have shown to depress excitatory transmission in the spinal cord particularly, at the level of dorsal horn inter-neurons.

Unitary hypothesis of anaesthetic effect:

This hypothesis proposes that all inhalational agents share a common mechanism of action at the molecular level. The anaesthetic potency of inhalational agents correlate directly with their lipid solubility - Meyer Overton rule.



Sevoflurane has higher oil/gas partition coefficient compared to desflurane and hence more potent compared to desflurane. Since desflurane has lower oil/gas partition coefficient, the washout is faster and hence emergence is rapid compared to sevoflurane.

Critical volume hypothesis:

Neuronal membranes contain a multitude of hydrophobic sites in their phospholipid bi-layer. Anaesthetics binding to these sites could expand the bi-layer beyond the critical amount altering the membrane function.

Although inhalational agents have been suggested as contributing to neuro toxicity, they also have been shown to provide both neurologic and cardiac protective affects against ischemia-reperfusion injury. Ischemic preconditioning

implies that a brief ischemic episode protects a cell from future, more pronounced ischemic events. The mechanism of anaesthetic preconditioning is likely to be due to opening of K_{ATP} channels resulting in less mitochondrial calcium ion concentration and reduction of reactive oxygen species (ROS) production.

MINIMUM ALVEOLAR CONCENTRATION

The minimum alveolar concentration of an inhaled anaesthetic at 1 atmospheric pressure is the alveolar concentration that prevents movement in 50% of patients in response to a standard noxious stimulus (surgical incision). A MAC is a useful measure because it mirrors brain partial pressure.

MAC_{Awake}: The minimum alveolar concentration producing unconsciousness in 50% of the subjects (0.5 MAC).

MAC_{bar}: The minimum alveolar concentration of anaesthetic blocking the sympathetic nervous system response to a painful stimulus in 50% of subjects (1.3 MAC).

Roughly 1.3 MAC of any volatile anaesthetic has been found to prevent movement in about 95% of the subjects. Maintaining 0.7 MAC of an inhaled anaesthetic prevents awareness as effectively as the use of BIS monitor.

Factors increasing MAC:

1. Young individuals
2. Hyperthermia
3. Hyperthyroidism
4. Hypernatrimia
5. Chronic alcoholism

Factors decreasing MAC:

1. Elderly
2. Hypothermia
3. Hyperthermia > 42^{o}C
4. Acute alcohol intoxication
5. Anaemia
6. Hypoxia
7. Hypovolemia
8. Hyponatrimia
9. Hypocalcimia
10. CNS depressants - Alpha$_2$ agonists, Volatile agents, Local anaesthetics except cocaine

One of the most striking is a 6% decrease in MAC per decade of age, regardless of volatile anaesthetics.

MAC value peaks at the age of 1 year approximately 50% greater than adult values, then decline to reach adult levels on the onset of puberty.

VAPORIZERS

Vaporizer is a device that changes a liquid anaesthetic agent into its vapour and adds a controlled amount of that vapour to the fresh gas flow or to the breathing system.

Standards:

1. The effects of variations in ambient temperature and pressure, tilting, back pressure, input flow rate and gas mixture composition on vaporizer performance must be stated.

2. The average delivered concentration shall not deviate from the set value by more than ± 20% or ± 5% of the maximum setting whichever is greater without back pressure.

3. The average delivered concentration shall not deviate from the set value by more than + 30% or – 20% or by more than + 7.5% or – 5% of the maximum setting whichever is greater with pressure fluctuations.

4. A system that prevents gas from passing through the vapourizing chamber or reservoir of one vaporizer and then through that of another must be provided.

5. The output of the vaporizer shall be < 0.5% in the OFF or zero position, if the zero position is also the OFF position.

6. The control knobs must open counter clockwise.
7. Either the maximum or minimum filling levels or the actual usable volume and capacity shall be displayed.
8. The vaporizer must be designed so that it cannot be overfilled when in the normal operating position.
9. Vaporizers unsuitable for use in the breathing system must have non-interchangeable proprietary or 23 mm fittings. The direction of gas flow must be marked.
10. Vaporizers suitable for use in the breathing system must have standard 22 mm fittings or screw threaded weight bearing fittings or screw threaded weight bearing fittings.

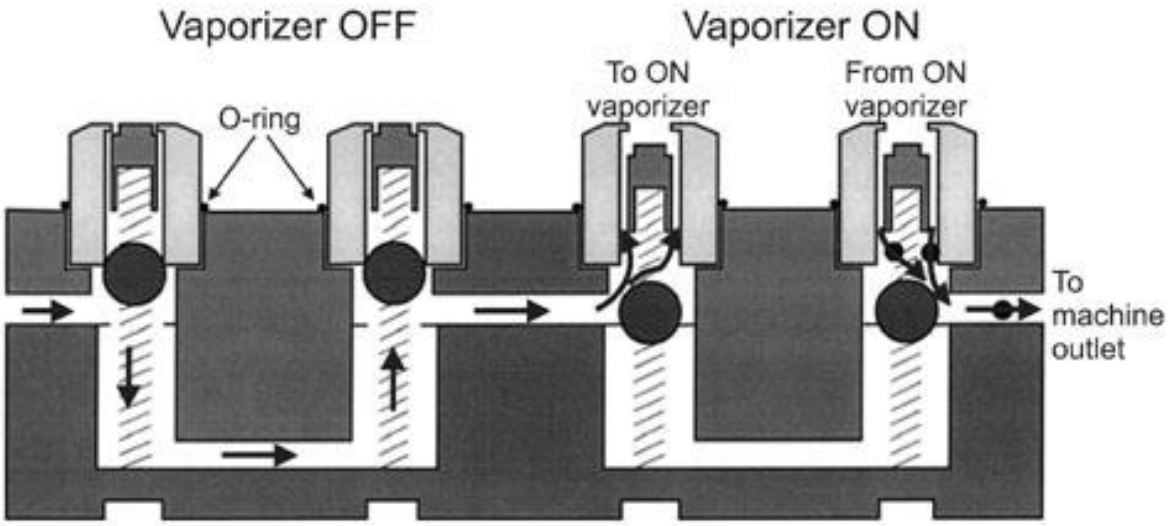
Select-a-tec system:

It consists of a pair of port valves for each vaporizer position. Each vaporizer has a special mounting bracket containing two plungers (Spindles), which fits over the port valves. The weight of the vaporizer and an O-Ring around

each port valve create a seal between the mounting system and the vaporizer. On the back of each vaporizer is a locking lever.

Before mounting the vaporizer, the control dial must be in the OFF position and any adjacent vaporizer must be turned off. The locking lever on the vaporizer must be unlocked. The vaporizer is fitted onto the mounting system and locked in position. To remove a vaporizer, the control dial is turned off, and the locking lever moved to the unlock position. The vaporizer can then be lifted off the manifold.

When the vaporizer is turned ON, two plungers move downwards, pushing the valves, opening the valve ports so that gas passes through the vaporizer.



When the vaporizer is turned OFF or if the mounting position is empty, it is isolated from the fresh gas flow.

Interlock devices:

Interlock – vaporizer exclusion systems prevent more than one vaporizer from being turned on at a time.

Hazards:

- Incorrect agent
- Tipping
- Over filling
- Reversed flow
- Control dial in wrong position
- Leaks
- Vapour leak into the fresh gas line
- Contaminants in the vapourizing chamber

- Physical damage
- No vapour output
- Projectile

PENLON SIGMA DELTA VAPORIZER

The front has a colour coded control dial that locks in the 0 position. To use the vaporizer, the dial is pushed inwards and rotated counter clockwise to the desired concentration. When the control dial is turned off, it will automatically spring outward to the locked position. At the bottom is the liquid level indicator with the maximum and minimum level marks. Three different filling devices are available: Funnel fill, keed fill and quick fill. At the base of the filling mechanism is the means of drainage.

The vaporizer has a liquid capacity of 250 ml. At the minimum mark, the volume will be 35 ml. Approximately, 60 ml of liquid will remain in the wick,

after the vaporizer is drained. The vaporising chamber contains a wick. Temperature compensation is by means of a thermostat in the by-pass. The operating temperature range is 15 – 35^{o}C. The temperature compensating mechanism may need a minimum of 1-2 hours to compensate for the change in room temperature. The vaporizer is designed to operate between the fresh gas flows of 0.2 and 50 lit/min.

Barometric pressure effects are not clinically important usually. A steady back pressure of 10-15 kPa will reduce the vaporizer output. The effect is greatest at low vaporizer settings and low flow rates.

Hazards:

The penlon sigma delta may malfunction if exposed to excessively high temperature. The vaporizer control dial must be at 0 and the vaporizer must be upright during filling, if not there is possibility of over filling. If the vaporizer is transported while filled, the control dial should be in the 0 position. The dial must remain in the 0 position for atleast 10 mins after the vaporizer is attached to the anaesthesia machine, if not overdose is likely to occur. If a vaporizer has been transported with the control dial in the open position, it must be flushed with a 5 lit/min flow of gas for atleast 10 mins before use. If the vaporizer has been tipped or inverted during transport, the control dial must be set to a maximum output and run at 5 lit/min for 10 mins priority use.

This vaporizer is flow direction sensitive. If the gas flow is reversed, the output will be inaccurate.

Maintenance:

Calibration can be performed by using a suitable agent as analyser. If the calibration is outside the performance limits, the vaporizer must be serviced.

The manufacturer recommends that a major overhaul be performed every 10 years. Halothane models should have a major overhaul every 5 years. The halothane vaporizer should be drained periodically and the vapour discarded.

DRAGER D-VAPOR

The Drager D-Vapor is only for desflurane.

The power cable is connected to the vaporizer at the rear. The control dial on the top is used to switch the vaporizer on or off. Put it in the transport position and adjust the delivered agent concentration. Pusing the 0 button, on the front of the dial allows the dial to be rotated. The control dial locks in the 0 and transport position.

The D-Vapor filling system (SAF – T – Fill system) is located in the front of the vaporizer. The sealing plug closes the filling system when not in use. To fill the vaporizer, the button on the right side of the vaporizer is depressed to allow the sealing plug to be removed. The desflurane bottle is inserted into the filling mechanism. After filling, the button is depressed again to release the bottle from the filling device. The sealing cap is pressed into the filler until it locks in place. The vaporizer has a capacity of 300 ml. The agent level indicator is at the front on the inside. The top line indicates that the vaporizer is filled. The second line indicates when one complete bottle of desflurane (250 ml) will be needed to fill the vaporizer. The bottom line indicates that there are only 30 ml of agent remaining in the vaporizer.

For a high priority alarm, there is red flashing LED and for medium priority alarm, there is a amber flashing LED. The second LED is green and indicates that the vaporizer is operational. The third LED is red and indicates no output. The fourth LED is amber and indicates warm up. The fifth LED is amber and indicates that the vaporizer needs to be refilled. The bottom LED is amber and indicates battery.

If there is no power supply, there will be no LED illumination. When power is supplied, the vaporizer automatically runs a self test. All 6 LED’s should light. After the heating phase, the green operation LED flashes. The vaporizer is then ready to use.

The D-Vapor has its own battery back up. The battery back up will last for only 5 mins. If power is restored in less than 5 mins, there will be no interruption in output.

The reservoir containing the liquid desflurane is heated to a temperature of 40^{o}C and at a constant pressure of 2 bar, allowing the desflurane that leaves the reservoir to be fully saturated vapour. Fresh gas from the flow meters is conducted through the by-pass to the machine outlet. Flow resistance in the by-pass increases the pressure in the line and causes this pressure to be applied to a diaphragm in the regulating sensor. The sensor causes the proportioning valve to deliver saturated desflurane vapour, keeping the pressure between the fresh gas flow and desflurane flow in balance.

The vapoizer output will be affected by the carrier gas concentration. The output is reduced by 10% for air and 20% for nitrous oxide – oxygen mixture. The output accuracy is related to the volume of gas that passes through the vaporizer.

Hazards:

Cellular phones should not be used within a perimeter of 10 m. The D-Vapor is not designed to be used at an angle of more than 10 degrees. Greater angles could lead to overfilling.

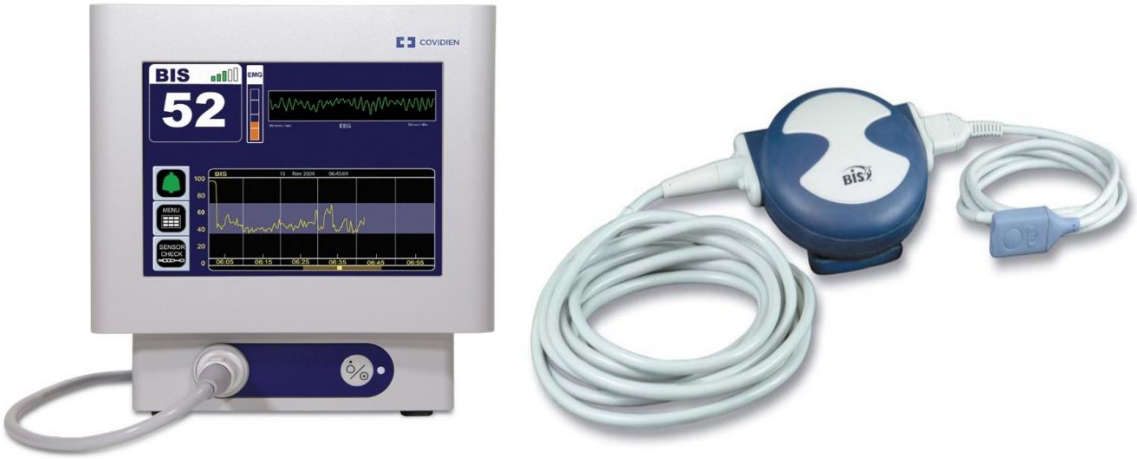
Maintenance:

It is recommended to have a continuous agent monitoring. In its absence, a weekly check of vapor output is recommended. The manufacturer requires inspection and service of the vaporizer by skilled personnel every year.

The following compounds should not be used to clean the vaporizer:

- Halogen-releasing compounds
- Strong organic acids
- Oxygen-releasing compounds

BISPECTRAL INDEX MONITOR



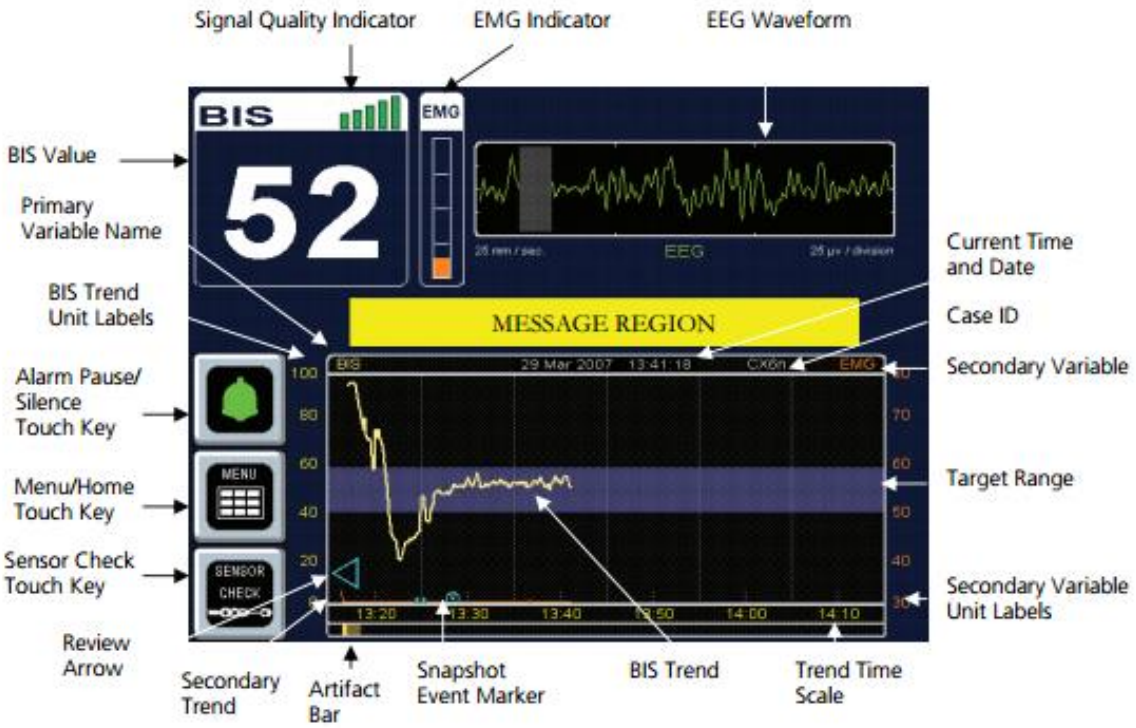
Bispectral index (BIS) is one of several technologies used to monitor depth of anaesthesia. BIS monitors are intended to replace or supplement Guedel's classification system for determining depth of anaesthesia. Titrating anaesthetic agents to a specific bispectral index during general anaesthesia in adults (and children over 1 year old) allows the anaesthetist to adjust the amount of anaesthetic agent to the needs of the patient, possibly resulting in a more rapid emergence from anaesthesia.

The BIS was introduced by Aspect Medical Systems, Inc. in 1994 as a novel measure of the level of consciousness by algorithmic analysis of a patient's electroencephalogram during general anaesthesia. This is used in conjunction with other physiologic monitoring such as electromyography to estimate the depth of anaesthesia in order to minimize the possibility of intraoperative awareness The bispectral index is a emperically derived scale that was proposed as a novel way to monitor level of consciousness among patients

receiving general anaesthesia and sedation. The algorithm processes the EEG in near real time and computes an index value between 0 and 100 that indicates the patient's level of consciousness.

BIS Quatro sensor:

After proper placement of sensors over the patient's forehead, it is connected via the patient monitor interface cable and the recordings in the display is viewed.



BIS combines information from three EEG analysis:

- Spectrogram
- Bispectrum
- Time domain assessment of burst suppression

The spectrogram is a decomposition of the EEG into its power content by frequency as a function of time. The bispectrum measures as a function of time the degree of non-linear coupling between pairs of frequencies in the spectrogram.

The BIS is an electroencephalogram-derived multivariant scale that correlates with the metabolic rate of glucose. Both loss of consciousness and awakening from anaesthesia are correlated with this scale. The BIS algorithm

works by measuring specific features of the spectrogram, the bispectrum and the level of burst suppression and uses a pre-determined weightage scheme to convert these features into the index value. Along with the index value, the unprocessed EEG, the spectrogram and the llevel of electromyographic activity are displayed in the monitor. The production of the index is computationally intensive.

The changes in the index are correlated with the level of consciousness. Primarily for many anaesthetics, the EEG shows lower frequency higher amplitude oscillations as patients achieve deeper states of unconsciousness. Exceptions to these are ketamine, dexmeditomidine and nitrous oxide. The dissociative anaesthesia produced by ketamine is associated with prominent high frequency oscillations rather than slow wave oscillations. As a cosequence, patients can be unconscious with ketamine but have unexpectedly high index values. With dexmeditomidine, slow oscillations are prominent during sedation, with BIS values typically in the unconscious range. Nitrous oxide increases the amplitude of high frequency EEG activity and decreases the amplitude of low frequency EEG activity, yet it has little to no effect on the BIS index.

Anaesthetic states and the bispectral index

BIS index value	100	Awake - Responds to normal voice
	80	Light/Moderate sedation - May respond to loud commands or mild proding /shaking
	60	General anaesthesia - Low probability of explicit recall -Unresponsive to verbal stimulus
	40	Deep hypnotic state
	20	Burst suppression
	0	Flat line EEG

Benefits of using BIS:

- Reduction in primary anaesthetic use4
- Reduction in emergence and recovery time4
- Improved patient satisfaction36
- Decreased incidence of intraoperative awareness, defined as the patient having explicit recall of events that transpire during the time of general anaesthesia.

Limitations of BIS:

- BIS values are affected by the choice of anaesthetic agent. This finding means that a patient with a BIS score of 60 anesthetized with one combination of agents may be more deeply sedated than another patient with the same score but anesthetized with a different combination of drugs. In addition, the BIS monitor appears unable to accurately track changes in consciousness produced by certain anaesthetics, specifically ketamine and nitrous oxide.
- The changes in the BIS algorithm resulting from updating and refinement of the producer's database make it difficult to compare results obtained by different investigators using different versions of the BIS monitor. This fact also leaves hospital-based anaesthesiologists uncertain as to whether findings based on earlier versions of the BIS system are still valid.
- BIS values are difficult to correlate with other measurements of anaesthetic depth or altered consciousness.
- Standard BIS scores are not useful in monitoring special patient populations, particularly critically ill patients with unstable body temperatures and patients with dementia.

REVIEW OF LITERATURE

1. In study done by Strum E.M. *et al*, postoperative recovery after desflurane versus sevoflurane anaesthesia in morbidly obese adults (body mass index >/=35) who underwent gastrointestinal bypass surgery via an open laparotomy was compared. It was concluded that morbidly obese adult patients who underwent major abdominal surgery in a prospective, randomized study awoke significantly faster after desflurane than after sevoflurane anaesthesia and the patients anaesthetized with desflurane had higher oxygen saturation on entry to the PACU.

2. A study of sixty gynaecological day-case patients were anaesthetised with either desflurane or sevoflurane in oxygen/nitrous oxide, following intravenous induction was done by Mahmud M.A. *et al*. Time to eye opening and orientation following anaesthesia were significantly faster in the desflurane group (2.8 min/4.8 min) than in the sevoflurane group. Time to being ready for discharge home was also significantly earlier in the desflurane group (3 h compared with 3.5 h).

3. A prospective, randomised, double-blind, multicentre trial was done by Myles PS, *et al*. Adult patients at high risk of awareness were randomly allocated to BIS-guided anaesthesia or routine care. Patients were assessed by a blinded

observer for awareness at 2–6 h, 24–36 h, and 30 days after surgery. An independent committee, blinded to group identity, assessed every report of awareness. The primary outcome measure was confirmed reduced awareness under anaesthesia at any time.

4. In this study done by Komatsu R, *et al*, a quantitative systematic review of randomised, controlled trials that compared remifentanil to short-acting opioids (fentanyl, alfentanil, or sufentanil) for general anaesthesia was performed. Postoperatively, remifentanil was associated with faster recovery (difference in extubation time of −2.03, 9.5% CI, −2.92 to −1.14 min), more frequent postoperative analgesic requirements (1.36, 1.21–1.53) and fewer respiratory events requiring naloxone (0.25, 0.14–0.47). Remifentanil had no overall impact on postoperative nausea (1.03, 0.97–1.09) or vomiting (1.06, 0.96–1.17), but was associated with twice as much shivering (2.15, 1.73–2.69). Remifentanil does not seem to offer any advantage for lengthy, major interventions, but may be useful for selected patients, e.g. when postoperative respiratory depression is a concern.

5. In the systematic review by Gupta A. *et al*, postoperative recovery and complications using four different anaesthetic techniques was done. It was observed that no differences were found between propofol and isoflurane in

early recovery. However, early recovery was faster with desflurane compared with propofol and isoflurane and with sevoflurane compared with isoflurane. It was concluded that the differences in early recovery times among the different anaesthetics were small and in favour of the inhaled anaesthetics.

6. In this study by White PF *et al*, outpatients undergoing superficial surgical procedures requiring general anaesthesia to one of two maintenance anaesthetic treatment groups were randomized. All patients were induced with propofol, 2 mg/kg IV, and after placement of a laryngeal mask airway, anaesthesia was maintained with either sevoflurane 1%-3% or desflurane 3%-8% in an air/oxygen mixture. It was found that the use of desflurane for maintenance of anaesthesia was associated with a faster emergence and a higher incidence of coughing. Despite the faster initial recovery with desflurane, no significant differences were found between the two volatile anaesthetics in the later recovery period. Both volatile anaesthetics should be available for ambulatory anaesthesia.

7. In the study done by Rortgen D *et al*, the cognitive recovery profiles in elderly patients after general anaesthesia with desflurane or sevoflurane was evaluated. Propofol and fentanyl were administered for induction of anaesthesia, followed by either desflurane 2%±4%or sevoflurane 1%–1.5% with nitrous oxide 65% in oxygen. The use of desflurane was associated with

a more rapid emergence from anaesthesia (6.3 ± 2.4 min versus 8.0 ± 2.8 min) and a shorter length of stay in the post anaesthesia care unit (213 ± 66 min versus 241 ± 87 min). In conclusion, desflurane is associated with a faster early recovery than sevoflurane after general anaesthesia in elderly patients. However, recovery of cognitive function was similar after desflurane and sevoflurane-based anaesthesia.

8. In this study done by Saros *et al*, time from anaesthetic discontinuation until first response to command (T1); from response to command until ability to swallow (T2); and from anaesthetic discontinuation to recovery of ability to swallow (T3) in 120 patients within three BMI ranges (18–24, 25–29, and _30 kg m22) were observed. All received sevoflurane or desflurane, delivered via an LMA. It was found that prolonged sevoflurane administration and greater BMI delay airway reflex recovery. The contribution of BMI to this delay is more pronounced after sevoflurane than desflurane.

9. The aim of the study by McKay *et al*, was to compare desflurane vs sevoflurane kinetics and dynamics in morbidly obese patients and their recovery profile when no premedication had been used. Twenty-eight unpremedicated obese patients were randomly allocated to receive either sevoflurane (n¼14) or desflurane (n¼14) as the main anaesthetic agent. Time from discontinuation of the anaesthetic drugs to eye opening on verbal

command, squeezing the observer's hand on command, extubation, stating their name, giving their correct date of birth, discharge from the recovery room, and duration of the surgery and anaesthesia were also recorded. The wash-out phase was faster for desflurane during the total observation period. When desflurane was used, recovery was also faster.

METHODOLOGY

Having obtained the Institutional ethical committee approval, a total of 70 patients scheduled for elective laparoscopic surgeries expected to last for less than 2 hours to be performed under General Anaesthesia were enrolled in the study after informed consent.

Inclusion Criteria:

- Age > 18 years
- ASA I & II

Exclusion Criteria:

- Age < 18 years
- ASA > II
- Patient refusal
- Pregnancy
- History of alcohol or drug abuse

Patients were randomly assigned into two groups of 35 each as group S (Sevoflurane) and group D (Desflurane), via a computer generated randomised table. No anxiolytic or sedative medication were administered to the patients. Upon arrival at the operating room, standard monitoring devices were placed

including pulse oximetry, automated blood pressure and electrocardiograph and the baseline recordings were made. Baseline recordings of capnography and BIS were also noted.

All patients were pre-oxygenated with 100% O_2 for 3 mins. Patients were premedicated with inj. glycopyrrolate 0.2 mg and inj. Fentanyl 100 mics. Induced with inhalation of O_2 (6 L/min) and sevoflurane 5% using penlon sigma vaporizer till a BIS value of 40 – 60 was reached. Inj. atracurium 0.5 mg/kg was administered and was intubated with an appropriate size cuffed ETT. In group D, within 10 mins of intubation, inhalational agent was changed to desflurane using a drager vaporizer. Maintenance of anaesthesia was with O_2:N_2O (33:67), titrated doses of either sevoflurane or desflurane and atracurium aliquots to keep a BIS range of 40 - 60. 6 mg alliquots of inj. Ephedrine were administered to treat hypotension defined as > 30% decrease in systolic blood pressure from the baseline value. Bradycardia defined as heart rate < 60/min was treated with 0.6 mg of inj. Atropine. Tachycardia defined as heart rate > 120/min and hypertension defined as > 30% increase in systolic pressure from baseline values were treated with bolus of 25 mics inj. Fentanyl. .

In both groups inj. Atracurium was not administered after letting out the carboperitoneum. Port sites were infiltrated with Local Anaesthetics. Controlled ventilation was maintained until the patient's first spontaneous breath was noted following which patient's ventilation was manually assisted. The neuro muscular

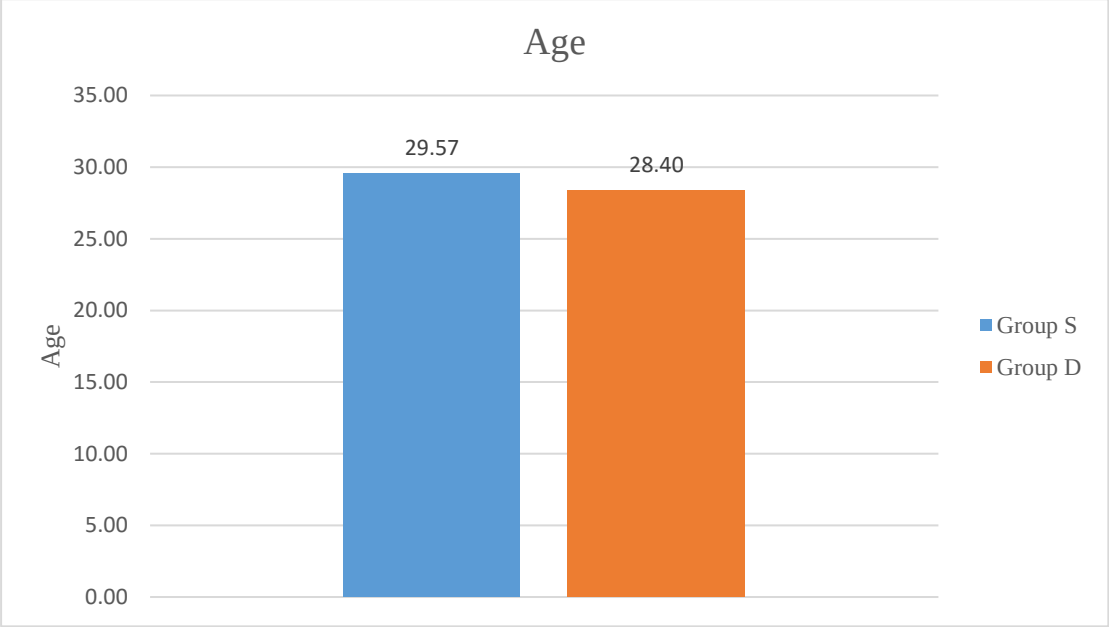
blockade was reversed with inj. Neostigmine 0.04 mg/kg and inj. Glycopyrrolate 0.01 mg/kg. Volatile anaesthetic was discontinued after the reversal. A stop watch was started from the discontinuation of volatile anaesthetics.

The following parameters were noted:

- Time to eye opening
- Time to squeeze hands
- Time to extubate
- Time to name
- Use of drugs/Supplemental O_2
- Time to shift the patient

STATISTICAL ANALYSIS

1. AGE DISTRIBUTION AMONG THE TWO GROUPS

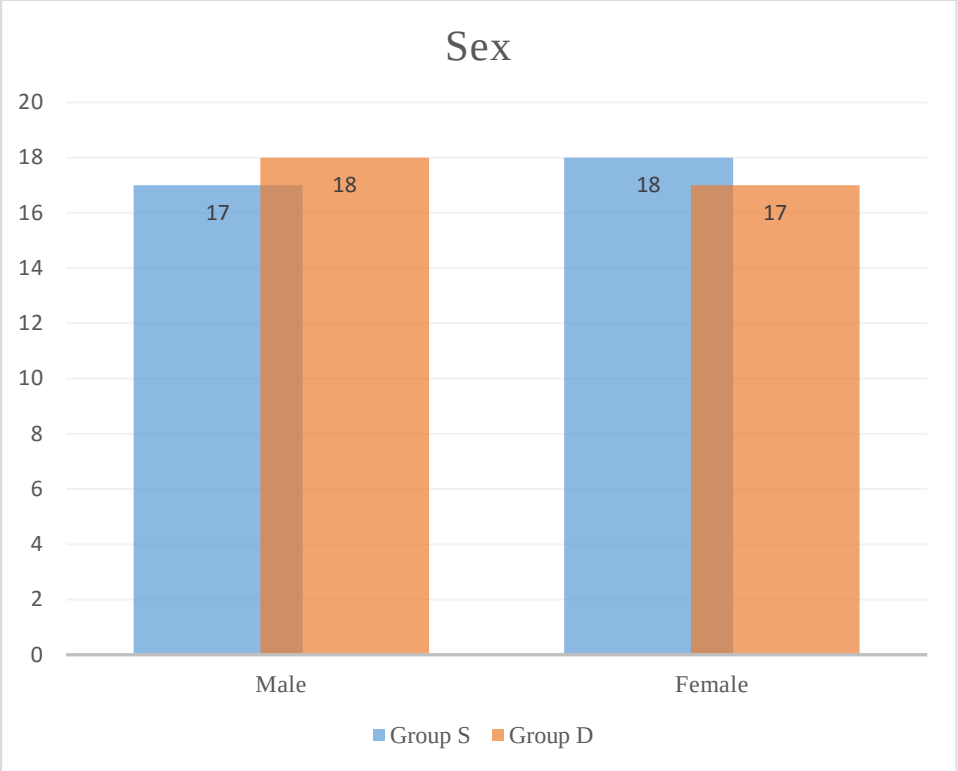


Both groups are comparable in age.

Age	Group S	Group D
Mean	29.57	28.40
SD	6.62	5.48
p value	0.214 Not Significant	

The two groups showed no significant change in age distribution.

2. SEX DISTRIBUTION AMONG THE TWO GROUPS

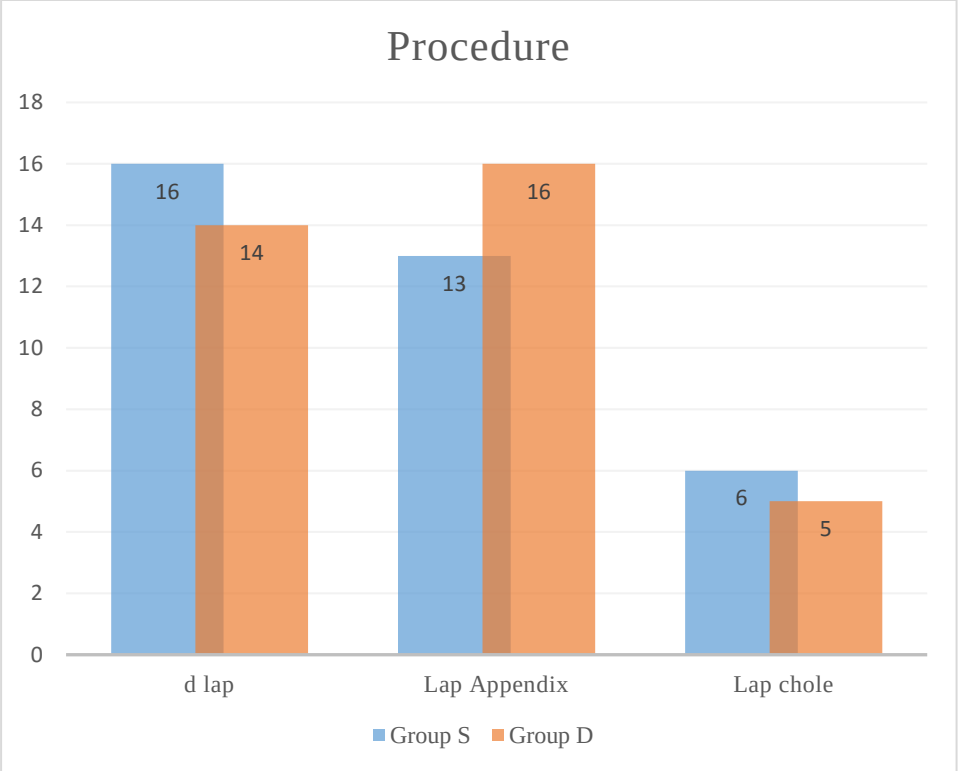


The graph shows that both groups are comparable in gender.

Sex	Group S	Group D
Male	17	18
Female	18	17
p value	0.4 Not significant	

The gender distribution both groups is not significant.

3. DISTRIBUTION OF PROCEDURES

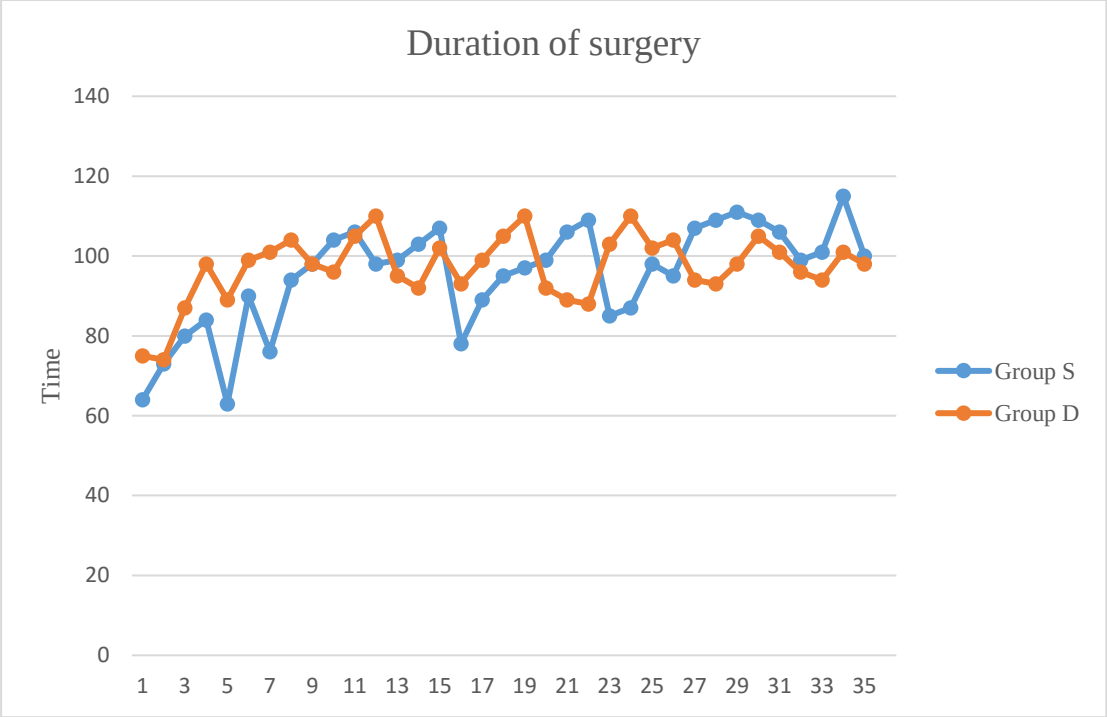


The procedure in both groups were comparable.

Procedure	Group S	Group D
d lap	16	14
Lap Appendix	13	16
Lap chole	6	5
p value	0.25 Not significant	

The case distribution in both groups is almost comparable.

4. DURATION OF SURGERY

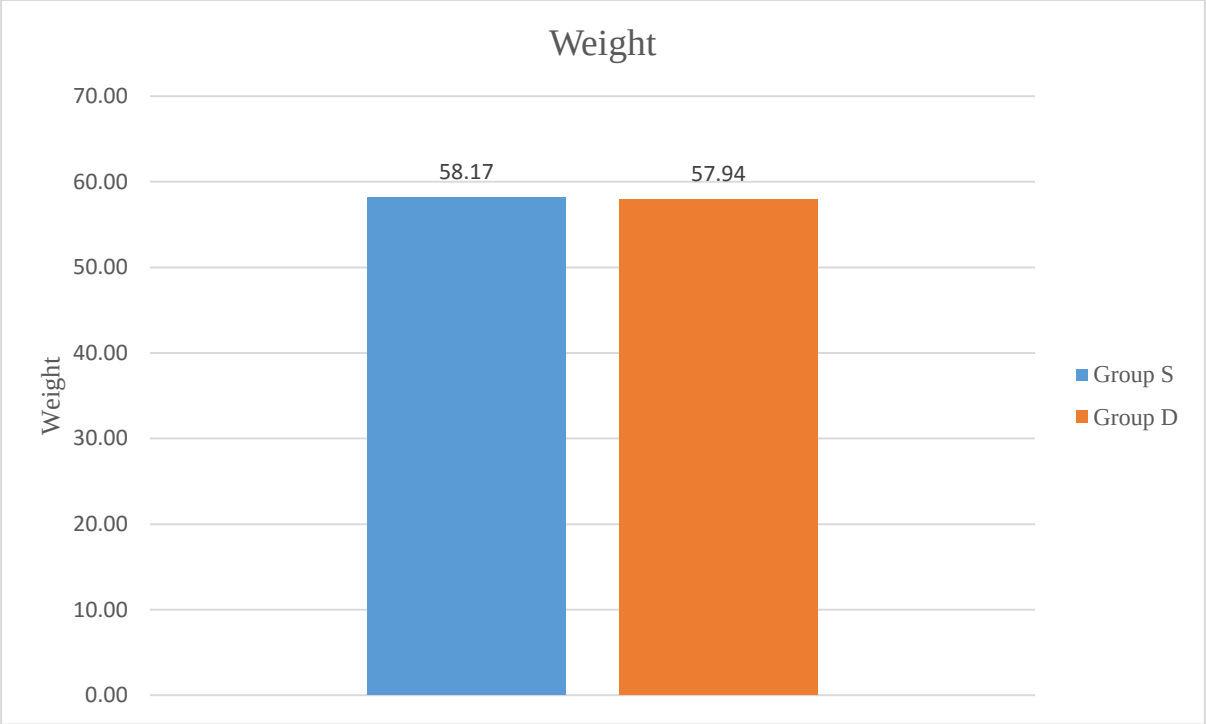


The duration of procedure in the two groups were comparable.

Duration of surgery	Group S	Group D
Mean	95.3	97.1
SD	12.95	8.23
p value	0.24 Not significant	

The p value comparing two groups is not significant.

5. WEIGHT IN TWO GROUPS

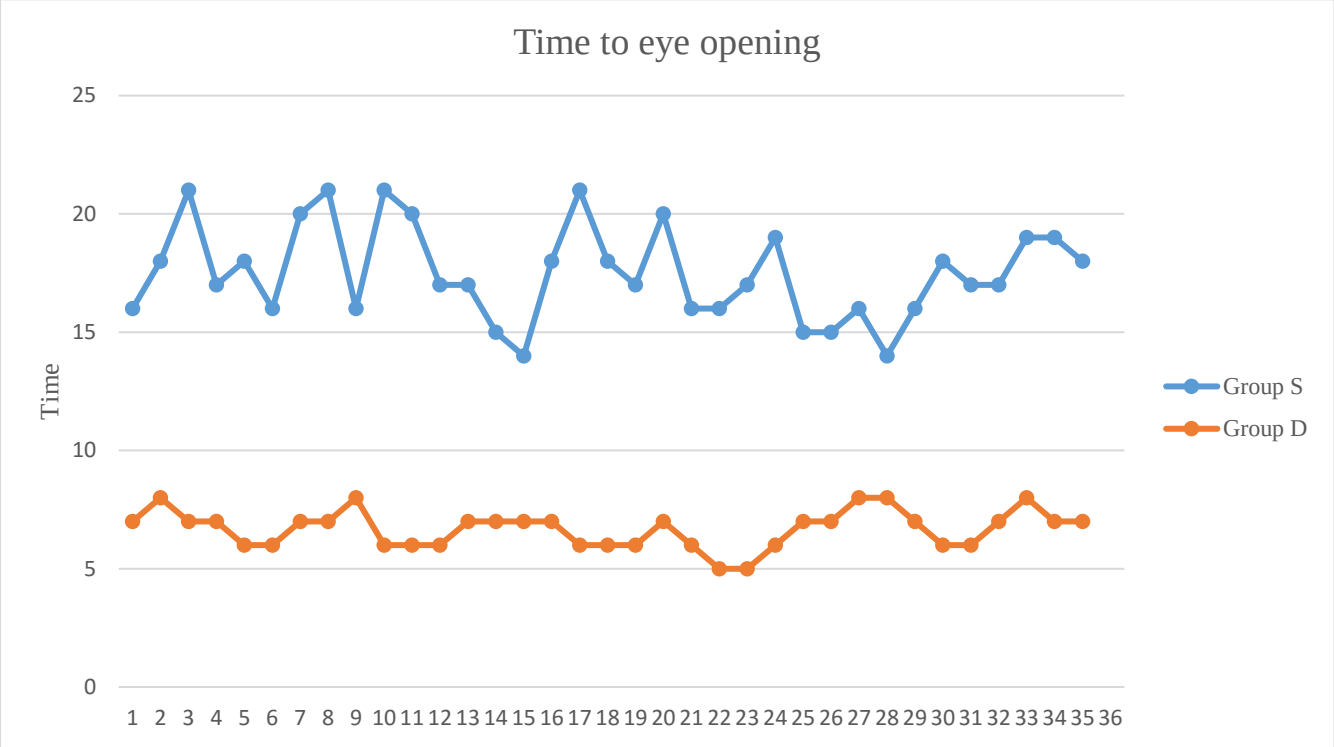


Both groups were comparable in weight.

Weight	Group S	Group D
Mean	58.17	57.94
SD	4.72	5.48
p value	0.43 Not significant	

The p value between the two groups is not of much significance.

6. TIME TO EYE OPENING

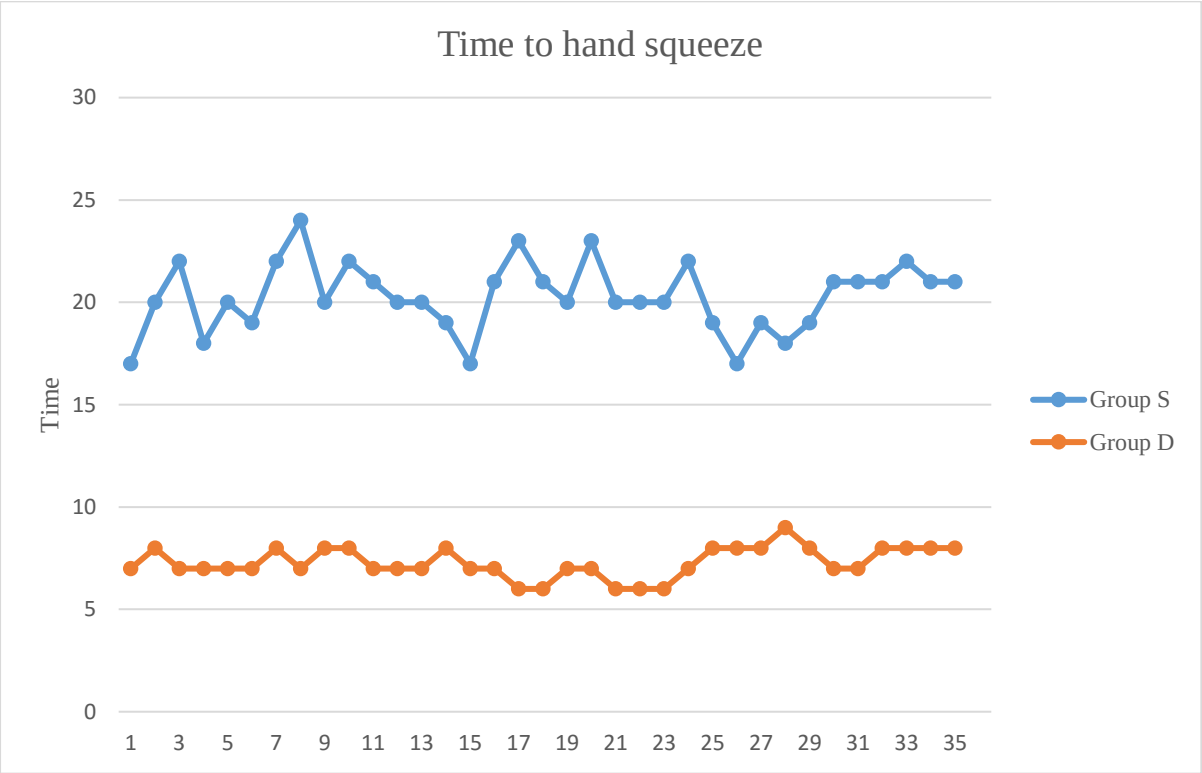


Time to eye opening on command after discontinuing inhalational agent in Group D is shorter than that in Group S.

Time to eye opening	Group S	Group D
Mean	6.4	18.7
SD	2.00	0.80
p value	<0.01 Significant	

The p value being < 0.01 is very much significant.

7. TIME TO HAND SQUEEZE

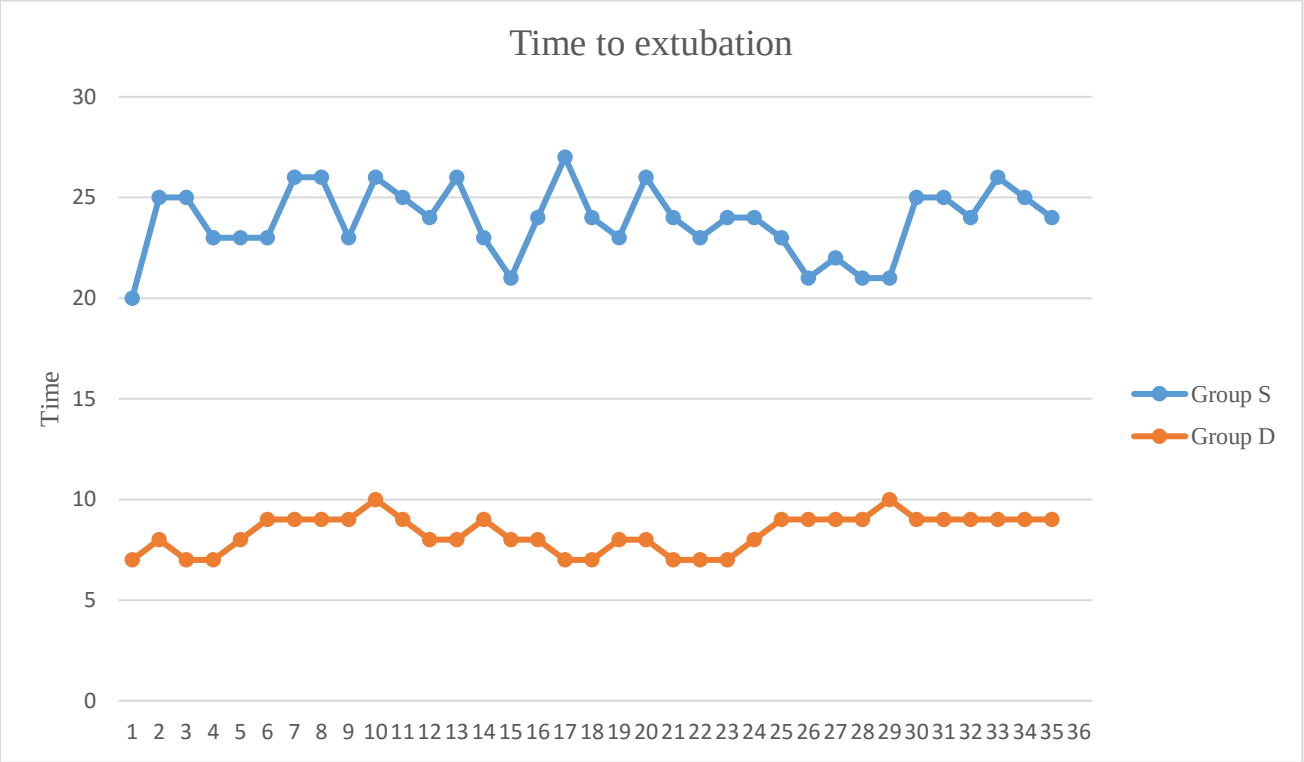


The time to hand squeeze on command is significantly shorter with desflurane compared to sevoflurane.

Time to hand squeezing	Group S	Group D
Mean	20.3	7.3
SD	1.70	0.70
p value	<0.01 Significant	

The p value comparing both groups is < 0.01 which is significant.

8. TIME TO EXTUBATION

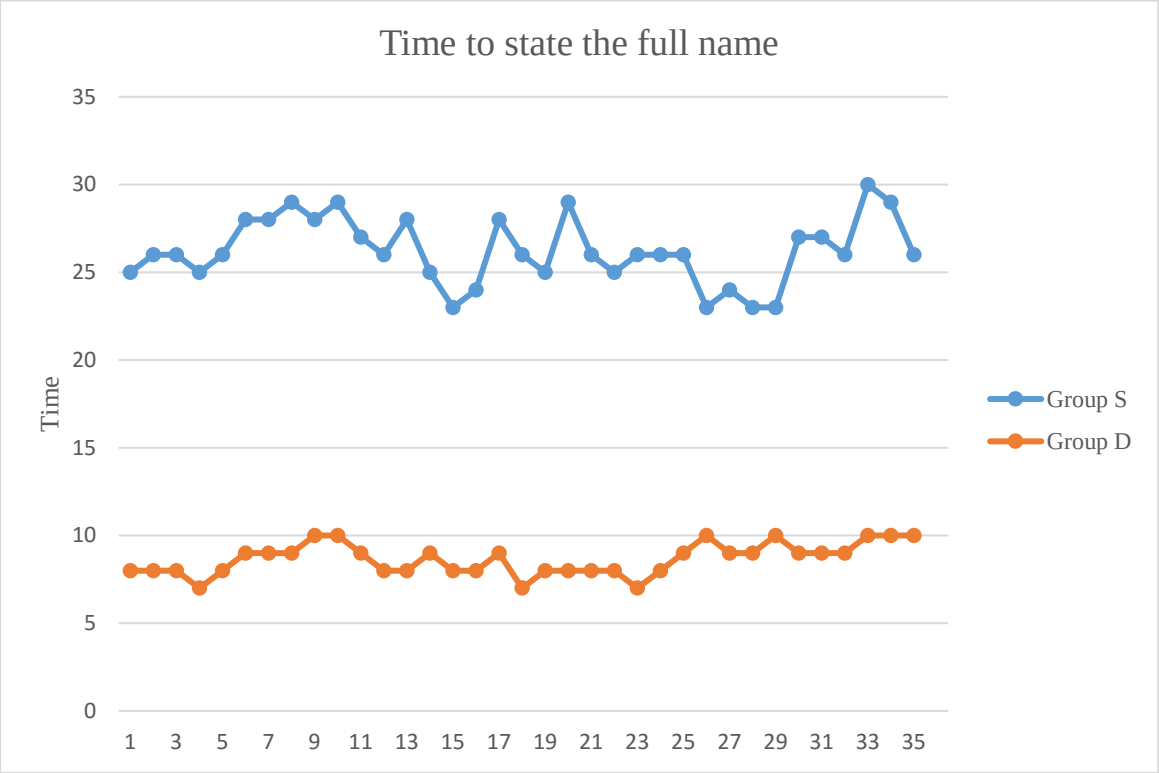


The time to tracheal extubation after discontinuation of inhalational agent is lesser with desflurane than with sevoflurane.

Time to extubation	Group S	Group D
Mean	20.3	7.3
SD	1.70	0.90
p value	< 0.01 Significant	

On comparing the sevoflurane and desflurane, the p value is < 0.01 which is significant.

9. TIME TO STATE FULL NAME



The time taken to state full name on command to check the orientation is shorter with desflurane than with sevoflurane.

Time to state the full name	Group S	Group D
Mean	26.2	8.7
SD	1.90	0.90
p value	< 0.01 Significant	

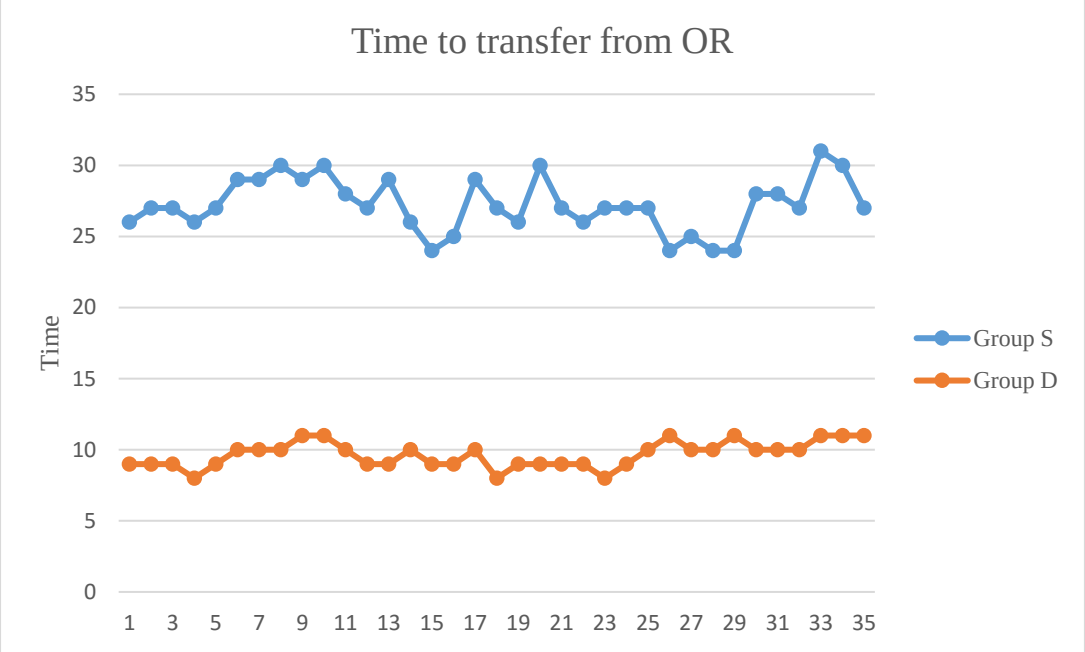
The p value is < 0.01 which is significant.

10.USE OF SUPPLEMENTAL DRUGS/ O_2

Use of drugs/Supplemental O_2	Group S	Group D
No. of cases	11	0

Out of 35 patients supplemental drugs /O_2 had to be used in 11 patients in the sevoflurane group and none of the patients in the desflurane group required them.

11.TIME TO TRANSFER FROM OT



Time taken to transfer the patients out of the OT is much shorter with desflurane than with sevoflurane as patients in Group S who were given medications to alleviate the emergence phenomenon had to be observed in the OT for few minutes.

Time to shift out of OT	Group S	Group D
Mean	27.2	9.7
SD	1.90	0.90
p value	<0.01 Not Significant	

The p value between the two groups is < 0.01 which is significant.

RESULTS

70 patients were included in the study and by computer randomization they received either sevoflurane or desflurane for the maintenance of general anaesthesia. The volatile induction did not precipitate any adverse events such as laryngospasm or arterial oxygen desaturation in any of the patients. Throughout the procedure, BIS index was maintained at 40 – 60.

None of the patients experienced awareness during anaesthesia. The baseline characteristics and the intra operative data were comparable between the two groups. In Group S maintained with sevoflurane, the shortest time for eye opening after cutting the anaesthetic agent is 14 mins and the longest time for the same is 21 mins. The mean time is 17.5 mins. In Group D maintained with desflurane, the shortest time for eye opening after cutting the anaesthetic agent is 5 mins and the longest time for the same is 8 mins. The mean time is 6.7 mins. The p value is < 0.01 which is quite significant. Likewise the shortest time taken to shift the patient out of the OT is 24 mins and the longest time is 32 mins in Group S with a mean value of 21.7 mins. In Group D, the shortest time taken to shift the patient out of the OT is 8 mins and the longest time is 11 mins with a mean value of 9.7 mins. The p value on comparing the time taken to shift the patient out of the OT in both groups is < 0.01 which is significant.

Similarly, the time taken to hand squeezing, extubation and the patient's ability to tell his full name is found to be significantly longer in the sevoflurane group when compared to the desflurane group. During emergence, however, supplemental drugs had to be administered in 11 patients of the sevoflurane group. Supplemental drug was either inj. propofol or inj. midazolam in titrated doses, to a maximum of 50 mg and 3 mg respectively.

Patients who received the injections were provided with supplemental oxygen until they responded well to oral commands. Both groups were satisfied regarding the anaesthesia.

DISCUSSION

In this randomised controlled study which included 70 patients posted for laparoscopic surgeries were divided into two groups of Group S who were induced with sevoflurane and maintained with the same and Group D who were induced with sevoflurane and switched over to desflurane within 10 mins of tracheal intubation and maintained with the same.

Sevoflurane being an agent with pleasant odour and with its non - irritating characteristics to the upper respiratory tract is the best inhalational agent now available for induction in both paediatric and adult patients. Moreover, the low blood/gas partition co-efficient, 0.69, leads to rapid rate of equilibration between alveolar and inspired concentrations favouring faster induction. Though desflurane has still lower blood/gas partition co-efficient, 0.42, it can't be used for induction as it has an ethereal and pungent odour which very much irritates the upper respiratory tract.

The advantages of sevoflurane are:

- Smooth, fast induction
- Rapid recovery
- Ease of use, requiring conventional vaporizers

The disadvantages are:

- Production of potentially toxic metabolites in the body
- Instability with carbon dioxide absorbers
- Relative expense

Though induction of anaesthesia with desflurane is very much limited by its pungent nature, it is possible to alter the depth of anaesthesia very rapidly and the rate of recovery of anaesthesia can be hastened than that following any other volatile anaesthetic agent.

Advantages of desflurane:

- It has low blood solubility, therefore it offers more precise control of maintenance of anaesthesia and rapid recovery.
- It is minimally biodegradable and therefore non-toxic to the liver and kidney.
- It does not cause convulsive activity on EEG.

Significant drawbacks:

- It cannot be used for inhalational induction because of its irritant effects on the airway.
- It causes tachycardia at higher concentrations.
- It requires a special vaporizer. Although, TEC-6 vaporizer is reasonably easy to use it is more complex than the more conventional vaporizers and the potential for failure may be higher.

- It is expensive.

The time taken for all the parameters included in the study after cutting the anaesthetic agent is significantly shorter for desflurane than for sevoflurane. Moreover the emergence from anaesthesia is also found to be smooth and pleasant with desflurane than with sevoflurane.

CONCLUSION

Changing the anaesthetic agent from sevoflurane to desflurane, after volatile induction with sevoflurane provides faster emergence and recovery compared with sevoflurane anaesthesia. This technique favours both smooth induction and rapid recovery with high patient's satisfaction.

SUMMARY

A total of 70 patients scheduled for elective laparoscopic surgeries expected to last for less than 2 hours to be performed under General Anaesthesia were enrolled in the study after informed consent. Patients were randomly assigned into two groups of 35 each as group S (Sevoflurane) and group D (Desflurane), via a computer generated randomised table. After pre-oxygenation, in Group S patients were induced with inhalation of O_2 (6 L/min) and sevoflurane 5% till a BIS value of 40 – 60 was reached. Inj. atracurium 0.5 mg/kg was administered and was intubated with an appropriate size cuffed ETT. In group D, within 10 mins of intubation, inhalational agent was changed to desflurane. Maintenance of anaesthesia was with O_2:N_2O (33:67), titrated doses of either sevoflurane or desflurane and atracurium alliquots to keep a BIS range of 40 - 60.

The study parameters included were time taken to eye opening to command, squeeze hands on command, extubation, to name himself and to shift the patient out after cutting the inhalational anaesthetic agent. Use of drugs to alleviate the emergence phenomenon if any, were also noted.

The values recorded were displayed on the Microsoft Excel 2016 and the mean was calculated. The standard deviation was calculated with the values recorded in both groups. The p value was calculated using student's t test and

depending on the significance, conclusion was made and the p value is said to be significant if it is < 0.05.

We conclude that induction with sevoflurane and changing to desflurane in the early part of anaesthesia not only provides smoother induction but also a rapid and smoother recovery from anaesthesia.

MADURAI MEDICAL COLLEGE
MADURAI, TAMILNADU, INDIA -625 020
(Affiliated to The Tamilnadu Dr.MGR Medical University,
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ETHICS COMMITTEE CERTIFICATE

Name of the Candidate	:	Dr. Anne Feno .A
Course	:	PG in MD., Anaesthesia
Period of Study	:	2015- 2017
College	:	MADURAI MEDICAL COLLEGE
Research Topic	:	Effects of changing from sevoflurane to desflurane on the recovery profile after sevoflurane induction: A Randomized controlled study
Ethical Committee as on	:	06.09.2016

The Ethics Committee, Madurai Medical College has decided to inform that your Research proposal is accepted.

Member Secretary Chairman Dean / Convenor

DEAN
Madurai Medical College
Madurai-20

06 SEP 2016

PROFORMA

Patient	
Age	
Sex	
Weight	
Procedure	
Duration of surgery	
Time to eye opening	
Time to hand squeeze	
Time to extubation	
Time to state the full name	
Use of supplemental drugs/ O_2	
Time to transfer from OT	

Group S											
Patient	Age Distribution	Sex Distribution	Distribution of procedure	Duration of surgery	Weight	Time to eye opening	Time to hand squeeze	Time to extubation	Time to state the full name	Use of supplemental drugs/ O_2	Time to transfer from OT
Avinash	18	M	LC	64	60	16	17	20	25	N	26
Indra	21	F	LA	73	54	18	20	25	26	N	27
Akila	35	F	DL	80	57	21	22	25	26	N	27
Saranya	30	F	DL	84	53	17	18	23	25	N	26
Jeganath	35	M	LA	63	64	18	20	23	26	N	27
Prabhu	33	M	LC	90	66	16	19	23	28	Y	29
Harini	19	F	DL	76	62	20	22	26	28	Y	29
Raj	22	M	LC	94	45	21	24	26	29	Y	30
Amala	23	F	LA	98	48	16	20	23	28	Y	29
Jothi	37	F	DL	104	52	21	22	26	29	Y	30
Eswaran	34	M	LC	106	60	20	21	25	27	N	28
Murugan	31	M	LA	98	59	17	20	24	26	N	27
Abishek	32	M	DL	99	57	17	20	26	28	Y	29
Karthik	39	M	DL	103	58	15	19	23	25	N	26
Vignesh	37	M	LA	107	60	14	17	21	23	N	24
Nisha	34	F	LC	78	61	18	21	24	24	N	25
Kumar	27	M	DL	89	63	21	23	27	28	Y	29

Group S											
Patient	Age Distribution	Sex Distribution	Distribution of procedure	Duration of surgery	Weight	Time to eye openi ng	Time to hand squee ze	Time to extubation	Time to state the full name	Use of supplemental drugs/ O_2	Time to transfer from OT
Chitra	23	F	DL	109	57	16	20	23	25	N	26
Karunaakara n	27	M	DL	85	56	17	20	24	26	N	27
Divya	29	F	LA	87	58	19	22	24	26	N	27
Arul	31	M	DL	98	60	15	19	23	26	N	27
Gayathri	31	F	LA	95	59	15	17	21	23	N	24
Arjun	34	M	DL	107	58	16	19	22	24	N	25
Ashok	40	M	LA	109	57	14	18	21	23	N	24
Purnima	40	F	DL	111	57	16	19	21	23	N	24
Bharathi	39	F	LC	109	56	18	21	25	27	Y	28
Renuka	29	F	LA	106	54	17	21	25	27	N	28
Hari	19	M	DL	99	64	17	21	24	26	N	27
Lakshmi	20	F	LA	101	63	19	22	26	30	Y	31
Saveetha	31	F	DL	115	63	19	21	25	29	Y	30
Annapurni	37	F	LA	100	66	18	21	24	26	N	27
Meena	26	F	LA	95	65	18	21	24	26	N	27
Sanjay	29	M	DL	97	56	17	20	23	25	N	26
Kiruba	20	F	LA	99	53	20	23	26	29	Y	30
Pradeep	23	M	DL	106	55	16	20	24	26	N	27

GROUP D											
Patient	Age Distribution	Sex Distribution	Distribution of procedure	Duration of surgery	Weight	Time to eye opening	Time to hand squeeze	Time to extubation	Time to state the full name	Use of supplemental drugs/ O_2	Time to transfer from OT
Raghavan	20	M	DL	75	57	7	7	7	8	N	9
Selvakumari	18	F	DL	74	53	8	8	8	8	N	9
Abinaya	31	F	DL	87	48	7	7	7	8	N	9
Prabhu	31	M	LC	98	60	7	7	7	7	N	8
Muthulakshmi	37	F	LA	89	59	6	7	8	8	N	9
Madhan	26	M	LA	99	53	6	7	9	9	N	10
Shanthi	25	F	LA	101	54	7	8	9	9	N	10
Satheesh	24	M	LA	104	66	7	7	9	9	N	10
Selvanathan	27	M	DL	98	68	8	8	9	10	N	11
Janani	28	F	LA	96	48	6	8	10	10	N	11
Muthukumar	38	M	DL	105	47	6	7	9	9	N	10
Raji	36	F	DL	110	49	6	7	8	8	N	9
Uma	33	F	LA	95	55	7	7	8	8	N	9
Palani	21	M	DL	92	58	7	8	9	9	N	10
Sneha	21	F	LC	102	57	7	7	8	8	N	9
Raghu	23	M	DL	93	59	7	7	8	8	N	9
Sandhiya	27	F	LA	99	60	6	6	7	9	N	10

GROUP D											
Patient	Age Distribution	Sex Distribution	Distribution of procedure	Duration of surgery	Weight	Time to eye opening	Time to hand squeeze	Time to extubation	Time to state the full name	Use of supplemental drugs/ O_2	Time to transfer from OT
Prabahar	25	M	DL	105	58	6	6	7	7	N	8
Raji	30	F	LA	110	59	6	7	8	8	N	9
Ananthi	40	F	DL	92	60	7	7	8	8	N	9
Akhilan	39	M	LA	89	64	6	6	7	8	N	9
Santhanaakshmi	34	F	LC	88	63	5	6	7	8	N	9
Chandru	33	M	DL	103	62	5	6	7	7	N	8
Bhavani	32	F	LA	110	61	6	7	8	8	N	9
Radhika	30	F	LA	102	59	7	8	9	9	N	10
Vijay	29	M	LC	104	57	7	8	9	10	N	11
Sangeetha	29	F	LA	94	56	8	8	9	9	N	10
Subramani	21	M	DL	93	49	8	9	9	9	N	10
Suresh	24	M	LA	98	57	7	8	10	10	N	11
Thiyagarajan	24	M	DL	105	59	6	7	9	9	N	10
Venkatesh	27	M	LA	101	70	6	7	9	9	N	10
Priya	27	F	LA	96	58	7	8	9	9	N	10
Sivan	29	M	DL	94	57	8	8	9	10	N	11
Barani	29	F	LA	101	65	7	8	9	10	N	11
Suresh	26	M	LC	98	63	7	8	9	10	N	11

S – SEVOFLURANE

D – DESFLURANE

Y – YES

N – NO

LC – LAPAROSCOPIC CHOLECYSTECTOMY

DL – DIAGNOSTIC LAPAROSCOPY

LA – LAPAROSCOPIC APPENDECTOMY

EFFECTS OF CHANGING FROM SEVOFLURANE TO DESFLURANE

ON THE RECOVERY PROFILE AFTER SEVOFLURANE

INDUCTION: A RANDOMIZED CONTROL STUDY

A STUDY OF 70 CASES

DISSERTATION SUBMITTED FOR

DOCTOR OF MEDICINE

BRANCH X (ANAESTHESIOLOGY)

APRIL 2017

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

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