



Nasopharyngeal Symptoms caused by Abnormal Inflation of the Endotracheal Tube in Patients undergoing Cervical Spine Surgery

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ABSTRACT

Background: Abnormal balloon inflation of the endotracheal tube can cause nasopharyngeal symptoms. The objective is to describe Signs and Symptoms caused by the Abnormal Insufflated Balloon of the Endotracheal Cannula on patients undergoing Cervical Spine Surgery under General Anesthesia.

Methods: descriptive study, 39 patients underwent cervical spine surgery under general anesthesia, all of them were older than 18 years old and ASA I and II. The pressure balloon inflation of the endotracheal tube was measured by a manual manometer VBM Medizintechnik GmbH, measurements were made at the beginning of the procedure, and every hour during the transanesthetic period. The patients underwent a questionnaire about their symptoms on the recovery area and 24 hours after extubation.

Results: 39 patients, 59% men, 41% women. Average age was 47, minimum 15 - maximum 77, SD 14.26 years old. The average pressure balloon inflation at the moment of intubation was 30.7 mmHg and at the moment of extubation was 29.07 mmHg. The symptoms presented on the Recovery Care Unit and at 24 hours were: pain, inflammation, dysphagia, foreign body sensation.

Conclusion: The pressure balloon inflation of the endotracheal cannula is important, because a pressure greater than 30mmHg produce symptoms. Changes on the patient's position produced variations on the balloon pressure; therefore, continuous monitorization of the pressure balloon must be done.

Key words: Endotracheal Tube; Cervical Spine Surgery; Symptoms and Clinical Signs.

INTRODUCTION

The endotracheal intubation is a frequently employed technique in the operating room, it is used as a vital support measure to keep the airway safe and thereby ensure adequate tissue oxygenation (1).

The Endotracheal Cannula (EC) with high volume balloons are used to facilitate the connection between the patient and the mechanical fan, with its insufflation prevent leakages around the EC, therefore, ensuring adequate pressurization during positive pressure ventilation; however, hyperinflation of the endotracheal cannula balloon causes mucosal damage by restricting the capillary blood flow. The inappropriate filled of the balloon is associated with a high morbidity rate, either by overpressure or by lower pressure (2).

The tracheal capillary perfusion pressure has been estimated at 25 mmHg and has an inverse relationship to the pressure of the tracheal cannula balloon. Tracheal arterioles are located in the submucosa and oriented circumferentially forth between cartilages and longitudinally in the rear membranous portion (3).

The mucosa turns pale at 30mmHg and white at 37mmHg and the blood flow stops at 45mmHg. These findings suggest that blood flow is initially altered with balloon pressure levels of 22 mmHg and that complete occlusion of tracheal capillaries occurs at 37 mmHg (4).

The ischemic endpoint of the mucosa produced by high

endotracheal cannula balloon consists on necrosis and infection, followed by scar formation and stenosis (5,6). Most are resolved spontaneously, however, some progress to laryngeal granulomas and stenosis secondary to healing (5, 7).

The complications as stenosis and tracheomalacia occur mainly under the first tracheal ring (6). The initial changes are functional, such as the diminished velocity or total interruption of the tracheal mucus (7).

The early changes includes flattening, fusion and erosion of respiratory epithelial cells, the ciliary function deteriorates or disappears as the irritation produced by the balloon of the tracheal cannula also produces constriction of the smooth muscle of the trachea (8).

The adverse effects of the tracheal intubation are considered according to their incidence, on two groups. Frequent adverse effects: infection, haemorrhage, aspiration, subcutaneous emphysema, laryngeal granulomas, pneumothorax, pneumomediastinum, atelectasis, laryngeal edema, laryngeal ulceration, laryngeal granulomas, laryngeal and tracheal stenosis and tracheomalacia, and infrequent adverse effects: cricoarytenoid subluxation, cricoarytenoid scars, vocal cord paralysis, tracheal necrosis, tracheal rupture, paratracheal abscesses, tracheoesophageal and tracheovascular fistulas (7, 9-10).

The most frequent symptom after extubation is dysphonia and it has been reported in up to 80% of the patients, when persist, paralysis or vocal paresis occur secondary to recurrent

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laryngeal nerve compression by the endotracheal cannula balloon over the thyroid cartilage or the placement just below or adjacent to the vocal cord. Dysphagia and sore throat occur in half of patients after extubation. The more time the patient is under intubation the more the laryngeal damage occurs (11).

The cough and sore throat are common symptoms and their incidence is as high as 30% and 55% respectively. The probable causes may include mechanical compression by the endotracheal cannula balloon or physico-chemical stimulation of the tubes additives (12).

However, correlation between the mucosal damage degree and the severity of symptoms is unknown because symptoms are always subjective (11). It has been suggested that sore throat incidence and blood-streaked expectoration, increased after longer intubation as well as sore throat incidence, even more with intubation longer than 180 minutes. It possible means that pressure and time are two important variables on morbidity after endotracheal intubation (11-12).

The first used endotracheal cannula balloons were of low volume and high pressure. Nowadays, the standard is a great diameter, high volume and low pressure balloon, which transmits less pressure with more uniform distribution over the tracheal wall, therefore, less possibility of causing injuries.

At present, high volume and low pressure endotracheal balloons are made as an attempt to decrease complications secondary to them, trying to maintain lower transmitted pressure. However, complications attributed to endotracheal cannula balloons are still frequent (13).

In 1977 Nordin on a study conducted on rabbits, observed that when endotracheal cannula balloon inflated pressure exceeded 25 mmHg, mucosal ischemia presented and that lesions are directly related to the cuff pressure, finding damage almost in all of those pressures higher than 100 mmHg. He suggests that is more relevant the pressure level on the mucosa than the intubation time on the etiology of tracheal morbidity (14). Seegovin and Hasselt in 1984, on a human study rated the capillary blood flow in the tracheal mucosa through endoscopic technique, they observed the capillary blood flow compromised at pressures higher than 30 H₂O cm and a complete obstruction at pressures higher than 50 H₂O cm (15).

Carroll and Grenvik measured the pressure within the cuff through an aneroid manometer, at this moment an electronic, digital, instrument called P-V Gauge exists, which easily adapts to the endotracheal cannula cuff and has great accuracy on its measures, with a variation of ± 1 H₂O cm (11).

As morbidity has been documented for overpressure, problems due to deflation have been attributed as well. Tobin and Grenvik in 1984 mentioned the oropharynx of the patients as the principal source of microorganisms responsible for nosocomial pneumonia, entry facilitated by the presence of tracheostomies and endotracheal cannulas (16). The palpation method may contribute to overpressure, therefore, is inadequate. Listening to leakages is not either recommended.

The aim of this study is to identify clinical signs and symptoms caused by the abnormal inflation of the endotracheal cannula balloon on patients undergoing cervical spine surgery under general anesthesia, in the recovery care unit (RCU) and 24 hours later, as well as to identify abnormal inflation of the endotracheal cannula balloon as risk for each sign and symptom.

MATERIAL AND METHODS

Study type: cohort study, descriptive, performed in the High Specialty Medical Unit of the Orthopedics and Traumatology Hospital of the Mexican Institute of Social Security (IMSS), from January to December of 2014.

Subjects: Scheduled patients for Cervical Spine Surgery who underwent General Anesthesia affiliated to IMSS were included, older than 18 years old, both genders, ASA (American Society of Anesthesiologists) I and II, endotracheal intubation with armed cannula, without steroids administration before or after the surgery and those who accepted to be included in the study through a filling of a consent informed letter.

Patients were excluded if they presented with tracheolaryngeal anatomic abnormalities, with more than three failed endotracheal intubation attempts or the anesthesiologist did not accept to participate in the study.

Methodology: patients were intubated with armed cannula, its diameter was selected based on the intern diameter, 8 mm cannula was used for adult men and 7 mm cannula for adult women. The anesthesiologist checked leakage absence around the endotracheal cannula and measure the inflated balloon pressure by a manual (VBM Medizintechnik GmbH) manometer. Initially the balloon was adjusted at a pressure of 29 mmHg or lower. Later measures of the inflated balloon were made, every hour during the transanesthetic period, in every repositioning of the patient and before the endotracheal cannula withdrawal. The symptoms were evaluated by direct interrogatory at the RCU as well as 24 hours after the procedure and the swelling caused by direct or indirect laryngoscopy. We established as normal a pressure of <29 mmHg for the endotracheal cannula balloon inflation and erythema or edema or both as swelling.

The variables were, age, gender, size and diameter of the cannula, inflation pressure of the cannula, patient position; the sample size was established by the investigator given by the total of patients during the time of the study.

Statistics: Descriptive statistics was performed with central trend measures and dispersion. Fischer test for relative risk (RR) for abnormal inflation of the endotracheal cannula balloon and the development of clinical signs and symptoms presented by the patients χ^2 to demonstrate the hypothesis (difference of proportions) we considered statistics significance a value of $p < 0.05$.

RESULTS

A total of 39 patients were included, 23 (59%) were men and 16 (41%) women, the average age was 47, minimum 15 - maximum 77, SD 14.36 years old; the average weight was 72.53 kilograms, minimum 46 - maximum 96, ± 10.88 kilograms, average size was 162.48 centimeters, minimum 140 - maximum 178, ± 9.96 centimeters. The average Body Mass Index (BMI) was 27.43, minimum 20.96 - maximum 35.20, SD 3.07 of which 8 (20.51%) patients had a BMI bigger than 30 and 31 (79.4%) less than or equal to 29. The average of the endotracheal cannula number used was 8, minimum 7 - maximum 9.5, SD 0.54 mm.

In all patients an armed cannula was used, the balloon pressure during the surgical procedure is described below. (Table I)

Table 1: Balloon pressure during surgery.

Measure	Average	Minimum	Maximum	SD
Intubation	23.74	18	29	3.11
First hour	32.05	19	48	6.92
Second hour	26.79	19	50	12.10
Third hour	31.57	24	55	11.39
Supine	30.74	18	50	6.51
Prone	28.12	16	46	13.59
Before extubation	29.07	14	50	7.02

Abbreviations: SD = Standard Deviation.

During the surgical procedure, the inflated balloon pressure was less than or equal to 29 mmHg on 15 (38.5%) and bigger than or equal to 30 mmHg on 24 (61.5%) patients.

Those patients who did not showed symptoms, in the RCU were 14 (35.9%) and 24 hours after surgery were 12 (30.8%). The symptomatology of patients is shown on table 2. (Table II)

Table 2: Signs and symptoms in Recovery Care Unit and 24 hrs later.

Symptoms and Signs	RCU Frequency	Percentage %	Frequency 24 hrs	Percentage %
None	14	35.9	12	30.8
Dysphagia	1	2.6	3	7.7
Swelling	7	17.9	1	2.6
Pain	4	10.3	5	12.8
Foreign body sensation	3	7.7	4	10.3
Two or more symptoms	10	25.6	14	35.9

Abbreviations: RCU= Recovery Care Unit, n=sample, %=percentage, hrs=hours.

At 24 hours, the symptoms associated to the patient position during surgery were: prone position (n=33), 13 (39.39%) did not present symptoms, 2 (6.06%) dysphagia, 5 (15.15%) pain, 3 (9.09%) foreign body sensation and 10 (30.30%) presented two or more symptoms; supine position (n=6), 1(16.66%) dysphagia, 1 (16.66%) foreign body sensation, 4 (66.66%) two or more symptoms and none presented pain.

The relative risk for the symptomatology development on patients with abnormal inflated endotracheal cannula balloon, resulted positive only for foreign body sensation (RR=3.57, CI 95%=2.85-3.91) and for the presence of two or more symptoms (RR=1.19, CI 95%=1.01-1.38). The risks for the rest of the symptoms on the patients are shown in table 3. (Table III)

Table 3: Relative Risk to developing signs and symptoms secondary to abnormal inflation of the endotracheal cannula balloon.

Symptoms and Signs	RCU RR	CI 95%	24 hrs later RR	CI 95%
Dysphagia	0	-	0	-
Swelling	0.89	0.21 - 1.2	0	-
Pain	0.59	0.22 - 0.99	1.19	1.01 - 1.35
Foreign body sensation	3.57	2.85 - 3.91	0	0.88
Two or more symptoms	1.19	1.01 - 1.38	0.95	1.12

Abbreviations: RR=Relative Risk, CI=Confidence interval, RCU=Recovery Care Unit, hrs=hours.

No statistically significant differences in symptoms in the RCU and 24 hrs later in patients with normal and abnormal balloon inflation, $p > 0.05$ Chi square were found. (Table IV)

Table 4: Chi-Square values for inflation pressure of the balloon and the development of symptoms on the RCU and 24 hours later.

Time of measure	Symptoms present n	Symptoms Absent n	(X ²) Value of p
RCU			
Normal pressure (\leq 29mmHg)	5	1	$p > 0.05$
High pressure (\geq 30mmHg)	20	13	
After 24 hrs			
Normal pressure (\leq 29mmHg)	4	2	$P = > 0.05$
High pressure (\geq 30mmHg)	23	10	

Abbreviations: RCU=Recovery Care Unit, hrs=hours, n=sample, X²=Square Chi, \geq =more than or equal to, \leq =less than or equal to, p=statistical significance.

DISCUSSION

Inadequate endotracheal cannula balloon inflation may compromise and alter laryngeal structures, secondary to the direct contact of the cannula with the airway structures, resulting in mucosal injuries which might be mild but annoyed to the patient.

Nowadays there are plenty of endotracheal cannulas varieties. The high volume and low pressure cannulas are used to prevent gas leakage, pulmonary aspiration and tracheal injuries, as well as to decrease symptomatology on the patient undergoing general anesthesia.

However, at the moment of inflate a balloon above normal range, a greater pressure over the tracheal walls is directly caused. At a pressure of 40 H₂O cm the tracheal mucosa and submucosa perfusion is deficient; there is loss of ciliary mucosa, ulceration and bleeding. Serious complications may be reached such as tracheal stenosis or tracheoesophageal fistula (15-16).

The endotracheal cannula balloon pressure is not measured on a routine manner on the anesthetic procedures, which contributes to the appearance of symptoms that appear commonly on the immediate postoperative such as, dysphagia, sore throat, foreign body sensation, problems to speak, increased secretions, pain to swallow and hoarseness which commonly decreases in a maximum of 48 hours (24). However, because the pressure measurement is very simple to perform, this must be measure continuously to prevent injuries.

Our study origins from the necessity to acknowledge the signs and symptoms caused by the different inflation pressures on the endotracheal cannula balloon on the supine and prone position in which the patients are placed during cervical spine surgery.

With respect to gender, our population distribution was slightly higher in men (59%) compare to women (41%). It occurred more frequently on male patients on the RCU and at 24 hours later, this possibly related to the threshold and the anatomical oropharynx position which is more anterior and bigger in diameter than in women and the necessity to inflate with more volume the endotracheal cannula balloon.

However, the pain perception is influenced by complex interactions between biological variables (gonadal hormones, genetics, pain circuit and central nervous system variations) and psychological variables (depression, anxiety, culture, gender expectative role, social learning factors and importance given to pain). Big differences exist on these variables among individuals and from the viewpoint of gonadal hormones and pain, the variability is deep (16).

Among the principal findings, in spite of men having a superior neuronal density than women, females activate exclusive zones; this suggests dysmorphism in response to pain. The pain is strongly related to hormonal processes, reason why pain in women depends on part of the variation of their hormonal cycle (18).

The average BMI in our population was 27.48, which is considered as overweight (17). This can be an aggravating factor since overweight and obesity difficult mobilization, increase the approaching and surgical time.

The injury caused by having the balloon for a longer time, may cause more symptomatology. Indifferent to type of cannula, all were managed by armed cannulas. This probably does not influence on the symptomatology presented by the patients, since the difference between both types lies on the internal metallic rings which have not direct relation with the patient anatomical structures. However, the rigidity of the armed may cause some difference, which may be reason for further studies.

The average pressure of the inflated balloon at the beginning of the anesthetic procedure was 30.74 mmHg and only in 38.5% the pressure was less than or equal to 29 mmHg, this is consistent with the literature which indicates that pressures higher than 30 mmHg are inadequate for anesthetic procedures (17).

Regarding the average pressure of the balloon at the moment of extubation it decreased to 29.07 mmHg. This proves that with the passage of time the balloon pressure decrease in

compare to the initial. Yet it is a high value if we consider that the tracheal pressure capillary perfusion is 25 mmHg. The average balloon inflation at the beginning was 23.74%, however later this inflation increased, probably secondary to the approach or the presence of surgical material used (separators, forceps, etc). This differs from the literature that mentions that cervical spine surgery is less painful (18-19).

On the RCU, the 35.9% of patients did not present symptoms, 2.6% presented dysphagia, 10.3% pain, 7.7% foreign body sensation and 25.6% two or more symptoms. The correct inflation of the endotracheal balloon is important to avoid discomfort and complications on the patients undergoing an anesthetic procedure, however, due to the variation found in the inflation levels, we can say it is not measured or is not given the proper importance (6).

We can conclude that in patients undergoing cervical spine surgery, the most frequent laryngeal symptomatology caused by excessive inflation of the endotracheal cannula balloon is pain and the presence of two or more symptoms. These symptoms are present more frequently in men than in women, both in the RCU and after 24 hours. The excessive inflation of the endotracheal cannula balloon is a positive risk factor in the RCU to foreign body sensation and two or more symptoms at the 24 hours for pain; men is a positive risk factor both in the RCU and after 24 hours.

REFERENCES

1. Franco-Grande A, Álvarez-Escudero J, Cortes-Laiño J. Historia de la Anestesia en España. Madrid:Aran;2005.
2. Muñoz VE, Mojica S, Gómez JM, Soto R. Comparación de la presión del manguito del tubo orotraqueal estimada por palpación frente a la medición tomada con un manómetro. Revista Ciencias de la Salud 2011; 9(3): 229-236.
3. Soberanes-Ramírez L, Martínez-Ayala O, Baltazar-Torres JA, Salazar-Escalante DC, Oláis-Moguel CA. Correlación entre la presión del globo de la cánula traqueal medida por el método electrónico y la medida por el esfigmomanómetro de mercurio. Med Crit Ter Intens 2006;XX(2): 69-74.
4. Seegobin RD, Van Hasselt GL. Endotracheal cuff pressure and tracheal mucosal blood flow: Endoscopic study of effects of four large volume cuffs. Br Med J 1984; 288(6422):965-968.
5. Wujtewicz MA, Sawicka W, Owczuk R, Dylczyk-Sommer A, Wujtewicz M. Tracheal tube cuff pressure depends on the anaesthesiologist's experience. A follow-up study. Anaesteziol Intens Ter 2009, 41(4): 205-8.
6. Benjamin B. Prolonged intubation injures of the larynx: endoscopic diagnosis, classification, and treatment. Ann Otol Rhinol Laringol 1993;160(5): 1-15.
7. Sengupta P, Sessler DI, Maglinger P, Wells S, Vogt A, Durrani J, et al. Endotracheal tube cuff pressure in three hospitals and the volume required to produce an appropriate cuff pressure. BMC Anesthesiology 2004;4(8):1-6.
8. Payne DK, Romero MD. Tracheoesophageal fistula formation in intubated patients: Risk factors and treatment with high-frequency jet ventilation. Chest 1990;98(1)161-164.
9. Zarogoulidis P, Kontakiotis T, Tsakiridis K, Karanikas M, Simoglou C, Porpodis K, et al. Difficult airway and difficult intubation in postintubation tracheal stenosis: a case report and literature review. Ther Clin Risk Manag 2012; 8:279-86.
10. Zias N, Chroneou A, Tabba MK, Gonzalez AV, Gray AW, Lamb CR, et al. Post tracheostomy and post intubation tracheal stenosis: Report of 31 cases and review of the literature. BMC Pulmonary Medicine 2008;8:1-9.
11. Sole ML, Aragon D, Bennett M, Johnson R. Continuous Measurement of Endotracheal Tube Cuff Pressure. How Difficult Can It Be? AACN Adv Crit Care 2008;19(2):235-243.
12. Nordin U. The trachea and cuff-induced tracheal injury. Acta Oto-laryngologica. Supplementum 1977; 345:1-71.
13. Seegobin RD, van Hasselt GL. Endotracheal cuff pressure and tracheal mucosal blood flow: endoscopic study of effects of four large volume cuffs. Br Med J (Clin Res Ed) 1984;288(6422):965-968.
14. Tobin MJ, Grenvik A. Nosocomial lung infection and its diagnosis. Crit Care Med 1984;12(3):191-199.
15. Rello J, Sonora R, Jubert P, Artigas A, Rué M, Vallés J. Pneumonia in intubated patients: role of respiratory airway care. Am J Respir Crit Care Med 1996; 154(1):111-5.
16. Cerqueira-Braz JR, Camacho-Navarro LH, Harumi-Takata I, Nascimento-Júnior P. Endotraqueal tube cuff pressure: need for precise measurement. Sao Paulo Med J/Rev Paul Med 1999;117 (6):243-7.
17. Alves-Mota LA, Barbosa de Cavalho G, Almeida-Brito V. Laryngeal complications by orotracheal intubation: literature review. Int Arch Otorhinolaryngol 2012;16(2):236-245.
18. Eknayan G. Adolphe Quetelet (1796-1874)—the average man and indices of obesity. Nephrol Dial Transplant 2008; 23:47-51.
19. Bruder N, Dufour H. Anesthésie pour hernie discale. In Conférences d'actualisation. Paris: Elsevier;1996 pp. 59-70.