A COMPARATIVE STUDY OF 2 AGENTS, AIR AND DISTILLED WATER FOR INFLATION OF THE CUFFS OF ENDOTRACHEAL TUBES DURING LAPAROSCOPIC SURGICAL PROCEDURES UNDER GENERAL ANAESTHESIA

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ABSTRACT

BACKGROUND & AIM

During Nitrous Oxide+ Oxygen anaesthesia and during laparoscopic surgeries using carbon dioxide for creating pneumoperitoneum, if cuff of endotracheal tube is inflated with air, cuff pressure can rise to dangerous limits and it can produce ischemia of tracheal mucosa. Hence distilled water as an alternative agent to air for inflation of cuffs of endotracheal tubes was used for our study. Our aim is to investigate the difference in increase of intra-cuff pressure with time during laparoscopic surgical procedures under general endotracheal anaesthesia with Nitrous oxide+ Oxygen+ relaxant technique when cuffs of endotracheal tube were inflated by air & distilled water.

METHODS

Fifty patients (n=50) undergoing different laparoscopic surgical procedures under general endotracheal anaesthesia were randomly divided into 2 groups. In group A, air was used & in group D, distilled water was used to inflate the cuffs of endotracheal tubes. General anaesthesia was given with Nitrous oxide+ Oxygen+ relaxant technique. The intra-cuff pressures of endotracheal tube cuffs were recorded in the beginning and at the end of laparoscopic surgical procedures. Increase of pressures with time were recorded and analysed.

RESULTS

In group in whom we inflated the cuffs with air, there was a significant increase in intra-cuff pressures with time and there was definite diffusion of gases into the cuffs. Increase of pressure with time was statistically highly significant (P=0.00001). But in group in whom we used distilled water to inflate the cuffs, there was no change in the volume of water used for inflation and water came out of cuffs at the end of the laparoscopic surgical procedures. No additional air could be aspirated from the cuffs at the end of laparoscopic surgeries in distilled water group, indicating that there was no diffusion of gases into the cuffs or the gases diffused got dissolved in distilled water. Hence there was no increase of volume distilled water. Hence there was absolutely no change of intra cuff pressure with time in distilled water group of patients. Absolutely, no change of intra-cuff volume and pressure with time in distilled water group. There was statistically significant increase of intra-cuff pressure with time (P=0.00001) in group of patients in whom we used air to inflate the cuffs of endotracheal tubes.

CONCLUSION

Distilled water may be considered as more preferable agent than air for inflation of cuffs of endotracheal tubes during laparoscopic surgical procedures under general anaesthesia with Nitrous oxide+ Oxygen+ relaxant technique.

KEYWORDS

Endotracheal tube cuff pressure; Laparoscopic surgeries; General anaesthesia.

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INTRODUCTION: Endotracheal intubation is an important step during general anaesthesia for laparoscopic surgeries. Inflation of cuff is done (a) to save anaesthetic gases and vapours, (b) to prevent aspiration of secretions from oral cavity and regurgitated gastric secretions, (c) to ventilate lungs with required tidal volume and pressure, (d) to prevent displacement of endotracheal tube with change of position of head.(1) During anaesthesia with Nitrous oxide+ oxygen, due to diffusion of Nitrous oxide into cuff, intra-cuff pressure increases with time of GA and with IPPV.(2) During laparoscopy carbon dioxide gas is generally used to create pneumoperitoneum to allow endoscopic surgical procedure. This gas also diffuses into the cuff and adds to the increase of intra-cuff pressure.(3) IPPV increases intra-thoracic pressure, can transmit some positive pressure into cuff and hence adds to increase of intra-cuff pressure.(3) Pressure from outside in the form of retraction of trachea during thyroidectomy, anterior spinal fusion procedure and other

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neck surgeries can add to the increase of intra-cuff pressure.[4]

The intra-cuff pressure rises sometimes to dangerous levels resulting in (a) ischemia of tracheal mucosa, causing tracheal ulceration (b) oedema of respiratory passage resulting in croup and respiratory insufficiency, (c) tracheobronchitis, (d) tracheal stenosis, (e) negative pressure pulmonary oedema, (f) Iatrogenic tracheo-oesophageal fistulas, (g) laryngeal complications resulting in change of voice and vocal nodules and (h) recurrent laryngeal nerve palsies.[5],[6],[7],[8],[9],[10],[11] All these complications are avoidable with simple precaution, monitoring of intra-cuff pressure periodically, and avoiding all manoeuvres which can increase intra-cuff pressure. Various authors have advised various techniques to avoid raise of intra-cuff pressure during laparoscopic surgeries. In our study, we used distilled water for inflation of cuff and compared it with inflation by air.

METHODS: After clearance from Ethics Committee of our Hospital and after taking informed consent in writing, 50 patients (n=50) posted for elective and emergency laparoscopic surgeries under general anaesthesia were randomly divided into two groups. 25 patients in Group A (n=25) and 25 patients in Group D (n=25).

We had selected the following groups of patients for our study (1) ASA 1 to 3, elective and emergency surgeries, (2) Ages between 15- 60 years, (3) both sexes (4) controlled diabetes and hypertension.

We excluded the following groups of patients from our study (1) ASA 4 and 5, (2) complex biochemical problems like diabetic ketoacidosis (3) unstable cardiovascular, respiratory, CNS and renal function (4) pregnant women, (5) children below 15 years and very old patients above 60 years.

There were 17 male patients and 33 female patients in our study. Portex endotracheal tubes (disposable) with high volume and low pressure cuffs were used in our study. For every patient in distilled water group, the correct size endotracheal tube was kept in vertical position with cuff downwards, the cuff was inflated with distilled water and was sucked out with a syringe. This manoeuvre was performed repeatedly with distilled water in syringe till all the initial air pockets were removed from the cuff.

After pre-anaesthetic checkup and preparation, all the patients posted for laparoscopic surgeries were received into pre-anaesthesia room, and were premedicated with (1) Glycopyrrolate 0.01 mg/kg IM + (2) Fentanyl 1 microgram/kg IM 45 minutes before the surgical procedure. Intravenous line was taken and infusion of 500 mL of Ringers lactate was started.

30 to 45 minutes after premedication, patients were shifted on to the operation table, noninvasive BP, pulse oximeter, ECG, capnograph, and hourly urine output monitors were connected. After preoxygenation for 5 minutes with 100% oxygen by mask, general anaesthesia was induced with sleep dose of Thiopentone sodium (maximum 5 mg/kg) or propofol 2.5 mg/kg, and intubated with Portex cuffed endotracheal tube of adequate size (which was already prepared, lubricated and kept ready), after skeletal muscle relaxation with succinylcholine (1 mg/kg IV). For 25 distilled water group patients, after general anaesthesia was induced and endotracheal intubation was done and inflation of cuff was done with 5-8 mL of distilled water till the pilot balloon becomes full. Then, pilot balloon was pressed to displace water into the cuff. Pilot balloon was compressed till the air leak disappears over trachea when auscultated (volume just required to obliterate the space around cuff and not producing undue pressure on tracheal mucosa). The amount of distilled water injected into cuff was noted for every case.

For 25 air group patients, after endotracheal intubation, the cuff was inflated with air with a syringe through Portex cuff inflator and pressure monitor, till the air leak disappears over trachea when auscultated. The beginning cuff pressure was measured and recorded.

General anaesthesia was maintained with Nitrous oxide+ oxygen+ halothane 0.5-1% or enflurane 0.5-1% +vecuronium, IPPV in closed circuit with soda lime canister in circuit or with semi-closed circuit with soda lime canister in circuit with minimal leak. Patients were positioned in the required position for laparoscopic surgery and the planned endoscopic surgery was conducted after inflating the peritoneal cavity with required amount of carbon dioxide.

When the surgical procedure was finished, patients were kept in supine position, all anaesthetic gases and vapours were stopped, and 100% oxygen continued through same circuit. Non-depolarizing skeletal muscle relaxant effect was reversed with glycopyrrolate 0.02 mg/kg + neostigmine 0.08 mg/kg. When the patient became fully conscious and all protective reflexes returned, oral suction was done.

For air group of patients, final intra-cuff pressure was recorded with Portex cuff pressure monitor and inflator and the cuff was deflated with a syringe. When the cuff was completely empty, extubation was done.

For distilled water group of patients, distilled water in the cuff was sucked with syringe and when the cuff was completely empty, extubation was done. When only the initial amount of water came out and no additional air could be aspirated from the cuff, we took for granted that the intra-cuff pressure did not increase during the surgical procedure.

All the patients were shifted into recovery room, kept in 30^0 prop up position, oxygenation by Hudson's mask, and with all monitors except capnograph. Patients were observed for postintubation and postextubation complications like croup, stridor, cough, hoarseness of voice, and any other complication resulting in respiratory insufficiency till next day morning (roughly for 24 hours) in our recovery room and later in the postoperative ward till the patients were discharged (roughly for 1 week to 10 days).

Details of surgical procedures performed:

Surgical Procedure	Number of cases
Appendectomy	22(44%) (7 elective +15 emergency)
Cholecystectomy	26(52%) (all elective)
Diagnostic laparotomy	1(2%)(elective)
Hysterectomy	1(2%)(elective)

RESULTS: (a) The average time for which the endotracheal tube was kept inflated was 1 hour to 3 hours 30 minutes. Mean was 2.245 hours, and standard deviation was 0.7328. (b) Initial intra-cuff pressure=20 cm of water. (c) Increased pressure range in air group= 24 cm to 42 cm of water (mean=33.04 cm of water, standard deviation=5.9828). (d) The correlation coefficient of increase of pressures with time in air group of patients was 0.7977(strong positive correlation). Increase of cuff pressure with time in our air group of patients was statistically very highly significant P=0.00001. (e) Postextubation problems due to high intra-cuff pressure and ischemia of tracheal mucosa like croup, stridor and postextubation respiratory insufficiency were not observed in any of our patients (both groups). (f) There was no change in volume of distilled water injected and aspirated from cuffs of endotracheal tubes at the end of the surgery in our distilled water group of patients (both graphs are overlapping). Absolutely, no additional air could be aspirated from the cuffs showing that the anaesthetic gases and carbon dioxide diffused into the cuff got dissolved in distilled water without increasing the volume of distilled water. Hence we concluded that there was no change of intra-cuff pressure throughout surgical procedure.

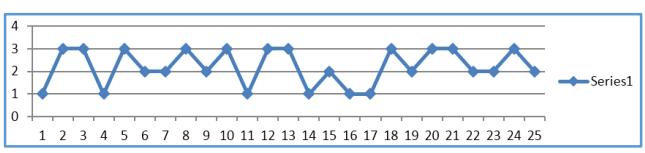

Chart 1: Time of inflation of cuff in group D patients

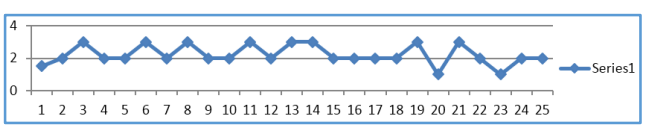

Chart 2: Time of inflation of cuff in group A patients

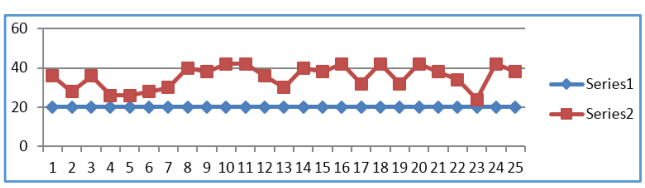

Chart 3: Cuff pressure changes with time in group A

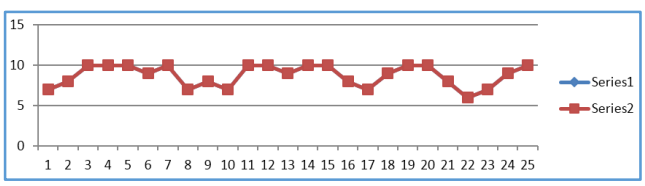

Chart 4: Volume of distilled water injected and sucked out after the surgical procedure in group D

DISCUSSION: For laparoscopic surgeries under general anaesthesia, endotracheal intubation is a time tested technique. Anaesthesia through Pro-Seal LMA was suggested as an alternative technique by some authors, because it did not guarantee against aspiration of gastric juice, and it was not permitting change of position of the head or the patient from supine to any other required position, it was not a much popular technique.[12] Cuffed endotracheal tube is being used during general anaesthesia for laparoscopic surgeries to prevent aspiration of oral and gastric secretions to prevent wastage of anaesthetic gases, and to do IPPV perfectly, satisfying peak inspiratory flow rate and pressure required for inflation of both lungs satisfactorily.[13] Low volume high pressure cuffed endotracheal tubes when used for general anaesthesia, produced tracheal mucosal ischemia, ulceration, tracheal stenosis, vocal cord nodules, producing postextubation stridor, croup, and respiratory insufficiency.[14] Thoracic epidural anaesthesia along with general anaesthesia was suggested for preventing hypertension during endotracheal intubation in old patients with hypertension by some authors.[15] For preventing dangerous autonomic reflexes like hypertension, hypotension, bradycardia and arrhythmias because of vagal stimulation, inflation of cuff of endotracheal tube by alkalinised lignocaine or plain lignocaine of various percentages or 4% lignocaine spray before intubation was suggested by a number of authors.[16],[17],[18],[19],[20] Inflation of cuff of endotracheal tubes with air during laparoscopic surgeries has definite disadvantage as the Nitrous oxide+ oxygen, and carbon dioxide diffuses into the cuff producing increase of intra-cuff pressure to dangerous levels.[21] Intermittent deflation of cuff during laparoscopic surgeries was suggested by some authors as a solution for this problem, but it did not prevent the postextubation tracheal problems.[22] When the cuff of endotracheal tube inflated with air intra-cuff pressure had raised to dangerous levels producing postextubation stridor, croup, tracheal ischemia, ulceration.[23] In our patients in whom air was used to inflate the cuffs of endotracheal tubes also there was statistically highly significant increase of intra-cuff pressure with time, (P=0.0001) but no respiratory insufficiency, croup or irritant cough was observed in any of our patients (both the air& distilled water groups). In our distilled water group patients, there was no increase of intra-cuff pressure, and hence no possibility for postextubation tracheal problems. In our air group patients also there were no postextubation problems observed, maybe because the increased intra-cuff pressure with time had not reached dangerous levels to produce tracheal mucosal ischemia, but that possibility definitely would have been there if the laparoscopic surgical procedure had extended for longer time.

Pressure applied over trachea in the form of retraction for a long time, as in the cases of anterior cervical fusion procedure, and when the cuff of endotracheal tube was inflated by air intra-cuff pressure had definitely raised to dangerous levels resulted in postextubation respiratory insufficiency and vocal cord problems.[24] If water is used to

inflate the cuff of endotracheal tubes and when pressure is applied over trachea, water gets displaced into the pilot balloon and hence no possibility of increase of intra-cuff pressure. In our distilled water group patients, there was displacement of distilled water into the pilot balloon whenever there was some pressure over trachea. We had pressed the pilot balloon whenever we observed some air leak, and in that way we had re-inflated the cuff of endotracheal tube with displacement of distilled water from the pilot balloon back into the cuff.

Limitations of our study was we could not record the intra-cuff pressure with Portex cuff inflation meter in our distilled water group patients, as the pressure of water was not communicating with meter. We injected distilled water into the cuff of endotracheal tube just enough to prevent air leak around endotracheal tube, and aspirated the same amount of distilled water, we inferred that the intra-cuff pressure did not increase with time during laparoscopic surgeries.

Another important difficulty we faced in our study was "at the end of surgical procedure before extubation distilled water had to be aspirated with syringe through the port of the pilot balloon". Distilled water will not come out automatically if the pilot balloon is plucked out before extubation. (As practiced in western countries like USA).

CONCLUSION: Whenever general anaesthesia is given for laparoscopic surgical procedures and when the cuffs of endotracheal tubes are inflated with air, anaesthetic gases and carbon dioxide will diffuse into the cuffs of endotracheal tubes, raising intra-cuff pressure to dangerous levels with time of general anaesthesia. Hence we infer from our study that "distilled water may be considered as more preferable agent for inflation of cuffs of endotracheal tubes during laparoscopic surgeries under general anaesthesia given with Nitrous oxide+ Oxygen+ relaxant technique and when carbon dioxide is used to create pneumoperitoneum".

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