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CLINICAL RESEARCH

Endotracheal tube cuff pressure increases in patients undergoing shoulder arthroscopy: a single cohort study

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KEYWORDS
Airway management;
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Abstract
Background and objectives: Several airway complications can occur during shoulder arthroscopy including airway obstruction, pleural puncture, and subcutaneous emphysema. It was hypothesized that the irrigation fluid used during a shoulder arthroscopic procedure might increase the cuff pressure of the endotracheal tube, which can cause edema and ischemic damage to the endotracheal mucosa. Therefore, this study aimed to evaluate the relationship between irrigation fluid and endotracheal tube cuff pressures.
Methods: Forty patients aged 20 to 70 years with an American Society of Anesthesiologists (ASA) score I or II, scheduled for elective arthroscopic shoulder surgery under general anesthesia, participated in our study. We recorded endotracheal tube cuff pressures and neck circumferences every hour from the start of the operation. We also recorded the total duration of the anesthesia, operation, and the total volume of fluid used for irrigation.
Results: A positive correlation was shown between endotracheal tube cuff pressures and the amount of irrigation fluid ($r = 0.385$, 95% CI 0.084 to 0.62, $p = 0.0141$). The endotracheal tube cuff pressure significantly increased at 2 and 3 hours after starting the operation ($p = 0.0368$ and $p = 0.0245$, respectively). However, neck circumference showed no significant difference.
Conclusions: Endotracheal tube cuff pressures increased with operation time and with increased volumes of irrigation fluid used in patients who underwent shoulder arthroscopy. We recommend close monitoring of endotracheal tube cuff pressures during shoulder arthroscopy, especially during long operations using a large amount of irrigation fluid, to prevent complications caused by raised cuff pressures.
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PALAVRAS-CHAVE
Manejo das vias aéreas;
Anestesia;
Endotraqueal;
Artroscopia

Aumento da pressão do balonete do tubo endotraqueal em pacientes submetidos a artroscopia do ombro: estudo de coorte

Resumo
Justificativa e objetivos: Diversas complicações das vias aéreas podem ocorrer durante a artroscopia do ombro, incluindo obstrução das vias aéreas, punção pleural e enfisema subcutâneo. Levantou-se a hipótese de que o fluido de irrigação utilizado durante artroscopia do ombro possa aumentar a pressão do balonete do tubo endotraqueal, podendo causar edema e lesão isquêmica na mucosa traqueal. Portanto, este estudo teve como objetivo avaliar a relação entre o fluido de irrigação e a pressão do balonete do tubo endotraqueal.
Métodos: Participaram do estudo 40 pacientes com idades entre 20 e 70 anos com classificação do estado físico I ou II da American Society of Anesthesiologists (ASA), programados para cirurgia artroscópica do ombro, eletiva e sob anestesia geral. Registramos as pressões do balonete do tubo endotraqueal e as circunferências do pescoço a cada hora, a partir do início da cirurgia. Também registramos a duração anestésica e cirúrgica, assim como o volume total de líquido de irrigação empregado.
Resultados: Foi encontrada correlação positiva entre a pressão do balonete do tubo endotraqueal e a quantidade de líquido de irrigação (r = 0,385; 95% IC 0,084 a 0,62; $p = 0,0141$). A pressão do balonete do tubo endotraqueal registrou aumento significante 2 e 3 horas após o início da cirurgia ($p = 0,0368$ e $p = 0,0245$, respectivamente). No entanto, a circunferência do pescoço não mostrou diferença significante.
Conclusões: As pressões do balonete do tubo endotraqueal aumentaram com o tempo de cirurgia e com o aumento do volume de líquido de irrigação utilizado em pacientes submetidos a artroscopia do ombro. Recomendamos a monitorização rigorosa da pressão do balonete do tubo endotraqueal durante artroscopia do ombro, especialmente nos procedimentos longos em que grandes volumes de fluido de irrigação são empregados, para evitar complicações causadas por pressões elevadas do balonete.
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Introduction

Shoulder arthroscopy is a common surgical procedure used for diagnosing and treating shoulder diseases.[1] More than 500,000 procedures are performed annually in the United States.[1] The incidence of complications is as low as 1% and reported major complications including brachial plexus injury, pneumothorax, and pneumomediastinum.[2] In rare cases, the irrigation fluid administered into the shoulder joint may cause fatal airway obstruction and subcutaneous emphysema.[3]

In patients receiving shoulder arthroscopy under general anesthesia, Endotracheal Tube (ETT) intubation is performed for use in mechanical ventilation. In order to avoid complications due to excessive cuff pressures during ETT intubation, a cuff pressure of 20 to 30 mmH_2O is recommended. Sufficient cuff pressure can minimize complications such as aspiration.[4–6] However, the pressure of the cuff can be altered by various factors depending on the surgical environment and the operation time. If the cuff pressure increases, mucosal edema and ischemic injury due to compression of the mucosal wall in the trachea can occur. These are the main causes of a sore throat after ETT intubation.[7]

No previous study has reported on the relationship between the ETT cuff pressure and the amount of irrigation fluid administered in patients receiving shoulder arthroscopy. Therefore, we aimed to evaluate the relationship between the cuff pressure after ETT intubation and the amount of irrigation fluid used in shoulder arthroscopy.

Methods

This is a single cohort study. This study protocol was approved by the Institutional Review Board of the College of Medicine, Inje University Seoul Paik Hospital (IIT-2014-192) and is in accordance with the Helsinki Declaration. Participants provided written informed consent.

Forty adult patients aged 20 to 70 years, with an ASA score of I or II who underwent elective shoulder arthroscopy were included in our study. Patients who received emergency surgery; patients with a difficult airway (Mallampati score ≥ 3), with a high risk of aspiration during the surgery; upper respiratory tract infection within 2 weeks of the operation; chronic obstructive pulmonary disease or asthma, with a chronic cough lasting more than 3 weeks; and smokers were excluded from the study.

Patients were anesthetized under hemodynamic monitoring, including Noninvasive Blood Pressure (NIBP), Electrocardiogram (ECG), pulse oximetry, Bispectral Index (BIS), Cardiac Output (CO), and Stroke Volume Variation (SVV) using Flotrac™. After induction of anesthesia, propofol 2 mg kg^{-1} and rocuronium 0.6 mg kg^{-1} were administered. ETT intubation was performed using a size 7.0 ETT for

women and size 7.5 for men.[8] The cuff pressure was measured with a pressure gauge, and the air was injected into the air sac at the minimum pressure that ensured no leakage during ventilation (maximum pressure of 40 cmH_2O). The posture of the patient was then changed from the supine position to the beach-chair position while vital signs were stabilized. The patient was maintained under anesthesia using mechanical ventilation with desflurane (4–10 volume %) and the administration of remifentanil (0.05–0.1 mcg. kg^{-1} min^{-1}) during the operation. The BIS was maintained between 40 and 60. The fresh gas flow of air and O_2 was 1.5 L. The pressure of the arthroscopy irrigation pump (10k® pump, CONMED) was 60 mmHg and the irrigation fluid used was normal saline.

Variables

Immediately after patients entered the operating room, their vital signs were measured at 5-minutes intervals. During surgery, CO and SVV remained within ±20% of the baseline value in each patient. An anesthesia resident not involved in the study measured the following variables: gender, height, weight, American Society of Anesthesiologists (ASA) physical status, diagnosis, and operation type; cuff pressure measured by a direct intracuff-pressure measurement technique using a manometer; ΔETT cuff pressure = cuff pressure at the end of surgery − cuff pressure measured initially; total volume of fluid used for irrigation (L); neck circumference at the level of the cricoid cartilage. The level at the first measurement was indicated by a mark, and the same part was measured the following time using a tape measure; duration of the anesthesia and operation (min); hemodynamic status including CO and SVV using FloTrac™; total volume of intravenous fluid administered (mL); occurrence of any severe complications and adverse events.

The variables were recorded at induction of anesthesia, after change of patient positioning, at every 1-hour intervals after induction of anesthesia, and the end of the surgery.

Statistical analysis

All analyses were performed using MedCalc® version 15.6.1 (MedCalc Software, Mariakerke, Belgium). To confirm the change in pressure of the intubated tube cuff owing to shoulder swelling before and after the operation, the mean difference in pressure expected from the pilot study was 2 mmHg and the deviation was 3 mmHg based on the pilot study. Adopting a type 2 error (β) at 20% or 80% power and a dropout rate of 10%, a total of 40 patients were included in the study.

Comparative analyses of repeated measurement variables were analyzed by repeated-measures ANOVA. The associations between the amount of irrigation fluid and the ΔETT cuff pressure were analyzed using the Spearman correlation (r). A p-value of < 0.05 was considered statistically significant. Normally distributed data were presented as the mean ± standard deviation.

The primary outcome was to evaluate the correlation between the amount of irrigation fluid and the ΔETT cuff pressure. The secondary outcome was to evaluate the relationship between the duration of surgery and the ΔETT cuff pressure. Neck circumference was also evaluated.

Table 1 Demographic data.

Variables	
Sex (male/female)	22/18
Age, year (median, Q25–75)	56 (54–63)
Height, cm (mean, SD)	162.1 [8.35]
Weight, kg (mean, SD)	65.8 [10.46]
ASA (I/II)	20/20

Values are expressed as absolute mean [standard deviation], median (25th–75th percentiles), or absolute number.

Table 2 Operation data.

Variables	
Anesthetic time (min)	181 (38.95)
Operation time (min)	118.25 (44.04)
Irrigation fluid (L)	17.5 (6.55)
Fluid input (mL)	1086 (217.57)

Values are expressed as absolute mean (standard deviation).

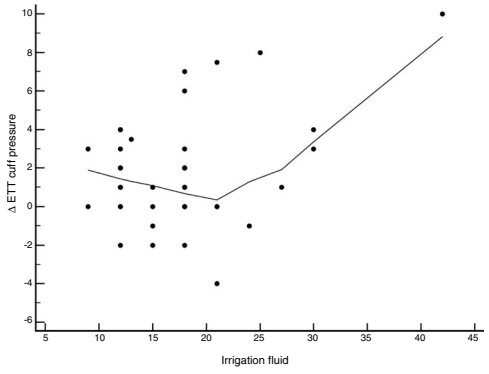

Figure 1 The ΔETT cuff pressure and the amount of irrigation fluid showed a positive correlation (r = 0.385, 95% CI 0.084 to 0.62, p = 0.0141).

Results

The demographic data of the 40 patients and the surgical parameters are shown in Tables 1 and 2, respectively. Of the 40 cases, there were 27 cases of Rotator Cuff Tear (RCT), 8 cases of long head of biceps tendon tear, 2 cases of RCT with stiffness, 1 case of RCT with subcapsular cyst, 1 case of RCT with Superior Labrum Anterior-Posterior (SLAP) tear, and 1 case of RCT with calcific tendinitis. Arthroscopic rotator cuff repair and subacromial decompression were performed. Capsulotomy, coracoplasty, biceps tenodesis, and calcification removal were also performed where necessary.

The ΔETT cuff pressure showed a positive correlation with the amount of irrigation fluid used during the shoulder arthroscopic procedure (r = 0.385, 95% CI 0.084 to 0.62, p = 0.0141) (Fig. 1).

There was a statistically significant difference between the ETT cuff pressure after the first, second, and third hours of the surgery. The increase in ETT cuff pressure was sta-

Table 3 Measurement parameters (n = 8).

	Neck circumference, cm	*p*-value	Cuff pressure, cm H_2O	*p*-value
Baseline	37.69 [0.95], 34.5–41		28.75 [0.75], 28–30	
After 1 hour	38.27 [0.87], 34.7–42	0.526	32.125 [1.15], 28–32	0.138
After 2 hours	38.7 [0.88], 34.9–42	0.178	32 [1.13], 29–34	0.037
After 3 hours	38.9 [0.9], 35.5–43	0.059	32.37 [1.29], 29–38	0.025

Values are expressed as an absolute mean [standard error], minimum–maximum.

tistically insignificant an hour after the surgery ($p = 0.138$). However, the ETT cuff pressure significantly increased at 2 and 3 hours after starting the operation ($p = 0.0368$ and $p = 0.0245$, respectively) (Table 3). However, neck circumference showed no significant difference (Table 3). Intravenous fluid showed no significant correlation to ΔETT cuff pressure ($p = 0.722$).

None of the patients had lethal complications such as a pneumothorax or airway obstruction during the operation. In this study, the pressure of the cuff during surgery was measured to an average of 30 mmHg and a maximum of 40 mmHg. However, there were no reported cases of neck pain or hoarseness in the recovery room.

Discussion

The purpose of this study was to evaluate the relationship between the pressure of the ETT cuff and the amount of irrigation fluid used during general anesthesia in patients who underwent shoulder arthroscopy. There was a positive correlation between the ΔETT cuff pressure, and the amount of irrigation fluid used. ETT cuff pressure also increased with increasing operation times. There was an insignificant increase in cuff pressure 1 hour after the surgery. However, there was a significant increase in the cuff pressure at 2 and 3 hours after the surgery. In other studies, arthroscopic surgery has shown a significant increase in side effects such as edema.[9] In this study, the neck circumference showed a tendency to increase with increasing operation times, but this was not statistically significant.

However, because the irrigation fluid can pressurize the airway through and outside the retropharyngeal space,[9] the neck circumference may not be an accurate indicator of soft tissue edema. Cuff pressure is, therefore, thought to be a clinically more accurate indicator of edema. The results of this study suggest that it is difficult to evaluate the degree of edema by only using neck circumference measurements. This limitation could be overcome, and significant results could be obtained by using ultrasound for evaluating the degree of edema rather than simple neck circumference measurements.[10]

In shoulder arthroscopy, extra-articular leakage of the irrigation fluid may develop, but this is usually resorbed without symptoms within 12 hours.[11] The factors that promote extra-articular leakage include patient obesity, high pressures, and long durations of the wash fluid inflow.[12,13] However, several cases of complete airway obstruction after shoulder joint endoscopy have been reported.[12,14–16] Shoulder joint endoscopy is an outpatient procedure with no airway protection, and irrigation fluid during surgery can be highly dangerous for patients with airway mucosal edema.[14–16] A cuff pressure of approximately 30 mmHg or more may cause mucosal ischemia and pain.[4–6] However, despite cuff pressures of up to 40 mmHg used in this study, no cases of hoarseness or pain were reported.

An important finding in our study is that that there is a correlation between arthroscopic irrigation fluid used and the various factors that affect it as demonstrated in this study. We can monitor the ETT cuff pressure and if its value increases during shoulder arthroscopy, we should control it to reduce the incidence of postoperative throat pain.

The limitations of this study were that the measurement was performed by one investigator to ensure measurement accuracy, and the study design itself leads to the difference in operation time.

Summary

In conclusion, we recommend close monitoring of endotracheal tube cuff pressures during shoulder arthroscopy, especially during prolonged operations using a large volume of irrigation fluid to prevent complications caused by increased cuff pressures.

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Conflict of interest

The authors declare no conflicts of interest.

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