Detection and Prevention of Overinflation of the Tracheal Tube Cuff During Surgery at a Tertiary Care Hospital: A Quality Improvement Initiative

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Millions of tracheal intubations are performed annually in the United States, making it one of the most common interventional procedures. Excessive inflation of the tracheal cuff (pressure >30 cm H_2O) can obstruct the microvasculature of the tracheal mucosa, leading to tracheal ischemia and ulceration.[1] Elevated tracheal cuff pressures can lead to short-term complications, such as sore throat and blood-streaked expectoration, as well as long-term risks, including tracheal stenosis and rupture.[2] Clinical studies indicate that tracheal cuff pressures are frequently higher than the recommended range.[3] These cuff pressures can be even further elevated intraoperatively through changes in patient positioning, increased airway pressure, and the use of nitrous oxide (N_2O).[4,5]

Current practitioner adherence to recommended monitoring practices, such as using a manometer to ensure proper inflation, is inconsistent and influenced by factors such as limited access to supplies, time constraints, and gaps in provider education.[6,7] Using an educational intervention to providers, the primary aim of this quality improvement project was to decrease the incidence of tracheal cuff overinflation by 50% from current practice over a period of 16 weeks in patients undergoing noncardiac surgery at a tertiary care hospital. This project included assessment of baseline rates of cuff overinflation and practice patterns of tracheal cuff inflation and monitoring.

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METHODS

The project was reviewed by the institutional review board at UT Southwestern Medical Center, Dallas, TX, which waived the need for informed consent due to the deidentified nature of the data. The target population consisted of nonobstetric adult patients undergoing surgery under general anesthesia with tracheal intubation. Exclusions consisted of patients intubated with specialized tubes (laser-resistant, metal-reinforced, double-lumen), or having surgeries where the tracheal cuff pilot was not accessible for measurement (eg, prone position, head/neck surgery). The outcome measure was a decrease in incidence of tracheal cuff overinflation (pressure >30 cm H_2O).

Since the rate of baseline overinflation was unknown, cuff pressures were measured in a convenience sample of 100 patients over a 4-week period. Anesthesia providers were blinded to pressure measurements. Alongside this data collection, anesthesia providers (attending anesthesiologists, residents, and nurse anesthetists) were surveyed to identify their typical methods for assessing tracheal cuff pressure and perceived barriers to optimal cuff pressure management.

After completing the measurements, targeted educational sessions were delivered to the anesthesia providers, consisting of presentations detailing the mechanisms of tracheal ischemia and the risks/complications associated with overinflation. Additionally, a demonstration of optimal cuff pressure measurement using a manometer was conducted. The baseline measurements and survey findings were also presented to reinforce the importance of adopting optimal cuff pressure monitoring and adjustment practices. Finally, manometers (AG Cuffill, Hospitech Respiration Ltd.) were supplied in each operating room. Within 16 weeks postintervention, tracheal cuff pressures were measured in a second convenience sample of 63 patients to assess the impact of the intervention.

Data Analysis

Frequencies and percentages were used to describe categorical variables. Mean, median, standard deviation, and interquartile range (IQR) were used to summarize cuff pressure and other continuous data. χ^2 tests were used to compare rates of overinflation pre- and postintervention.

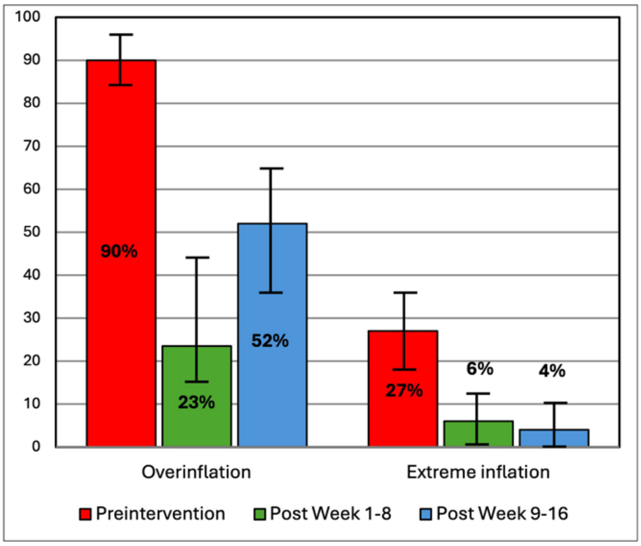
RESULTS

The Table describes some baseline characteristics of the patients, providers, airway management, and cuff pressures pre- and postintervention. The rate of cuff overinflation at baseline was 90% and was not associated with the type of provider inflating the cuff. Overinflation rates were similar when N_2O was used (90%) or not used (89%). A survey from 71 providers (46% attending anesthesiologists, 39% nurse anesthetists, 11% residents) revealed that the most common methods used to assess the cuff pressure were palpation of the cuff pilot (66%) followed by observation of the syringe plunger stopping (45%). After the intervention, manometers were used in 59% of cases, and the rate of tracheal cuff overinflation was 44%, significantly decreasing by approximately 50% compared to baseline ($P < .0001$) (Figure).

Table. Characteristics of Patients and Tracheal Cuff Pressures Pre- and Postintervention

Characteristic	Preintervention (n = 100)	Postintervention (n = 63)
Female sex, n (%)	51 (51)	33 (52.4)
Body mass index, kg/m^2 (mean, SD)	30.7 (6.9)	30.9 (7.8)
Weight, kg (mean, SD)	86.3 (22.6)	84.4 (18.9)
Height, cm (mean, SD)	167 (10.2)	166.0 (11.6)
Manometer used, n (%)	1 (1.0)	37 (59)
Provider who inflated cuff, n (%)		
Anesthesiology resident	8 (8.0)	11 (17.5)
Attending anesthesiologist	30 (30.0)	10 (15.9)
Nurse anesthetist	50 (50.0)	35 (55.6)
Other	12 (12.0)	7 (11.1)
Tracheal tube size (ID), n (%)		
6	3 (3.0)	3 (4.8)
6.5	15 (15.0)	5 (8.0)
7	52 (52.0)	38 (60.3)
7.5	17 17.0)	7 (11.1)
8	13 (13.0)	10 (15.9)
Nitrous oxide used, n (%)	71 (71.0)	40 (63.5)
Duration of intubation (min)		
Median (IQR)	146 (107–240)	214 (144–294)
Tracheal cuff pressure (cm H_2O)		
Mean (SD)	76.8 (45.3)	25 (30)
Median (IQR)	65.3 (44.9–108.8)	37.6 (23.5–40.0)
Range	9.5–236.6	7–134

Abbreviations: ID, internal diameter; IQR, interquartile range; SD, standard deviation.



Bars on the columns represent 95% Confidence intervals for the proportions.
Overinflation refers to cuff pressure > 30 Cm H_2O. Extreme inflation is defined as cuff pressure > 100 Cm H_2O

Figure. Change in rates of cuff overinflation and extreme cuff inflation (cuff pressure >100 cm H_2O) before and after intervention.

When a manometer was used, the rate of appropriate cuff inflation (cuff pressures of 20–30 cm H_2O) reached 70%, compared to only 19% when a manometer was not used. The incidence of cuff pressures greater than 100 cm H_2O was significantly reduced from 27% to 4.8% ($P < .0001$) (Figure). The intervention also resulted in decreased variability of cuff pressures, demonstrated by decreased standard deviation and interquartile ranges (Table). Of note, postintervention, the incidence of cuff overinflation was significantly higher in cases where N_2O was used compared to those without N_2O (52.5% vs 30.4%, respectively; $P < .0001$). Postintervention, cuff overinflation was lower in the first 8 weeks (23.5%) but increased to 52% during weeks 9 to 16.

DISCUSSION

The implementation of our quality improvement initiative led to a 50% reduction in tracheal cuff overinflation within our clinical practice. We demonstrated that a targeted training initiative, combined with an accessible monitoring device, decreased the incidence of cuff overinflation, potentially enhancing safety in patients undergoing general anesthesia in our clinical practice.

Our baseline data indicate that the use of nonquantitative methods to assess cuff pressures results in high rates of overinflation. The association between the frequency of manometer use and appropriate cuff inflation highlights the need for routine availability of such tools in operating rooms. However, the persistent rate of overinflation in cases involving nitrous oxide despite use of manometers suggests that cuff pressures may need more frequent adjustment when nitrous oxide is used, as it can increase cuff pressure over time due to diffusion.[4,8] A notable concern is that the initial success observed immediately after the intervention waned over time. This decline may reflect a need for ongoing reinforcement through periodic refresher training.

Limitations of this project include its single-institution design, which may limit generalizability to other institutions, and the relatively small sample size. However, the project had a 99% power to detect the differences found in overinflation rates. In addition, clinical outcomes, such as postoperative sore throat or airway bleeding, were not assessed. Finally, while our educational intervention improved cuff management, future efforts could focus on integrating routine cuff pressure monitoring into clinical practice more seamlessly through clinical decision support reminders in the electronic health record or periodic assessments.

In summary, this project reinforces the need for training anesthesia providers on appropriate cuff pressure monitoring practices and indicates that routine access to manometers in the operating rooms can significantly reduce cuff overinflation during anesthesia. For sustained improvements, ongoing monitoring paired with regular educational refreshers could be beneficial to maintain these enhanced practices.

DISCLOSURES

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