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Original Article / Orijinal Araştırma

Effects of Positive Airway Pressure at Extubation in Patients Undergoing Upper Airway-related Surgery

Ekstübasyon Sırasında Pozitif Basınç Uygulanmasının Üst Hava Yolu Cerrahisi Uygulanan Hastalarda Hava Yolu Komplikasyonlarına Etkisi

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ABSTRACT

Objective: The evidence base for extubation is limited, and some recommendations are based on traditional habits and expert opinion. We organized this study to provide an objective interpretation of the discussions regarding cuff deflation in extubation. Our aim was to reveal the results of maintaining positive airway pressure until tracheal extubation and removing the endotracheal tube with the half-deflated cuff.

Methods: This study was approved by the local ethics committee and performed in accordance with the ethical standards of the Declaration of Helsinki. Written informed consent was obtained from the patient. Patients were randomized to one of two groups using a sealed envelope technique. In the control group, patients were extubated using the conventional method. In the study group, the pressure adjustment valve was set to 20-30 cmH_2O, and positive pressure was maintained until extubation. After measuring the cuff pressure, the cuff was half-deflated, and the tracheal tube was removed.

Results: A total of 68 patients were included. There was no statistically significant difference between the groups in terms of complications except coughing.

Conclusion: The most important finding was the lack of a statistically significant difference between the two groups in terms of complications of extubation, except cough. This result is valuable because the main concern is laryngeal injury by a half-deflated cuff. We attributed the low incidence of cough to the excretion of irritants and the pressure gradient across the cuff after positive pressure. While there is a lack of clear data on laryngeal injury with an undeflated cuff, considering its advantages, it is reasonable to introduce this technique into daily practice.

Keywords: Extubation, extubation complications, positive airway pressure

ÖZ

Amaç: Ekstübasyon uygulaması için kanıt temeli sınırlıdır, bu nedenle bu konudaki bazı öneriler kaçınılmaz olarak geleneksel alışkanlıklara ve uzman görüşüne dayanmaktadır. Bu çalışmayı ekstübasyonda kafın indirilmesi ile ilgili tartışmalara objektif bir yorum sağlamak için düzenledik. Amacımız hava yolu cerrahisi geçiren hastalarda trakeal ekstübasyonda kafın yarıya kadar indirilmesinin ve pozitif hava yolu basıncının korunmasının sonuçlarını ortaya koymaktır.

Yöntem: Bu çalışma yerel etik kurul tarafından onaylandı ve Helsinki Deklarasyonu'ndaki etik standartlara uygun olarak yapıldı. Yazılı bilgilendirilmiş onam alındı. Hastalar kapalı zarf tekniği kullanılarak iki gruptan birine randomize edildi. Kontrol grubundaki hastalar konvansiyonel yöntemle ekstübe edildi. Çalışma grubunda basınç ayar valfi 20-30 cmH_2O olarak ayarlandı ve ekstübasyona kadar pozitif basınç korundu. Kaf basıncı ölçüldükten sonra kafın havası yarıya indirildi ve trakeal tüp çıkarıldı.

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Bulgular: Çalışmaya toplam 68 hasta dahil edildi. Öksürük dışındaki komplikasyonlar açısından gruplar arasında istatistiksel olarak anlamlı fark yoktu.

Sonuç: Bu çalışmada en önemli bulgu öksürük dışında ekstübasyonun komplikasyonları açısından iki grup arasında istatistiksel olarak anlamlı fark olmamasıdır. Bu sonuç, temel endişenin havası tam inmemiş kaf ile larinks yaralanması olduğu düşünüldüğünde oldukça değerlidir. Çalışma grubundaki düşük öksürük insidansını, yarı sönük kaf tarafından irritan maddelerin atılımının kolaylaştırmasına ve pozitif basınçın sebep olduğu kaf proksimaline doğru olan basınç gradyanına bağladık. İndirilmemiş kaf ve pozitif basınç ile ekstübasyon sonrası laringeal yaralanma ile ilgili net veriler bulunmamakla birlikte, çalışmamıza dayanarak avantajları ve geleneksel uygulamanın potansiyel eksiklikleri göz önüne alındığında, bu tekniğin günlük pratiğe getirilmesi mantıklıdır.

Anahtar Kelimeler: Ekstübasyon, ekstübasyon komplikasyonları, pozitif havayolu basıncı

INTRODUCTION

Methods for extubation have recently gained interest because life-threatening post-extubation complications are 3 times more common than post-intubation complications.[1] In 2012, an extubation management guideline was published by the Difficult Airway Society. The importance, complications, methods, and timing of extubation were emphasized.[2] According to this guideline, it has been suggested that extubation during inspiration facilitates secretion and excretion and may reduce laryngospasm and breath-holding. Ikari and Sasaki[3] reported that extubation performed during inspiration reduces trauma and laryngospasm. The authors attributed this finding to the fact that the glottis remained open during inspiration. In the study of Andreu et al.[4], extubation immediately after giving positive pressure to the tube decreased secretion leak and aspiration. It was suggested in many studies that tracheal aspiration facilitates secretion leakage by creating negative pressure distal to the cuff.[5-8]

Besides the discussions on timing and suctioning issues about extubation, another point is deflating the cuff. The lack of evidence that the cuff should be deflated before extubation left the debate inconclusive.

The evidence base for extubation practice is limited; therefore, some recommendations on this subject are inevitably based on traditional habits and expert opinion. Because none of the claims mentioned above are based on a randomized controlled trial, we organized this randomized prospective study to provide an objective interpretation of these discussions regarding cuff deflation and extubation techniques.

In the study in which we examined the effect of a half-deflated cuff on extubation complications in patients who underwent surgery other than airway surgery in 2017, we found that breath-holding and sore throat were statistically significantly less common in the study group who were extubated with a half-deflated cuff.[9] With the knowledge that patients undergoing airway surgery have an even greater risk of complications after extubation due to secretion and blood accumulation in the airway, we conducted this study on patients who underwent airway surgery.[2-10]

The aim of this study was to reveal the results of maintaining positive airway pressure until tracheal extubation and removing the endotracheal tube (ETT) half volume deflating the cuff in patients undergoing airway surgery.

METHODS

Ethics and Selection of Participants: This study was approved by the İzmir Atatürk Training and Research Hospital Local Ethics Committee (decision no: 125, date: 16.09.2015) and performed in accordance with the ethical standards of the 1964 Declaration of Helsinki. Between September 2017 and December 2017, the patients underwent airway-related surgery (tonsillectomy, adenoidectomy, septoplasty, rhinoplasty, partial laryngectomy, larynx biopsy, vocal cord surgery, sinus surgery) under general anesthesia. The American Society of Anesthesiology (ASA) scores between 1 and3 and the age range of 18-65 years were included. Thyroid surgery and emergency surgeries, non-fasting, morbidly obese, pregnant patients, and patients with severe pulmonary disease, obstructive sleep apnea syndrome, severe cardiac failure, anemia, muscle disease, anesthetic drug allergy, and massive blood transfusion were excluded. During the specified period, 68 patients who met the inclusion criteria and agreed to participate in the study were included. Written informed consent was obtained from all patients. Patients were randomized to one of two groups using the sealed envelope technique.

Study Design: Age, gender, height, weight, body mass index (BMI), history of operation, comorbidities, history of allergy, ASA score, Mallampati score, and type of current operation were recorded.

Preoperative sedative agents were not administered. Standard monitoring (electrocardiography, non-invasive blood pressure, pulse oximetry, end-tidal CO_2) and train of four (TOF) monitorings were performed. Intravenous propofol (2-3 mg/kg), rocuronium (0.5-0.6 mg/kg), and fentanyl (1-2 mcg/kg) were administered for anesthesia induction.

The Cormack-Lehane score, size of the ETT, and number of intubation attempts were recorded. The ETT was inflated to a cuff pressure of 20-25 cmH_2O (adjusted with rosch endotest measuring device). Patients were ventilated

in a pressure-controlled mode with a tidal volume of approximately 6-8 mg/kg. The positive end-expiratory pressure was set to 5 cmH_2O. Vital findings were monitored and recorded continuously.

Sevoflurane was applied to a mixture of 50% oxygen nitrogen oxide for maintenance. At the end, the operation time was recorded. Sugammadex 2-4 mg/kg was administered to antagonize the neuromuscular agent.

The group of patients: In the control group, when the TOF ratio was >0.9, patients were extubated using the conventional method. In the study group, the pressure adjustment valve was set to 20-30 cmH_2O, and positive pressure was maintained until extubation. After measuring the cuff pressure, the cuff was half-deflated, and the tracheal tube was removed. The patient who could not breath was ventilated with a tight-fitting face mask with a Guedel airway.

Post-extubation breath-holding, laryngospasm, bronchospasm, nausea, vomiting, cough (choking), hemodynamic response to extubation (30% or more increase in heart rate and blood pressure compared to baseline), hypoxia (SpO_2 <90%), increased CO_2 in respiratory expiration gas with mask ($PetCO_2$ >40 mmHg), sore throat, and hoarseness were recorded.

Patients who were taken to the postoperative care unit were followed up until the Modified Aldrete Score arrived at 10 points, and it was recorded whether they had nausea/vomiting, hoarseness, and sore throat during the follow-up.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) software for Windows version 21.0 (SPSS Inc., Chicago, IL, USA). The normality of the distribution was analyzed using the Kolmogorov-Smirnov test. The chi-square test was used to compare categorical variables. For the descriptive statistics of the study, the mean and standard deviation for the data conforming to the normal distribution were shown using the median, 25th percentile, and 75th percentile for the data that did not comply with the normal distribution. For comparison of continuous independent variables that meet parametric assumptions, the Independent samples t-test was used to compare continuous variables, and the Mann-Whitney U test was used to compare continuous independent variables that do not meet parametric assumptions. The level of significance was set at.

RESULTS

A total of 68 patients, including 30 females (44.1%) and 38 males (55.9%), were included in the study. The mean age was 33.32 years and BMI was 23.83 kg/m^2. The mean operation duration was 100.29 min.

The general characteristics of the patients, including their age, gender, height, weight, BMI, number of intubation attempts, time of operation, history of past operation/comorbidities, ASA score, history of medication, history of allergy, Mallampati score, Cormack-Lehane classification, and size of tracheal tube, are presented in Tables 1 and 2. There was no statistically significant

Table 1. General characteristics of patients with continious variables

	Total (n=68)		Groups				
			Control (n=34)		Study (n=34)		p
	Mean±SD	Median (percentile 25-75)	Mean±SD	Median (percentile 25-75)	Mean±SD	Median (percentile 25-75)	
Age (years)	33.32±14.12	28.00 (21.00-43.50)	33.44±14.71	28.50 (21.00-46.00)	33.21±13.72	27.50 (21.00-43.00)	0.768*
Height (cm)	170.84±9.26	170.00 (165.00-176.50)	172.00±9.33	171.00 (165.00-180.00)	169.68±9.18	170.00 (164.00-175.00)	0.301*
Weight (kg)	69.88±14.20	69.50 (57.50-80.00)	70.53±12.80	70.00 (60.00-80.00)	69.24±15.64	66.50 (56.00-80.00)	0.500*
BMI	23.83±3.81	23.59 (20.75-26.78)	23.81±3.70	23.61 (21.55-26.78)	23.85±3.98	23.59 (20.43-26.78)	0.961
NIA	1.04±0.21	1.00 (1.00-1.00)	1.03±0.17	1.00 (1.00-1.00)	1.06±0.24	1.00 (1.00-1.00)	0.558*
Duration of operation (minute)	100.29±57.05	90.00 (52.50-150.00)	99.85±59.50	90.00 (55.00-150.00)	100.74±55.38	90.00 (50.00-150.00)	0.936*

*Mann-Whitney U test.
cm: Centimeter, kg: Kilogram, BMI: Body mass index, NIA: Number of intubation attempt, SD: Standard deviation

difference between the groups in terms of general characteristics.

Complications following extubation are presented in Table 3. When cough after extubation was compared, it was observed that there were more cough complications in the control group, and this difference was statistically significant (p=0.046). No bronchospasm occurred in either group. When breath-holding, laryngospasm, bronchospasm, nausea/vomiting, hemodynamic response, hypoxia, hypercapnia, throat ache, and hoarseness were compared, no statistically significant difference was found between the groups.

One patient in the study group had laryngospasm and required positive pressure ventilation with a mask (for 3 minutes) and the Larson maneuver. She did not develop any other complications following extubation. In the study group, one patient had hypoxia and one patient had hypercapnia. In the control group, no patients had laryngospasm, hypoxia, or hypercapnia.

Table 2. General characteristics of patients with cathegorical variables

		Total		Groups				p
				Control		Study		
		n	%	n	%	n	%	
Sex	Female	30	44.1	14	41.2	16	47.1	0.625
	Male	38	55.9	20	58.8	18	52.9	
History of past operation/ comorbidities	Present	40	58.8	20	58.8	20	58.8	1
	Absent	28	41.2	14	41.2	14	41.2	
ASA grade	1	24	35.3	10	29.4	14	41.2	0.31
	2	44	64.7	24	70.6	20	58.8	
History of medication	Present	58	85.3	31	91.2	27	79.4	0.171
	Absent	10	14.7	3	8.8	7	20.6	
History of allergy	Present	58	85.3	29	85.3	29	85.3	1
	Absent	10	14.7	5	14.7	5	14.7	
Mallampati score	1	51	75	26	76.5	25	73.5	0.601
	2	16	23.5	8	23.5	8	23.5	
	3	1	1.5	0	0	1	2.9	
Type of surgery	Adenoidectomy	1	1.5	1	2.9	0	0	0.325
	Adenotoncillectomy	1	1.5	1	2.9	0	0	
	Direct laryngeal biopsy	10	14.7	7	20.6	3	8.8	
	Functional endoscopic sinus surgery	12	17.6	4	11.8	8	23.5	
	Concha surgery	1	1.5	1	2.9	0	0	
	Nasal septum	39	57.4	19	55.9	20	58.8	
	Toncillectomy	4	5.9	1	2.9	3	8.8	
Cormack-Lehane classification	1	51	75	25	73.5	26	76.5	0.727
	2	14	20.6	8	23.5	6	17.6	
	3	3	4.4	1	2.9	2	5.9	
Size of tracheal tube	5	1	1.5	1	2.9	0	0	0.633
	5.5	3	4.4	2	5.9	1	2.9	
	6	5	7.4	3	8.8	2	5.9	
	6.5	1	1.5	1	2.9	0	0	
	7	10	14.7	5	14.7	5	14.7	
	7.5	22	32.4	8	23.5	14	41.2	
	8	26	38.2	14	41.2	12	35.3	

ASA: American Society of Anesthesiologists

Ten patients in both groups had breath holding. Hoarseness developed in a total of 8 patients (6 control group, 2 study group; p=0.129) and all of them were relieved before post-anethesia care unit discharge. Nausea/vomiting complications were similar in the groups (5 vs. 4, p=0.5). Hemodynamic response (7 vs. 10, p=0.401) and throat ache (10 vs. 12, p=0.604) were higher in the study group, but differences were not statistically significant.

DISCUSSION

The most important finding in this study is the lack of a statistically significant difference between the two groups in terms of complications of extubation, except cough. We believe that this is an important point for the controversy on cuff deflation and positive pressure application before extubation, as the major issue was the lack of a randomized controlled trial. In 2006, in a letter to the editor, Shamsai[11] reported his "new" technique of removing the ETT without deflating the cuff. He argued that the inflated cuff removes secretions from the upper trachea and glottis during extubation. He reported that the common problems associated with extubation and injury to the vocal cord or glottis are never seen with this technique. Naturally, the safety of the technique was questioned as it requires good evidence. Since the main topic of discussion is the concern that the half-deflated cuff may cause injury to the epiglottis and vocal cords, and it is not an easily acceptable change to completely reverse the daily practice, we wanted to conduct a stepwise experiment. Accordingly, we deflated the cuff at half the volume rather than not deflating at all.

For Shamsai's[12] method, another subject of criticism was the ability of manual control of the pilot balloon to reliably estimate cuff pressure.

Monitoring the cuff pressure before extubation ensures that the cuff does not inflate further by nitrous oxide. Thus, we have ruled out cuff pressure estimation from the pilot balloon.

In 2016, inspired by Shamsai[13], Priebe reported his modified new technique. He monitored the cuff pressure instead of manually checking the pilot balloon, and he removed the tube after applying 30-40 cm H_2O pressure to the

Table 3. Complications

		Total		Groups				p
				Control		Study		
		n	%	n	%	n	%	
Breath-holding	Absent	48	70.6	24	70.6	24	70.6	1
	Present	20	29.4	10	29.4	10	29.4	
Laryngospasm	Absent	67	98.5	34	100	33	97.1	0.5
	Present	1	1.5	0	0	1	2.9	
Bronchospasm	Absent	68	100	34	100	34	100	-
	Present	0	0	0	0	0	0	
Nausea/vomiting	Absent	59	86.8	29	85.3	30	88.2	0.5
	Present	9	13.2	5	14.7	4	11.8	
Cough	Absent	57	85.1	26	76.5	31	93.9	0.046
	Present	10	14.9	8	23.5	2	6.1	
Hemodynamic response	Absent	51	75	27	79.4	24	70.6	0.401
	Present	17	25	7	20.6	10	29.4	
Hypoxia	Absent	67	98.5	34	100	33	97.1	0.5
	Present	1	1.5	0	0	1	2.9	
Hypercapnia	Absent	67	98.5	34	100	33	97.1	0.5
	Present	1	1.5	0	0	1	2.9	
Throat ache	Absent	46	67.6	24	70.6	22	64.7	0.604
	Present	22	32.4	10	29.4	12	35.3	
Hoarseness	Absent	60	88.2	28	82.4	32	94.1	0.129
	Present	8	11.8	6	17.6	2	5.9	

airway. He claimed that none of the 2,500 patients to whom he applied this method had any problems related to extubation. Based on his impressions, this technique reduces post-extubation upper airway problems and non-upper airway-related hypoxemia.

Due to our observations, more secretions and blood were extruded with the tube in extubations made with a half-deflated cuff compared with the traditional method. Thus, the need for oropharyngeal suctioning after extubation is decreased.

Because of the lack of statistically significant differences in demographic characteristics, tube size, cuff volume, number of intubation attempts, and operation type between the two groups, the incidence of complications deriving from these factors, such as sore throat and hoarseness, is equally affected.

The second important finding of the current study is the statistically significantly low incidence of cough in the study group. Secretion and hemorrhage make extubation difficult in patients undergoing airway-related surgery, and it can be easier by the elimination of these factors. We attributed the low incidence of cough in the study group to the facilitation of excretion of these irritants by the half-deflated cuff and positive pressure. With the pressure gradient across the cuff after positive pressure, secretion, blood, and surgical debris are removed above the cuff. These findings overlap with the study of Andreu et al.[14], which reported coughing higher in number compared with the traditional method. Reducing cough during extubation is important in head and neck surgery to prevent hypertensive response and increase intracranial pressure. From another aspect, reducing cough could also reduce the transmission of some diseases via droplets or airborne routes. We think that this factor especially gained importance after the pandemic.

Although it has been stated that cough is one of the causes of laryngospasm in the studies performed, there was no statistically significant difference in laryngospasm between the two groups in our study. Contrary to the study by Kern et al.[15], hypertension and tachycardia due to coughing were more common but not statistically different between groups.

It has been reported that the application of positive pressure reduces hypoxia and accordingly laryngospasm, and even increases the glottis adductor reflex threshold by providing recruitment in the lungs.[3] In our study, hypoxia was observed in only one patient in the study group. Contrary to previous claims, no statistically significant result was obtained in terms of the frequency of hypoxia or hypercarbia in our study.

It is possible that these non-overlapping results may be more pronounced and make a difference by not deflating the cuff at all, providing increased and maintained positive pressure and positive end-expiratory pressure.

The idea that extubation without deflation of the cuff will cause laryngeal damage is generally advocated based on self-extubation complications in the intensive care unit. However, studies reporting this hypothesis have some limitations. According to the study cited by Atkins et al.[16], laryngeal trauma in 4 of 50 self-extubated patients was associated with self-extubation, whereas laryngeal trauma in 5 of 50 patients in the control group was associated with intubation.

Laryngeal injury may be a complication of intubation or may be due to many other factors in patients admitted to the intensive care unit. Therefore, these etiologic factors cannot be excluded in studies reporting that self-extubation causes laryngeal damage.[17,18]

In addition, although there was no statistically significant difference in hypoxia and hypercarbia between the groups, when the cuff is deflated, theoretically, positive airway pressure cannot be maintained until the moment of extubation, and effective lung inflation and recruitment before extubation cannot be performed.

While there is a lack of clear data on laryngeal injury following extubation with a half-deflated cuff and positive pressure and there are potential shortcomings associated with traditional practice considering its advantages based on our study, it is reasonable to introduce this technique into daily practice after conducting more randomized controlled studies.

Study Limitations

Limitations of our study include the small size of the study population, inability to strictly differentiate the origin of the complication, whether it is due to intubation or extubation, and finally, although the cuff is not fully deflated, the positive pressure may not be maintained by the half-deflated cuff.

CONCLUSION

Maintaining positive airway pressure until tracheal extubation and removing the ETT with a half-deflated cuff reduced cough complications; however, there was no difference between the conventional method in terms of other airway problems. Although this study provides a benchmark, further prospective studies with larger sample sizes are required to support the safety and advantages of this method.

Ethics

Ethics Committee Approval: This study was approved by the İzmir Atatürk Training and Research Hospital Local Ethics Committee (decision no: 125, date: 16.09.2015).

Informed Consent: Consent form was filled out by all participants.

Peer-review: Externally and internally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices - Concept - Design - Data Collection or Processing - Analysis or Interpretation - Literature Search - Writing: N.D., M.Ö.

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REFERENCES

1. Asai T, Koga K, Vaughan RS. Respiratory complications associated with tracheal intubation and extubation. Br J Anaesth. 1998;80:767-75.
2. Difficult Airway Society Extubation Guidelines Group; Popat M, Mitchell V, et al. Difficult Airway Society Guidelines for the management of tracheal extubation. Anaesthesia. 2012;67:318-40.
3. Ikari T, Sasaki CT. Glottic closure reflex: control mechanisms. Ann Otol Rhinol Laryngol. 1980;89:220-4.
4. Andreu MF, Salvati IG, Donnianni MC, Ibañez B, Cotignola M, Bezzi M. Effect of applying positive pressure with or without endotracheal suctioning during extubation: a laboratory study. Respir Care. 2014;59:1905-11.
5. Wang TP, Li HH, Lin HL. Positive Airway Pressure at Extubation Minimizes Subglottic Secretion Leak In Vitro. J Clin Med. 2022;11:307
6. Hodd J, Doyle A, Carter J, Albarran J, Young P. Increasing positive end expiratory pressure at extubation reduces subglottic secretion aspiration in a bench-top model. Nurs Crit Care. 2010;15:257-61.
7. Young PJ, Rollinson M, Downward G, Henderson S. Leakage of fluid past the tracheal tube cuff in a benchtop model. Br J Anaesth. 1997;78:557-62.
8. Dave MH, Frotzler A, Madjdpour C, Koepfer N, Weiss M. Massive aspiration past the tracheal tube cuff caused by closed tracheal suction system. J Intensive Care Med. 2011;26:326-9.
9. Extubasyon sirasında pozitif basinc uygulanmasi havayolu ile ilgili komplikasyonlari azaltir mi? Turkish anesthesiology and reanimation congress. 2017, p. 195.
10. Parotto M, Cooper RM, Behringer EC. Extubation of the Challenging or Difficult Airway. Curr Anesthesiol Rep. 2020;10:334-40.
11. Shamsai J. A new technique for removal of endotracheal tube. Anesth Analg. 2006;103:1040.
12. Wax D. Where is the evidence? Anesth Analg. 2007;105:284-5.
13. Priebe HJ. Could "safe practice" be compromising safe practice? Should anesthetists have to deflate the cuff of the endotracheal tube before extubation? Minerva Anestesiol. 2016;82:236-9.
14. Andreu MF, Dotta ME, Bezzi MG, et al. Safety of Positive Pressure Extubation Technique. Respir Care. 2019;64:899-907.
15. Kern MJ, Gudipati C, Tatineni S, Aguirre F, Serota H, Deligonul U. Effect of abruptly increased intrathoracic pressure on coronary blood flow velocity in patients. Am Heart J. 1990;119:863-70.
16. Atkins PM, Mion LC, Mendelson W, Palmer RM, Slomka J, Franko T. Characteristics and outcomes of patients who self-extubate from ventilatory support: a case-control study. Chest. 1997;112:1317-23.
17. Cohn JE, Touati A, Lentner M, Weitzel M, Fisher C, Sataloff RT. Self-extubation Laryngeal Injuries at an Academic Tertiary Care Center: A Retrospective Pilot Study. Ann Otol Rhinol Laryngol. 2017;126:555-60.
18. Tong BCK. HHS public Access. Physiol. Behav. 2017;176:139-48.