ORIGINAL RESEARCH PAPER
VOLUME-6 | ISSUE-6 | JUNE-2017 | ISSN No 2277 - 8179 | IF : 4.176 | IC Value : 78.46
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

Effect of nitrous oxide and pneumoperitonium on ETT cuff pressure: Does ETT cuff pressure monitoting need to be made a standard of care??

Anaesthesiology

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ABSTRACT

Introduction: Sore throat due cuff over-inflation induced mucosal ischemia is a common side effect of general anaesthesia especially with N2O.Adequacy of cuff inflation can be easily measured using an aneroid manometer.We studied the effect of N2O and Air on intracuff pressure, the number of cuff deflations needed to maintain a cuff pressure of 25 cm H2O and the severity of sore throat caused by using either as carrier gas.

Materials & Method: 100 patients, between age of 18 to 60, ASA I or II physical status undergoing laparoscopic cholecystectomy under general anaesthesia were randomly divided into Group N-a mixture of 50% N2O & 50% O2 was used as carrier gas and Group A-a mixture of 50% Air & 50% O2 was used as carrier gas.Post intubation the endotracheal tube cuff was inflated till a pressure of 25 cm H2O using an aneroid manometer and noted every 10 min. Every time the cuff pressure was found to be above or below 25 cm H2O it was reset to 25 cm H2O.Post-extubation all patients were evaluated for complaint of sore throat in the recovery room and 12 hrs post extubation.

Results: The percentage rise in intra-cuff pressure in both groups was comparable for 10 minutes (P=0.644) & 20 minutes (P=0.096) but at 30 min (31.68%) it was highly significant (P < 0.001) in Group N. It was highest at 10 min in both groups, decreasing over time (18.08%) till 150 min in Group N and (1.92%) till 50 min in group A. Severity of sore throat was higher in group N both in recovery room and 12 hours post-operatively.

Conclusion: Postoperative tracheal mucosal injuries caused by cuff contact are frequent in patients in whom N2O is use as a carrier gas. We recommend the routine use an aneroid manometer for initial cuff inflation as well as for intraoperative monitoring during surgeries done using a N2O based anaesthesia technique. The initial increase in cuff pressure associated with pneumoperitoneum advocates cuff pressure monitoring in all laparoscopic surgeries regardless of the carrier gas used.

KEYWORDS:

Introduction

A critical function of the endotracheal tube is to seal the airway, thus preventing aspiration of pharyngeal contents into the trachea and to ensure that there are no leaks past the cuff during positive pressure ventilation. Complications ranging from nosocomial infections resulting from microaspiratio due to under inflation to catastrophes such as trachea-carotid erosion as a consequence of over inflation have been documented [1,2,3,4.]

High ETT cuff pressure leads to ischemic changes of tracheal mucosa, resulting in an oedematous change of the vocal cord as well as the tracheal mucosa. Intracuff pressure increases during nitrous oxide gas anaesthesia because the gas readily diffuses into the inside of cuff due to the high partial pressure gradient through the cuff membrane 8,9,10. In addition; laparoscopic surgeries, because of pneumoperitonium & Reverse Trendelenburg position, are associated with increase in inracuff pressures [13].

Conventionally, adequacy of cuff inflation is determined by palpating the pilot balloon which is an unreliable method[11,12.]

Cuff pressure can be easily measured with a small aneroid manometer, but this device is not widely available in all institutes. Also intraoperative cuff pressure assessment & adjustment will aid in decreasing cuff overinflation related post-operative morbidities. We designed this study to observe variation in intracuff pressure with 50% N2O & 50% O2 as compared to 50% Air and O2 during maintenance of anaesthesia using an aneroid cuff pressure manometer.

Materials and Method

A Prospective randomized controlled study was conducted on 100 patients undergoing laparoscopic cholecystectomy at Shree Krishna Hospital after approval from the Human Research and Ethical Committee. Written and informed consent was obtained from all the patients.

Patients were randomly divided into two groups after written & informed consent.

In Group A -a mixture of 50% N2O & 50% O2 was used as carrier gas.
In Group B- a mixture of 50% Air & 50% O2 was used as carrier gas.
All patients of ASA grade I & II physical status in the age group of 18 to 60 years undergoing elective laparoscopic cholecystectomy under general anaesthesia were included in the study.

Patients having Cormack Lehane grading of III & IV, contraindication to the use of nitrous oxide, upper respiratory tract infection, difficult intubation (>3 attempts), tracheostomised patients and patients with - laryngeal disease & laryngeal surgeries were excluded.

Patients were kept NBM for 8 hours prior to surgery. Preoperatively, intravenous access was established and Ringer Lactate started. Baseline vital parameters were recorded. All patients were given Inj.Ranitidine 1mg/kg i.v and Inj. Ondansetron 0.08mg/kg i.v 45 minutes before the surgery. The patients were premedicated with Inj. midazolam 0.15 mg/kg i.v and Inj.fentanyl 2 µg/kg i.v 20 min before the induction of anaesthesia. After arrival in the operating room, patients were placed in the supine position and SpO2, ECG and NIBP monitors were attached.

After preoxygenation for 3 min, anaesthesia was induced with Inj.Propofol 2-2.5 mg/kg i.v., neuromuscular block was achieved with Inj.Succinylcholine 2 mg/kg. Laryngoscopy was performed after confirming loss of all four twitches in response to train of four stimuli.

Endotracheal intubation was always performed by 2nd year anaesthesia residents and upwards. Standard induction and maintenance methods were followed in both the groups. Male and female patients were intubated with 8 and 7 mm size high volume low pressure cuffed portex endotracheal disposable tubes respectively.

After confirming the tube placement by auscultation, inhalational anaesthesia was initiated using sevoflurane in both groups. Air or

Nitrous were used as carrier gases along with oxygen, in patients as per randomization.

The endotracheal tube cuff was inflated till a pressure of 25 cm H2O using an aneroid manometer. The endotracheal cuff pressure was registered in both groups every 10 min after cuff inflation to 25 cm H2O. Every time the cuff pressure was found to be above or below 25 cm H2O it was reduced to 25 cm H2O.

Additional i.v.bolus of fentanyl (0.5–1 µg/kg) was administered to maintain surgical analgesia every 45 min.

Inj.Vecuronium (0.1 mg /kg) i.v was given for adequate muscle relaxation. Maintenance bolus doses of vecuronium were given only after 3 twitches of adductor pollicis on train of four stimuli.

Ventilation (Drager Primus) was controlled with a tidal volume of 7-8 ml/kg, and respiratory rate was adjusted to maintain an end-tidal carbon dioxide (EtCO2) value of between 35 to 45 mm Hg.

During laparoscopic procedure, the intra abdominal pressure was displayed and maintained at 15 mm Hg.

Before reversal patients were ventilated with 100% oxygen, switching off nitrous/air and at this time the last cuff pressure reading was taken. At the end of surgery, after confirming two twitches of adductor pollicis with train of four stimulus the neuromuscular block was reversed with Inj.Neostigmine (0.05 mg/kg) + Inj.Glycopyrolate (0.01 mg/kg) i.v.

Mechanical ventilation was maintained until spontaneous respiration returned.

The endotracheal tube was removed as soon as all of the following criteria were met:
1) Complete reversal of neuromuscular block (ulnar nerve T4/T1 ratio=1).
2) Spontaneous ventilation.
3) Ability to follow verbal commands.
4) Patient was haemodynamically stable.

The total duration of time since cuff inflation till its deflation was noted for both groups.

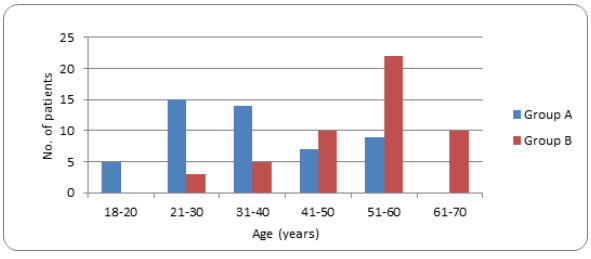
All patients were asked for any complain of sore throat or discomfort in throat in the recovery room, after they were fully conscious and oriented and were followed up 12 hrs after extubation.

The severity of sore throat and hoarseness was graded as:
(0) no complaints at all
(1) Minimal sore throat and no hoarseness
(2) Moderate sore throat and / or slight hoarseness
(3) Severe sore throat and / or severe hoarseness.

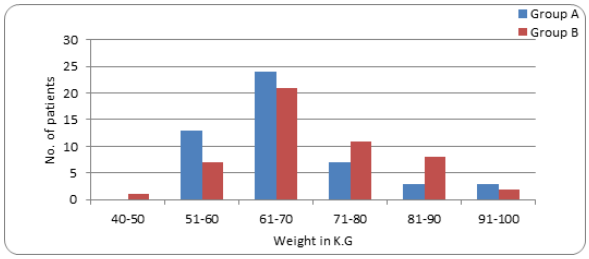
Statistical Analysis: Randomization was done using WINPIPE software. Data were summarized using proportions and mean. Continuous data were analysed using independent 't' test and categorical data were analyzed using Chi-square test. A 'P' value of <0.05 was regarded as statistically significant.

Results:
We studied total 100 patients (50 per group) with ASA 1 or ASA 2 physical status, between the ages of 18-60 years. The demographic data like age, height, weight and sex as well as duration of surgery were comparable in the two groups (Graphs 1 to 5)

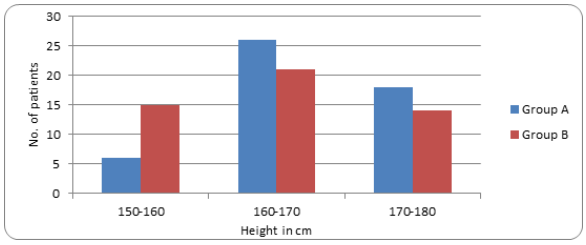
Graph 1: Age distribution between the two study groups



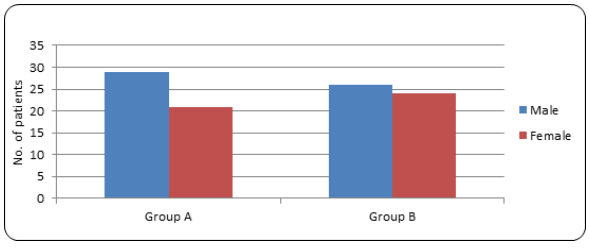
Graph 2: Weight distribution between the two study groups



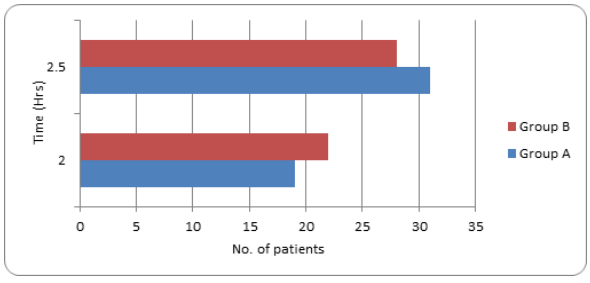
Graph 3: Height distribution between the two study groups



Graph 4: Sex distribution between the two study groups



Graph 5: Comparison of duration of surgery between the two study groups



Cuff- pressure changes in both groups
Complete data were obtained from all patients. The patient characteristics and anaesthesia time were comparable between both the two groups. The intracuff pressure was measured every 10 minutes in both the study groups.

In group A, a consistent increase in intracuff pressure was noted every 10 minutes for the entire duration of surgery, which was reset to 25 cm H2O after noting every reading. While in group B, a consistent increase in intracuff from the baseline of 25 cm H2O was observed for first 50 minutes which was reset to 25 cm H2O every reading, it remained at 25 cm H20 throughout the remaining duration of surgery.

The maximum intracuff pressure recorded was 41 cm H2O in group A and 40 cm H2O in group B (P = 0.74), both were recorded at 10 min. These were 64% and 60% higher than the baseline respectively.

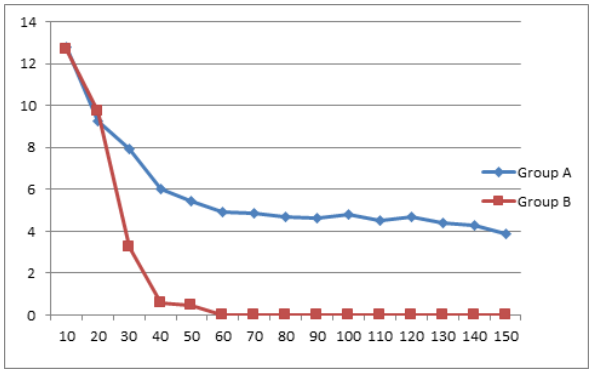
The percentage rise in intracuff pressure in both the study groups was comparable for 10 minutes (P=0.644) & 20 minutes (P=0.096).

The percentage rise in cuff pressure every 10 minutes was highly significant (P < 0.001) in group A after the initial 20 minutes i.e. at 30 min (31.68%).

It was highest (50.4%) at 10 min., decreasing over time (18.08%) at 150 min. in group A. In group B it was highest (51.2%) at 10 min,

decreasing over time (1.92%) at 50 min after which no increase in intracuff pressure was recorded. The rise in peak airway pressure after carboperitoneum was comparable between the two groups. There was no evidence of displacement of endotracheal tube in either group.

Graph 6: Comparision of mean change in cuff pressure above baseline(i.e 25 cm H2O) between two study groups



Graph 7: Comparison of mean cuff pressure between the two study groups

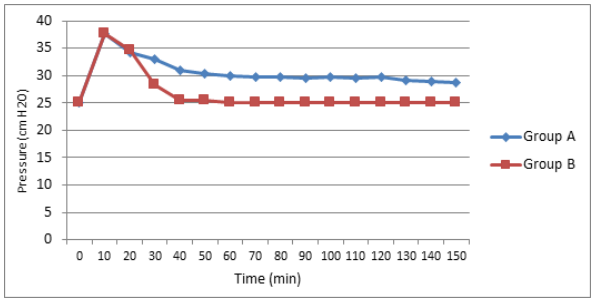


Table 1: Intracuff pressure changes over time in Group A & Group B

Time (min)	Group A (n=50)	Group B (n=50)	% Inc in cuff pressure over baseline (25 cm H2O)		95% Confidence Interval of the Difference		P value
			Group A	Group B	Lower	Upper	
0	25	25					
10	37.60± 2.38	37.80± 1.90	50.40	51.20	-1.056	0.656	0.644
20	34.28± 1.27	34.70± 1.21	37.12	38.80	-0.915	0.075	0.096
30	32.92±	28.26±	31.68	13.04	4.204	5.116	<0.000
40	31.04± 1.44	25.58± 1.07	24.16	2.320	4.956	5.964	<0.000 1
50	30.42± 1.14	25.48± 1.05	21.68	1.92	4.503	5.377	<0.000 1
60	29.92± 0.80	25	19.68	0	4.694	5.146	<0.000 1
70	29.86± 0.85	25	19.44	0	4.619	5.101	<0.000 1
80	29.70± 0.97	25	18.80	0	4.427	4.973	<0.000 1
90	29.64± 1.06	25	18.56	0	4.341	4.939	<0.000 1
100	29.80± 0.80	25	19.20	0	4.573	5.027	<0.000 1
110	29.52± 0.97	25	18.08	0	4.247	4.793	<0.000 1
120	29.70± 0.86	25	18.80	0	4.458	4.942	<0.000 1
130	29.15± 1.50	25	16.60	0	3.593	4.710	<0.000 1
140	29.03± 1.31	25	16.12	0	3.543	4.518	<0.000 1
150	28.66± 1.16	25	14.64	0	3.234	4.099	<0.000 1

Severity of sore throat in Recovery Room in both study groups:
As judged by the patient included in both the study groups; in the recovery room in terms of "none", "mild", "moderate" and "severe".
54% patients in Group A had moderate sore throat compared to 8% in Group B.
18% patients in Group A complained of severe sore throat. None of the patients in group B complained severe sore throat.
Only 4% patients in Group A had no complain of sore throat; whereas 56% patients of Group B did not complain of sore throat.

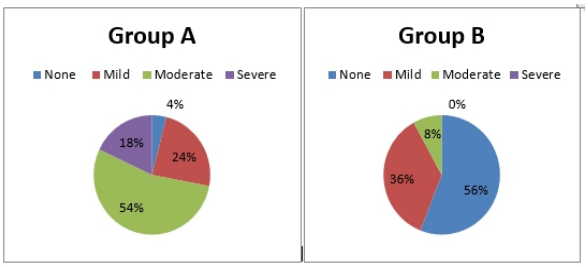
Severity of sore throat after 12 Hrs in both study groups:
As judged by the patient included in both the study groups; in terms of "none", "mild", "moderate" and "severe".

60% patients in Group A had mild sore throat compared only to 6% in Group B.

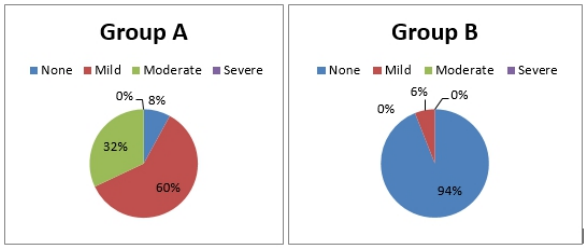
32% patients in Group A complained of moderate sore throat. None of the patients in group B complained moderate sore throat. No patient in either group had severe sore throat.

Only 8% patients in Group A had no complain of sore throat; whereas 94% patients of Group B did not complain of sore throat.

Graph 8: Severity of sore throat in recovery room



Graph 9: Severity of sore throat in recovery room



Mean No. of deflations in each Group:
The mean numbers of deflations on group A were 13.86±1.47 and in group B were 3.4±0.53.

Using Independent sample t test we conclude that the mean number of deflations in group A and group B was statistically significant.

Parameter	Group A	Group B	P Value
Mean no. of deflations	13.86(1.47)	3.4(0.53)	P<0.001

Discussion
Although, described as early as 1893 it was only during the polio epidemic of 1952, where cuffed tubes were used more prominently. The use of cuffed tubes is now a routine practice to ensure that there are no leaks past the cuff during positive pressure ventilation. Post-extubation sore throat is a common side effect of general anaesthetic and may partly result from ischemia of the oropharyngeal and tracheal mucosa 5, 6, 7. Other complications associated with inadequate cuff inflation include a wide spectrum from micro-aspiration related nosocomial pneumonia to over-inflation induced carotico-tracheal

erosion.

When using nitrous oxide (N2O) during general anaesthesia, particular attention should be paid to changes in cuff pressures. The increase in cuff pressure varies directly with the partial pressure of N2O and time, and inversely with cuff thickness. Prolonged, unmonitored use can lead to continuous increase in intra-cuff pressure thereby increasing the risk of pressure necrosis. Moreover, pneumoperitoneum created during laparoscopic surgeries along with Reverse Trendelenburg position are associated with increase in intra-cuff pressure.

Sharma et al (2013), studied cuff pressure changes in PLMA in 100 patients undergoing laparoscopic surgeries who were randomized into two groups of 50 patients each to receive an anaesthetic gas mixture containing either oxygen+N2O (group N) or O2 + air (group A).

The maximum intracuff pressure recorded in group N was 103 ± 4.7 mm Hg vs. 45.5 ± 1.5 mm Hg in group A. The percentage rise in cuff pressure every 10 minutes was also highly significant ($P < 0.001$) being maximum in first 10 min in group N. The results of this study demonstrate that the intracuff pressure of the PLMA increases progressively over time when the breathing gas mixture contains nitrous oxide.

Zeynep BY et al (2012) 13 compared the endotracheal tube cuff pressure alteration between patients undergoing laparoscopic and open cholecystectomy. 40 patients having ASA I–II physical status, who were scheduled for elective laparoscopic (group I) or open abdominal surgery (group II) were enrolled in the study. The endotracheal cuff pressure was registered every 5 min after tracheal intubation. They concluded that the CO2 pneumoperitoneum and Trendelenburg position used during laparoscopy increase endotracheal cuff pressure.

Karasawa et al (2003) 14 showed that, when the endotracheal tube cuff is repeatedly aspirated to avoid excessive cuff pressure during nitrous oxide anaesthesia stable cuff pressure is eventually achieved. During 67% nitrous oxide and oxygen anaesthesia, air filled cuffs of a standard tracheal tube were repeatedly deflated every 30 min for the first 3 hrs or 4 hrs to inhibit excessive pressure; the cuff pressure was monitored for an additional 3 hrs. They concluded that when the air filled cuff of the standard endotracheal tube is repeatedly deflated every 30 min for 4 hours, but not for only 3 hours, during nitrous oxide anaesthesia, a table cuff pressure can be achieved without further deflation of the cuff.

In our study, we observed a significant and progressive increase in endotracheal intra-cuff over time when nitrous oxide was used as a carrier gas as a part of balanced anaesthesia for laparoscopic cholecystectomy. However, the cuff pressure did not change significantly when air was used instead of nitrous oxide ($P < 0.001$). It also showed an initial comparable increase in the intracuff pressure during establishment of the pneumoperitoneum in both the groups and subsequent progressive increase in intracuff pressure only in the nitrous oxide group.

We recommend the routine use of cuff pressure monitor for initial cuff inflation as well as for intraoperative monitoring during prolonged surgery when using a N2O based anaesthesia technique, especially in laparoscopic surgeries.

Moreover, the initial increase in ETT cuff pressure associated with pneumoperitoneum advocates the use of cuff pressure monitoring in all laparoscopic surgeries regardless of the carrier gas used.

Furthermore, there is a direct relationship between intracuff pressure and incidence of postoperative sore throat. This further reinstates our recommendation of using a cuff pressure manometer routinely.

A fixed volume of air cannot be used universally to inflate ETT cuff in all patients. For effective ventilation, the cuff should be inflated just until it prevents an air leak. This is not possible to achieve by the palpatory method of pressure assessment, which currently is the more widespread method. This calls for a mandatory use of a manometer for initial ETT cuff inflation as well as monitoring.

We conclude that postoperative tracheal mucosal injuries as reflected by higher incidence of sore throat, caused by cuff contact are frequent in anesthetized patients in whom N2O is use as a carrier gas. This can be prevented by:

1) Routine use of cuff pressure manometer to inflate and monitor ETT cuff pressure.

2) Giving special attention to the endotracheal cuff pressure during the first half hour after establishment of pneumoperitoneum in laparoscopic surgeries, regardless of the carrier gas used.

3) Avoiding the routine use of N2O as a carrier gas (which is also a greenhouse gas) and using Air instead.

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