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Establishing changes in endotracheal cuff pressure with continuous monitoring in patients undergoing laparoscopic surgery in Trendelenburg position

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Abstract : *Background* : After endotracheal intubation, the endotracheal cuff gets inflated to a sufficiently high pressure to prevent air leaking. Placing a patient in Trendelenburg position and establishing a pneumoperitoneum affects the endotracheal cuff pressure.

Objectives : Determine the impact of these factors on the endotracheal cuff pressure.

Design and setting : This prospective, observational study was conducted in the Catharina Hospital (Eindhoven, the Netherlands).

Methods : This study included adult patients undergoing laparoscopic surgery. A routine endotracheal tube was inserted, in which the cuff pressure was continuously monitored.

Main outcome measures : The outcome of interest was a change in endotracheal cuff pressure after establishment of a pneumoperitoneum and/ or placing a patient in a Trendelenburg position.

Results : 39 patients were included. Cuff pressures increased significantly from the moment of pneumoperitoneum, placing a patient into a Trendelenburg position increased endotracheal cuff pressure and peak pressures even more. The highest endotracheal cuff pressure was 67 cm H_2O, the highest registered peak pressure was 35 cm H_2O.

Conclusion : Both endotracheal cuff pressure and peak pressure increased during laparoscopic surgical procedures with a pneumoperitoneum and the patient placed in Trendelenburg position. Measuring the endotracheal cuff pressure only after endotracheal intubation is insufficient and should be repeated during surgery on fixed moments.

Keywords : Endotracheal intubation ; endotracheal cuff pressure ; pressure monitoring ; mechanical ventilation ; general anesthesia.

Introduction

Endotracheal intubation is an ubiquitously employed medical procedure by anesthesia providers to apply respiratory support and mechanical ventilation during surgical procedures (1). During endotracheal intubation, a tube gets inserted in a patients trachea. A high volume low-pressure cuff is situated at the distal end of this tube, which is inflated with air to create a seal in the trachea (1). The endotracheal cuff pressure should be sufficiently high. A cuff pressure below 20 cm H_2O can cause complications such as air leakage, inadequate tidal volume, micro aspiration, and ventilator associated pneumonia (1, 2). On the other hand, a cuff pressure above 30 cm H_2O increases the risk of ischemia, necrosis, stenosis, tracheal rupture, and fistula due to compromising the tracheal mucosal perfusion (1, 2). Multiple studies have denoted an endotracheal cuff pressure within the range of 20 to 30 cm H_2O to be most optimal (1-3).

In routine clinical practice, the endotracheal cuff pressure is controlled directly after intubation and set within the range of 20 to 30 cm H_2O. Nonetheless, factors such as airway anatomy, cuff

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Ethical standards : The study protocol was approved by the Medical Ethics Committee (MEC-U, Nieuwegein, the Netherlands, reference W18.206, date of approval 20-11-2018, chairman dr. B. van Ramshorst).

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Written informed consent was obtained from all participants during their preoperative interview on the anesthesia department.

location, cuff material and structure, size and volume in the cuff, peak inspiratory pressure, positive pressure ventilation, and duration of endotracheal tube placement can alter endotracheal cuff pressure (3). In addition, suctioning, patient position and body movements, pneumoperitoneum, body temperature, patient-related factors, environmental circumstances, and therapeutic interventions also affects endotracheal cuff pressure (3). With many factors affecting endotracheal cuff pressure, there is challenging to maintain the cuff pressure within the optimal range.

Besides, with more and more surgical procedures being performed with a laparoscopic technique nowadays, patients are frequently placed in a Trendelenburg position in combination with the establishment of a pneumoperitoneum (4, 5). This results in an increased airway and endotracheal cuff pressure (4). Following this, it is suggested that endotracheal cuff pressure should be measured after changing a patient's position and the establishment of a pneumoperitoneum (5, 6).

Measurement of endotracheal cuff pressure is a simple and inexpensive procedure and should be applied in all patients undergoing surgery (5). However, subjective measurements to guide adjustment, or observation of the pressure value alone, may lead to inaccuracies. So, it is recommended to use an objective technique to determine the cuff pressure, thus Hockey et al. (7). Estimating the endotracheal cuff pressure using finger palpation is stated to be an easy but unreliable technique (8-10). Using a manual endotracheal cuff pressure manometer is more reliable, but a leak of air can occur when the device is fixed and disconnected (11). A previously performed meta-analysis of randomized controlled trials in Intensive Care patients showed that continuous monitoring of the cuff pressure reduced the incidence of pressures out the range of 20 to 30 cm H_2O when compared to measurements with the manual endotracheal cuff pressure manometer (12). Continuous measurement of the cuff pressure seems to be the most reliable technique, while this technique is rarely used in clinical anesthesia practice, mainly because a lack of standards or data to support its use (13).

Placing a patient in a Trendelenburg position and establishing a pneumoperitoneum affects the endotracheal cuff pressure, although its impact is unclear. Subsequently, changes in endotracheal cuff pressure affects a surgical patients safety. This gab of knowledge is important to administer anesthesia and provide mechanical ventilation in a safe way. Therefore, the current practical study was conducted and aimed to determine the impact of placing a patient in a Trendelenburg position and the establishment of a pneumoperitoneum on the endotracheal cuff pressure using continuous monitoring. Furthermore, the goal of this study was to demonstrate the moments on which the endotracheal cuff pressure must be checked during surgical procedures under previous described conditions.

Methods

This prospective, observational study was conducted between January and April 2019, and performed in the Catharina Hospital (Eindhoven, the Netherlands). Adult patients undergoing laparoscopic gynecological, urological or gastro-intestinal surgery under general anesthesia were asked to participate in this study on voluntary base, regardless their medical history, demographics or baseline characteristics, and ASA physical state. Patients were excluded if a non-standard endotracheal tube was inserted (double-lumen or neural integrity monitor electromyogram [NIM] tracheal tube), if nitrous oxide was used to maintain general anesthesia, and if the indication for surgery was under emergency or unplanned conditions. The study protocol was approved by the Medical Ethics Committee (MEC-U, Nieuwegein, the Netherlands, reference W18.206, date of approval 20-11-2018, chairman dr. B. van Ramshorst) and by the Institutional Review Board (Catharina Hospital, Eindhoven, the Netherlands, reference nWMO-2018.119, date of approval 04-01-2019), written informed consent was obtained from all participants during their preoperative interview on the anesthesia department.

Patients received premedication consisting of acetaminophen 1000 milligrams, and a Ringer's solution was administered through an intravenous cannula. Patients were preoxygenated for 3 minutes, where after anesthesia was induced with propofol 2 mg kg-1, sufentanil 0.1-0.2 µg kg-1, and rocuronium 0.6 mg kg-1. After induction of anesthesia, endotracheal intubation was performed using a Shiley™ Hi-Contour cuffed oral tracheal tube (Covidien Ireland Limited, Tullamore, Ireland), according to hospital policy and applicable guidelines (14, 15). As part of routine practice, a tube sized 7.0 was inserted in female patients, whereas male patients got a tube sized 8.0 inserted. Directly after intubation, endotracheal cuff pressure was set at 25 cmH_2O with the cuff pressure manometer (VBM Medizintechnik GmbH, Sulz am Neckar, Germany). Following this, continuous cuff pressure monitoring was started following the strategy as described by Kim et al. (16). Both systems (manual cuff pressure manometer and continuous cuff pressure monitoring) were calibrated by the technical engineering department of the hospital and adjusted to the situation in the operating theatre. Continuous endotracheal cuff pressure monitoring was continued throughout the surgical procedure, until removal of the endotracheal tube. Correction of endotracheal cuff pressures (increase or decrease by inflating or deflating the cuff with air) was not performed as long as no problems were observed with mechanical ventilation. General anesthesia was maintained with sevoflurane at an end tidal concentration of 1.8%, in 60% air in oxygen. Additional boluses of sufentanil and rocuronium were administered if necessary. All patients were monitored according to the ASA standards. During the surgical procedure, ulnar nerve T4/T1 TOF measurement was performed to maintain a deep neuromuscular blockade. The endotracheal tube was removed after completion of the surgical procedure and following criteria were met: reversal of neuromuscular block (ulnar nerve T4/T1 TOF ratio > 90%), return of spontaneous ventilation, and the ability to follow verbal comments. Patients were than transported to the postoperative care unit to receive postoperative care.

The outcome of interest was any change in endotracheal cuff pressure after placing a patient in a Trendelenburg position. Subsequently, the relation between the degrees of Trendelenburg position and changes in endotracheal cuff pressure was investigated. Secondary outcomes were the impact of abdominal CO_2 insufflation pressure on the endotracheal cuff pressure, the impact of the combination of a pneumoperitoneum and a Trendelenburg position on the cuff pressure, and the impact of patient and procedure related data on the endotracheal cuff pressure. To continue, peak pressure during mechanical ventilation was combined with the abdominal insufflation pressure of CO_2 during pneumoperitoneum and the degrees of Trendelenburg position to detect any relation.

Demographic and baseline characteristics of included patients (sex, age, BMI, ASA physical status) were provided from the local institutional clinical registry, which contains information in a computerized database from the preoperative screening. Information regarding endotracheal intubation and induction of anesthesia (tube size, tube depth, cuff pressure after intubation, time needed for intubation, peak pressures of the mechanically ventilated patient), and surgical procedure (degrees of Trendelenburg, CO_2 insufflation pressure, duration of the surgical procedure) were registered on for this study designed forms. Registration of data was performed on fixed moments : T0 (directly after intubation with the cuff pressure set at 25 cm H_2O) ; T1 (directly after the start of the surgery, incision) ; T2 (insufflation of CO_2 to establish a pneumoperitoneum) ; T3 (placing the patient into a supine Trendelenburg position) ; T4 (15 minutes after the start of the surgery as registered on T1) ; T5 (30 minutes after the start of the surgery as registered on T1) ; T6 (60 minutes after the start of the surgery as registered on T1) ; T7 (at the end of the surgical procedure, directly after disinflation of the pneumoperitoneum and placing the patient in the horizontal supine position) ; and T8 (just before removal of the endotracheal tube in a spontaneous breathing patient). Completed registration forms were analyzed.

Statistical analyses

Directly after endotracheal intubation, the cuff is inflated to a pressure of 25 cm H_2O. This cuff pressure was chosen arbitrary as the mean between 20 and 30 cm H_2O, which are denoted to be the lower and upper limit. Assuming a clinical relevant difference of 20% (endotracheal cuff pressure below 20 or above 30 cm H_2O), a minimum of 35 patients needed to be included to achieve α=0.05 and β=0.80. The normality assumption for continuous variables was assessed with the Kolmogorov-Smirnov test, which were expressed as mean and standard deviation (SD). Those values without a normal distribution were represented as median and interquartile range (minimum-maximum value). Discrete variables were expressed as frequencies with percentages. Paired-samples t-testing was used to detect differences regarding the outcome of interest on the several time points, based on its assumption for normal distribution. The Wilcoxon signed ranks test was used for variables without a normal distribution. Linear regression and Pearson ρ analyses were used to provide correlations and relations between variables and the outcome of interest. A P value less than 0.05 was considered statistically significant throughout the study. SPSS, version 25.0 (SPSS Inc., Chicago, USA) was used for all statistical analysis.

Results

Throughout the study, 39 patients were included. Of the included sample of patients, the

Table 1.

Differences in endotracheal cuff pressure during the surgical procedure

Moment	Endotracheal cuff pressure	CO_2 insufflation pressure	Degrees Trendelenburg	*P* value
T0	25.0 ±0.0	0	0	
T1	27.7 ±7.7	0	0	0.035
T2	32.5 ±9.0	22.7 ±3.6	0	< 0.001
T3	33.1 ±8.4	17.2 ±4.9	18.0 ±4.0	< 0.001
T4	32.3 ±8.7	14.4 ±2.4	18.9 ±5.6	< 0.001
T5	31.3 ±7.9	13.8 ±0.7	19.4 ±4.0	<0.001
T6	29.7 ±9.5	13.8 ±1.2	19.2 ±3.9	0.045
T7	27.6 ±8.2	0	0	0.051
T8	25.8 ±8.2	0	0	0.529

Data is represented as mean ±standard deviation. The endotracheal cuff pressure and CO_2 insufflation pressure are represented in cm H_2O. Comparisons were made with the baseline measurement at T0 and represented with P values. T0 (directly after intubation with the cuff pressure set at 25 cm H_2O); T1 (directly after the start of the surgery, incision) ; T2 (insufflation of CO_2 to establish a pneumoperitoneum) ; T3 (placing the patient into a supine Trendelenburg position) ; T4 (15 minutes after the start of the surgery as registered on T1) ; T5 (30 minutes after the start of the surgery as registered on T1) ; T6 (60 minutes after the start of the surgery as registered on T1) ; T7 (at the end of the surgical procedure, directly after disinflation of the pneumoperitoneum and placing the patient in the horizontal supine position) ; and T8 (just before removal of the endotracheal tube in a spontaneous breathing patient).

Table 2.

Differences in peak pressure during the surgical procedure

Moment	Peak pressure	CO_2 insufflation pressure	Degrees Trendelenburg	*P* value
T0	17.6 ±4.3	0	0	
T1	16.2 ±2.8	0	0	0.062
T2	22.6 ±5.8	22.7 ±3.6	0	< 0.001
T3	26.0 ±5.1	17.2 ±4.9	18.0 ±4.0	< 0.001
T4	25.3 ±4.5	14.4 ±2.4	18.9 ±5.6	< 0.001
T5	25.6 ±3.8	13.8 ±0.7	19.4 ±4.0	<0.001
T6	25.7 ±4.4	13.8 ±1.2	19.2 ±3.9	< 0.001
T7	17.5 ±3.2	0	0	0.885
T8	16.4 ±3.2	0	0	0.110

Data is represented as mean ±standard deviation. The peak pressure and CO_2 insufflation pressure are represented in cm H_2O. Comparisons were made with the baseline measurement at T0 and represented with P values. T0 (directly after intubation with the cuff pressure set at 25 cm H_2O) ; T1 (directly after the start of the surgery, incision) ; T2 (insufflation of CO_2 to establish a pneumoperitoneum) ; T3 (placing the patient into a supine Trendelenburg position) ; T4 (15 minutes after the start of the surgery as registered on T1) ; T5 (30 minutes after the start of the surgery as registered on T1) ; T6 (60 minutes after the start of the surgery as registered on T1) ; T7 (at the end of the surgical procedure, directly after disinflation of the pneumoperitoneum and placing the patient in the horizontal supine position) ; and T8 (just before removal of the endotracheal tube in a spontaneous breathing patient).

mean age was 46 ±14 years, the mean body mass index was 26.6 ±5.7, and 38 (97%) were of female sex. An endotracheal tube size 6.0 was inserted in 1 patient (3%), whereas 37 (94%) and 1 (3%) got a tube size 7.0 and 8.0 inserted respectively. Of the included patients were 37 (95%) planned for a gynecological procedure, and 2 (5%) for a gastro-intestinal procedure. All included patients were in stable hemodynamic conditions throughout the study period. In all cases, the surgical procedure started with the patient positioned in a horizontal supine position (0° Trendelenburg). During surgery, the patient was placed in a Trendelenburg position with a mean of 18.9 ±3.9 degrees. Insufflation pressure was started at a level of 22.7 ±3.6 cm H_2O, and a pneumoperitoneum was maintained during surgery with an insufflation pressure of 13.4 ±2.4 cm H_2O. The surgical procedure lasted a median of 100 (55 to 185) minutes.

Directly after endotracheal intubation, the endotracheal cuff pressure was set at 25 cm H_2O, with the patient in the horizontal supine position and no insufflation of CO_2. With respect to the baseline values, cuff pressure increased significantly from the moment of insufflation of CO_2 to establish a pneumoperitoneum (Table 1). The highest endotracheal cuff pressure as monitored during the study was 67 cm H_2O, whereas the lowest registered cuff pressure was 11 cm H_2O. A relation between endotracheal cuff pressure and the insufflation pressure of CO_2 was observed (R^2=4%, F=8.75, P=0.003), although the Trendelenburg position did not affect the cuff pressure (R^2=-0.5%, F=0.34, P=0.558). Nevertheless, the combination of a Trendelenburg position and abdominal insufflation of CO_2 had a stronger relation with the endotracheal cuff pressure (R^2=11%, F=20.31, P<0.001).

A mean peak pressure of 17.6 ±4.3 was recorded directly after intubation, with the patient in the horizontal supine position and no insufflation of CO_2. Peak pressure increased to 22.6 ±5.8 upon the insufflation of CO_2, as shown in Table 2. With placing a patient into a supine Trendelenburg position, pressures increased to 26.0 ±5.1. Regarding the peak pressure, highest measured value was 35 cm H_2O, and the lowest measured value was 12 cm H_2O. Placing a patient in a Trendelenburg position did not affect the peak pressure (R^2=0.1%, F=1.107, P=0.295), while the insufflation of CO_2 had a relation with the recorded peak pressure (R^2=14%, F=34.44, P<0.001). To add on this, peak pressure were even more affected by the combination of a Trendelenburg position and the insufflation of CO_2 (R^2=48%, F=145.99, P<0.001).

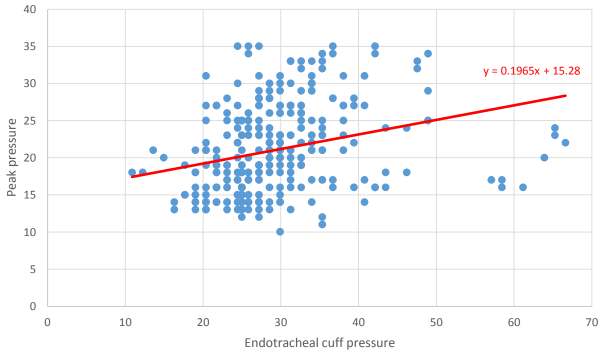
A strong correlation was objected between the endotracheal cuff pressure and peak pressure during mechanical ventilation, (ρ=0.29, P<0.001), as shown in Figure 1. This correlation was graphically made transparent in Figure 2, representing the measurements regarding degrees of Trendelenburg position and abdominal insufflation of CO_2 on the specific time points.

As a result of the analyses, endotracheal cuff pressure did not correlate with a patients sex (ρ=0.02, P=0.745), age (ρ=-0.01, P=0.878), BMI (ρ=-0.10, P=0.087) or ASA classification (ρ=0.05, P=0.371). Also the size of the inserted tube (ρ=0.06, P=0.285), depth of the tube (ρ=-0.01, P=0.950) and the duration of the procedure (ρ=0.03, P=0.643) did not influence the endotracheal cuff pressure. The peak pressure, on the contrary, had a positive correlation with a patients age (ρ=0.13, P=0.025) and BMI (ρ=0.29, P<0.001). The peak pressure was not affected by a patients sex (ρ=-0.03, P=0.587) or ASA classification (ρ=-0.04, P=0.526), nor by the size (ρ=0.01, P=0.878) and depth (ρ=-0.07, P=0.232) of the tube or the duration of the surgical procedure (ρ=-0.06, P=0.321). No confounding was observed during data-analyses.

Discussion

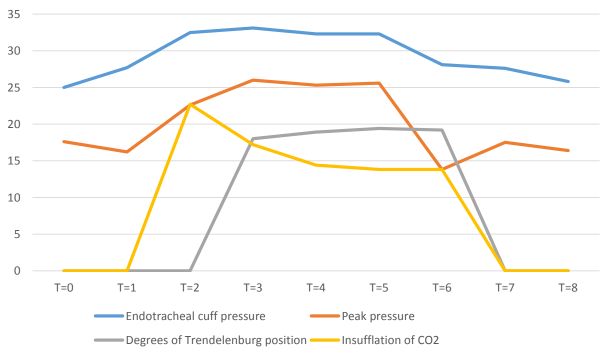
The current study aimed to explore changes in endotracheal cuff pressure after establishing a pneumoperitoneum and placing a patient in Trendelenburg position, to emphasize the added value of measuring the cuff pressure. Besides, the impact of a pneumoperitoneum and Trendelenburg position on the peak pressures were measured. As a result of this study, both cuff pressure and peak pressure increased significantly from the moment of

Figure 1. — Graphical presentation of the correlation between endotracheal cuff pressure and peak pressure



Cuff pressure (cm H_2O) is represented on the x-axis, peak pressure (cm H_2O) is represented on the y-axis. The reference line (red) represents the overall relation between both variables (y=0.1965x+15.28).

Figure 2. — Graphical presentation of outcome measurements for the included time moments



Data are represented as mean outcomes for the endotracheal cuff pressure (cm H_2O), peak pressure (cm H_2O), degrees of supine Trendelenburg position, and CO_2 insufflation pressure (cm H_2O) on different time points: T0 (directly after intubation with the cuff pressure set at 25 cm H_2O) ; T1 (directly after the start of the surgery, incision); T2 (insufflation of CO_2 to establish a pneumoperitoneum) ; T3 (placing the patient into a supine Trendelenburg position) ; T4 (15 minutes after the start of the surgery as registered on T1) ; T5 (30 minutes after the start of the surgery as registered on T1) ; T6 (60 minutes after the start of the surgery as registered on T1) ; T7 (at the end of the surgical procedure, directly after disinflation of the pneumoperitoneum and placing the patient in the horizontal supine position) ; and T8 (just before removal of the endotracheal tube in a spontaneous breathing patient).

insufflation of CO_2 to establish a pneumoperitoneum in combination with a patient is placed in a supine Trendelenburg position.

A common complication due to intubation is a high cuff pressure. It is well known that a correct inflation volume of the endotracheal cuff is recommended to ensure adequate ventilation and to prevent for adverse events. Nonetheless, there is no consensus on which method of endo-tracheal cuff pressure measurement to employ, particularly regarding the rationale and requirement for endotracheal cuff pressure monitoring intraoperatively (5, 8, 17, 18). In clinical practice, endotracheal cuff pressures are not routinely measured during the period an endotracheal tube is in situ, nor is repeated cuff pressure monitoring performed on fixed moments. In the meanwhile, monitoring of the cuff pressure is a simple, noninvasive and efficient way to achieve therapeutic cuff pressures in the range of 20 to 30 cm H_2O (5,19). This range is said to be adequate and safe (20).

Generally, a relative limited increase of endotracheal cuff pressure was observed in the current study, with a mean cuff pressure of 33.1 ± 8.4 at most. Measurements below the lower limit of 20 cm H_2O were not observed, in general. In a previous study, the odds ratio for the incidence of a cuff pressure below 20 cm H_2O was 0.03 (0.01 to 0.07) for continuous cuff pressure monitoring when compared to intermittent monitoring (12). For cuff pressures above the range of 30 cm H_2O, an odds ratio of 0.06 (0.03 to 0.15) was recorded in favor of continuous cuff pressure monitoring (12). Nonetheless, these data were from intubated Intensive Care patients. To best of our knowledge, such data is unknown for the intubated surgical patient during the intraoperative period, when a patient is placed in Trendelenburg position and with the establishment of a pneumoperitoneum. Despite, the application of continuous cuff pressure monitoring during a surgical procedure offers the anesthesia provider a tool to reduce the incidence of, particularly, increased cuff pressures. To add on this, this can be especially important in procures in which a patients is placed in Trendelenburg position with abdominal CO_2 insufflation for a longer period.

In clinical practice, endotracheal tubes with a high-volume low-pressure endotracheal cuff are used. This standard high-volume low-pressure endotracheal cuff is designed to presumably conform to the tracheal wall size, provide an air seal during inspiration, and prevent fluid leakage during expiration at safe tracheal wall pressures (21). The introduction of this high-volume low-pressure endotracheal cuff in the 1970s was even more thought to minimize complications by applying a safe pressure over a larger surface area in the trachea (21). Despite the use of high-volume low-pressure endotracheal cuffs, complications related to overinflating the endotracheal cuff remain frequent and vary in severity from transient sore throat with hoarseness and tracheal mucosa ulcers, to more serious and disabling adverse events such as nerve palsy, tracheal rupture or fistula (20). Even though the pathophysiology of post-intubation airway symptoms is not completely clarified, the mucosal damage that occurs at the cuff level and the cuff pressure are thought to be essential causative factors for tracheal morbidity (5). In line with this, several factors as a patients history of sore throat, cough, hoarseness, anticipated difficult intubation, existing obstructive or restrictive lung disease, or conversion to laparotomy should be measured in further studies as potential confounder for endotracheal cuff pressure and diverge peak pressures during mechanical ventilation.

Besides insufflation of a large volume in the endotracheal cuff, the endotracheal cuff pressure is also affected by factors regarding the surgical procedure. Yildirim et al. concluded that a pneumoperitoneum and Trendelenburg position increased endotracheal cuff pressure during laparoscopic surgery, whereas the endotracheal cuff pressures during open abdominal surgery did not change (5). Although this is in accordance with our results, increased degrees of Trendelenburg position and increased CO_2 insufflation pressures did not result in even further increased endotracheal cuff pressures. Unless the increased endotracheal cuff pressure, a study by Rosero et al. showed an increased peak airway pressure during pneumoperitoneum and the Trendelenburg position, which is in agreement with our study results (20). This increased peak airway pressure is caused by cranial displacement of the diaphragm and decreased intrathoracic volume due to establishment of the pneumoperitoneum and Trendelenburg positioning, of which the effects are thought to be further magnified in obese patients (20). The administration of a muscle relaxant and the maintenance of a deep muscular blockade throughout the procedure may have resulted in relative limited increase of endotracheal cuff pressure (22). Neuromuscular blockade results in the reduction of oropharyngeal dimension and increase in the laryngeal dimensions because of the loss of the muscular tension around the neck (22).

Peak pressures were affected by a patients age and BMI, as a result of the current study. With most patients included in this study being of female sex, a clarification can be that those have proportionally smaller lungs and airways compared with height-matched men (23). These anatomical sex-based differences may result in improved mechanical ventilator constraints and since women represent the most part of the sample, this might constitute a confounding factor (23). Notwithstanding, endotracheal cuff pressure did not correlate with patient or procedure related variables. Though, previous studies assumed that patients inter individual variability such as the anatomy of trachea, cuff positioning over trachea and cuff physical characteristics such as material, diameter, thickness, compliance, geometry were factors influencing the cuff pressure (24, 25).

Department-wide availability of manometers and education in its use resulted in an improved proportion of in-range cuff pressures, according to Stevens et al. (26). A study by Danielis et al. supports the need of continuous endotracheal cuff pressure monitoring (27). Continuous cuff pressure monitoring promptly identifies deviations from the pressure ranges and allows for rapid correction (27). Cuff pressure monitoring by an electronic manometer, to continue, was even steadier when compared to both continuous and intermittent monitoring (28). Wen et al. concluded continuous control of cuff pressure to offer more benefits in stabilizing the cuff pressure, although more studies are warranted to further evaluate the role of continuous monitoring of endotracheal cuff pressure (12). Manual palpation of the external cuff balloon on an endotracheal tube is, however, an inadequate method to determine and estimate the pressure existing inside the endotracheal cuff (9, 29, 30).

Limitations

Unless the clear results of this study and its clinical relevance, some considerations must be taken into account. At first, we used endotracheal tubes from one manufacturer in a single center setting. Generalizability of our results to other type of endotracheal tubes may be affected for this reason. Secondly, our cohort of patients was relatively small. A larger cohort of patients could possibly identify more differences regarding patient and procedure related procedures. Furthermore, our cohort consisted mainly of female patients with normal demographics. A cohort of patients including different surgical procedures and patient characteristics will possibly lead to changed results, improving its generalizability. At third, we applied a fixed protocol for induction and maintenance of general anesthesia. Different strategies to administer anesthesia may influence the study results, such as peak pressures for instance. Although we did not use nitrous oxide, may the endotracheal cuff pressure be subject of change when other gas mixes are used. Finally, this study did not focus on complications regarding an increased endotracheal cuff pressure. Despite the significant increase in endotracheal cuff pressure and peak pressure during pneumoperitoneum and a patient in Trendelenburg position as a result of our study, would it be interesting to identify the amount and severity of complications regarding this changes and determine its clinical relevance, based on several cutoff values of degrees of Trendelenburg and pressures of CO_2 insufflation.

Conclusion

This prospective, observational study focused on changes in endotracheal cuff pressure and peak pressure after establishing a pneumoperitoneum and placing a patient in Trendelenburg position. Both endotracheal cuff pressure and peak pressure increased during laparoscopic surgical procedures with a pneumoperitoneum and the patient placed in Trendelenburg position. Measuring the endotracheal cuff pressure only after endotracheal intubation is insufficient and should be repeated during surgery on fixed moments, especially after changing a patients position and establishing a pneumoperitoneum. Continuous measurement of endotracheal cuff pressure has a clear added value, with which an increasing cuff pressure can be noticed in an early timeframe. Further research needs to be performed to assess whether routine monitoring of cuff pressure results in improved patient outcomes.

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Declaration of interests. Authors have nothing to declare.

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