Post-Extubation Laryngoscopic Findings in Intensive Care Unit Patients

Original Article

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ABSTRACT

Background: While endotracheal intubation is lifesaving, it carries different risks and potential complications, especially the laryngeal ones. This study aimed to detect the laryngeal findings immediately after extubation in ICU patients and their risk factors.

Patients and Methods: This study was an observational cross-sectional study. 48 ICU extubated patients were examined, their ages ranged from 24:78 years. History taking and laryngeal examination were done for all participants using rigid laryngoscopy at inpatient wards immediately after discharge from the ICU.

Results: Dysphonia was the most common complaint (75%), and stridor was the least one (8.3%). Edema was the most prominent finding (75%). The least findings were stenosis, ulcer, hematoma, and dislocated arytenoid; each was found in (6.25%) of patients. During the short intubation period (1- 3 days): edema and erythema were only found and only one ulcer case was found. Edema increased from 6 cases in (1- 3 days of intubation) to 13 cases in (7- 9 days of intubation) and also 13 cases in (10- 12 days of intubation); granuloma appeared only when the change from short-term intubation to prolonged intubation. There was no specific duration for dislocated arytenoid, hematoma, or ulcers to appear. Immobility of vocal folds appeared after the 7th day of intubation; no stenosis cases were detected before the 10th day of intubation.

Conclusion: The laryngeal examination post-extubation is recommended for early detection of the laryngeal lesions to address and prevent further deterioration promptly.

Key Words: Intubation, larynx, post-extubation, prolonged intubation, short intubation.

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INTRODUCTION

Up to 20 million patients are intubated annually in intensive care units (ICU) around the world[1]. In ICU, respiratory support is often provided to patients who are having difficulty breathing or who require assistance with their breathing. The levels of respiratory support can range from less invasive methods, such as oxygen masks or nasal cannulas, to more invasive methods such as mechanical ventilation. For patients who require more intensive respiratory support, mechanical ventilation may be necessary to deliver air to the patient's lungs through an endotracheal tube or the tracheostomy tube. One of the main reasons for endotracheal intubation is to address hypoxia, hypercarbia, and the changes in acid-base balance, particularly respiratory acidosis[2].

Generally, intubation is needed in ICU patients after complicated surgeries and patients complaining of respiratory, cardiac, or any organ dysfunction. According to the Advanced Trauma Life Support (ATLS) guidelines, endotracheal intubation is indicated in patients with a Glasgow Coma Scale score of 8 or less who are unable to maintain their airways or protect their lungs. The endotracheal intubation may also be necessary in patients who require airway protection due to facial trauma, burns, or other injuries[3].

While endotracheal intubation is a life-saving and routine procedure, it is not riskless. It may cause injury to the larynx and other complications such as infection and damage to the teeth or gums, upper airway obstruction, laryngospasm, laryngeal injury, coughing, sore throat, dysphonia, and fluid leakage at the tracheal seal. Additionally, in rare cases, endotracheal intubation can cause severe complications such as cardiac arrest or brain injury. Laryngotracheal injury is a potential complication of endotracheal intubation and can be caused by a variety of factors; one of these factors is the duration of intubation. Prolonged intubation can cause irritation and trauma to

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the larynx and trachea, increasing the risk of injury. It is important to note that the specific duration for defining prolonged intubation may vary in different studies[4]. Prolonged intubation is defined differently in the research, ranging from over 24 hours to over 48 hours; other studies stated more than three days of intubation. The duration of prolonged intubation is associated with an increased risk of complications. The use of cuffed endotracheal tubes is another factor that can contribute to laryngotracheal injury. While cuffed tubes can prevent air leaks and improve ventilation, they can also increase the risk of pressure-related injury to the larynx and trachea, especially if the cuff pressure is not properly monitored[5].

Previous studies stated that high cuff pressure can cause tracheal erosions. This pressure refers to the pressure exerted by an inflatable cuff at the distal end of the endotracheal tube. When the cuff pressure is too high, it can cause irritation, trauma, and erosion of the tracheal mucosa. This can lead to a range of complications, including bleeding, infection, and tracheal stenosis[6]. Another study recommended that cuff pressure should be kept as low as possible to seal the airway, protect against aspiration, and prevent post-intubation airway stenosis. They suggested that cuff pressure should be monitored regularly and adjusted as needed to maintain an adequate seal while minimizing the risk of complications[7]. The size of the endotracheal tube can also contribute to the risk of laryngotracheal injury. The tubes that are too large can cause trauma and irritation to the airway, while the tubes that are too small can cause difficulty with ventilation[8-10]. In adults, the size of the endotracheal tube is typically selected based on the patient's sex and height. A size 7 tube is commonly used for women, while a size 8 tube is commonly used for men. However, this may vary depending on the individual patient's anatomy and the indication for intubation. For example, patients with larger necks or wider airways may require a larger tube. In some cases, bronchoscopy may be necessary during intubation, which may require the use of a larger tube. In these cases, the tube size may need to be increased by 0.5 for both men and women[11]. Overall, the selection of the appropriate endotracheal tube size is an important consideration in ensuring safe and effective intubation. Healthcare providers must carefully assess the individual patient's anatomy and other factors to ensure that the appropriate tube size is selected and monitor the patient closely for any complications that may arise. Emergency intubations carry a higher risk of injury compared to elective intubations, especially if a neuromuscular blocking agent is not used. The urgency of the situation may lead to suboptimal intubation conditions and potentially increase the risk of trauma to the airway structures. The skill level and experience of the operator performing the intubation are important factors that can impact the injury rates. Experienced operators who are proficient in intubation techniques are generally associated with lower complication rates. Additionally, the quality of intubation conditions, such as limited mouth opening, poor visualization, or difficult airway characteristics, can increase the risk of injury[12]. In addition, intubation can result in early, late, or even very late laryngeal complications. Early complications can include laryngeal edema, vocal fold palsy or paresis, desensitization of the laryngopharynx, aspiration or aspiration pneumonia, dysphagia, impaired saliva secretion management and airway protection, intubation granuloma, vocal folds ulceration, erythema, polyp, vocal folds atrophy or bowing, and temporary dysphonia. The late complications can include vocal folds palsy or paresis, arytenoid cartilaginous trauma such as fixation, subluxation, or dislocation, persistent laryngeal edema, dysphagia, vocal folds atrophy, anterior glottic web, impaired saliva secretion management and airway protection, aspiration, and prolonged dysphonia. Very late complications can include glottic or subglottic stenosis, and laryngeal or tracheomalacia[13].

A previous study classified the laryngeal findings post-extubation into 3 stages: normal; mild changes that include edema, hyperemia, and non-obstructive laryngomalacia; moderate or severe that includes laryngeal immobility, obstructive laryngomalacia, posterior glottic ulceration and granulation, subglottic ulceration, and granulation[14].

Another research classified the laryngeal lesions into 3 stages: mild alterations included hyperemia, edema, vocal fold hemorrhage, and non-obstructive laryngomalacia; moderate alterations included obstructive laryngomalacia, unilateral or bilateral glottal ulceration, arytenoid granulation, and partial subglottic ulceration; and severe alterations included vocal fold immobility, inter-arytenoid ulceration, inter-arytenoid granulation, total subglottic ulceration, and subglottic granulation[15].

This study aimed to detect the laryngeal finding that exists immediately after extubation in ICU patients and their risk factors.

PATIENTS AND METHODS:

This study was an observational cross-sectional study; after the ethical committee approval from The Institutional Review Board of Armed Forces College of Medicine (53 meetings, 11-2-2023), the participants were examined using rigid laryngoscopy at inpatient wards immediately after discharge from the ICU of Kobry El-kobba Military Medical Complex and Ain Shams university hospitals. 48 ICU extubated patients were examined, their ages ranged from 24:78 years; the study started in March 2023 and lasted for 6 months after the verbal consent from all patients.

Inclusion and exclusion criteria:

Inclusion criteria included: patients discharged from the ICU immediately after extubation, regardless they have voice complaints or not.

Exclusion criteria included: patients who complained of voice disorders before ICU admission and Intubation, patients with laryngeal malignancy who received radiotherapy or chemotherapy, patients in coma, and patients on tracheostomy following extubation.

The consecutive sample was taken from the extubated patients, and picked from the patients immediately discharged from the ICU to accomplish purposive sampling.

Methods:

The protocol of voice assessment[16] was applied:

History taking (either by patients' interview, doctor interview, or from patients' files) and examination as follows:

Personal history, and complaint, history included: diabetes mellitus, hypertension, GERD, rheumatoid arthritis, peptic ulcer, asthma, tuberculosis, smoking, alcohol drinking, other special habits of medical importance, radiotherapy, chemotherapy, previous surgeries especially laryngeal ones, previous ICU admission, previous intubation, previous tracheostomy, and neurological diseases.

The present history included: ICU admission cause, intubation type, intubation duration, tubal size, easy intubation, intubation trauma, steroid usage, and mechanical ventilation duration.

The laryngeal assessment

Rigid laryngoscopy was done to all the included patients, the larynx was inspected including the base of the tongue, vallecula, epiglottis, pyriform sinuses, arytenoids, false and true vocal folds, and the subglottis. The laryngeal assessment was done during phonation and respiration.

The post-extubation patients' complaints and laryngeal findings were distributed into 4 stages according to the intubation period, a short-term intubation stage (1- 3 days) and 3 prolonged intubation stages, each one was 3 days: (4- 6 days), (7- 9 days) and finally (10- 12 days).

In this study, post-extubation stenosis was graded according to Stauffer J L *et al*. 1981, who described and classified it into three groups according to degree of stenosis (11-25%, 26-50%, and > 50%). Subglottic stenosis is defined as narrowing just below the vocal folds, in the lowest part of the larynx and immediately above the first tracheal ring, but the cuff site is located below the sub-glottic area; it is related to tracheal rings[17].

Also, the clinical grading of acute changes seen in the larynx and trachea after extubation was graded according to Thomas R *et al*. 1995, who stated that grade zero means no changes; grade one includes the presence of erythema and edema; grade two includes slough; grade three includes glottic and sub-glottic narrowing; and grade four includes vocal fold paralysis[18].

Sample size calculation:

G POWER version 3.1 for Windows 10 was used. Using test family proportion difference from constant (binomial distribution, one sample case), we hypothesized a small effect size (0.255), an alpha error (0.05), a power (95%), and a constant proportion (50%), it was found that the sample size was 48 cases admitted to the ICU on MV collected during the period from March 2023 to September 2023[19].

Statistical Analysis:

Statistical analysis was done to determine the prevalence of laryngocopic findings after extubation of ICU patients and establish some relation between intubation and laryngoscopic findings. Data management and analysis of pre-coded data were done using the statistical package of the social science software program, version 26 (SPSS) to be statistically analyzed. Data was summarized using mean, SD, median, and IQR for quantitative variables and number and percent for qualitative variables. Mann Whitney U test and Fisher exact test were used for significance correlation assessment. Fisher's exact test is a statistical significance test used in the analysis of contingency tables, this type of table in a matrix format displays the multivariate frequency distribution of the variables.

RESULTS:

This study included 48 ICU patients (31 males and 17 females) with an age range of 24:78 years, they were examined by rigid laryngoscope immediately post-extubation after a detailed history. The type of intubation was only orotracheal (100%), the intubation attempts mean was (1.65) ranging from 1 to 5 trials the intubation duration median was 8 days, and the mean (6.77) days ranged from 1:12 days.

Table 1: The patients' complaints post extubation.

Patients' complaint	Number of patients (Total =48)	Percentage
Dysphonia	36	75%
Sore throat	19	39.6%
Cough	13	27.1%
Throat clearing	10	20.8%
Sputum production	13	27.1%
Stridor	4	8.3%
Hemoptysis	5	10.4%
Dyspnea	10	20.8%
Dysphagia	32	66.2%
Free of symptoms	6	12.5%

Table (1) shows the patients' complaints post-extubation presented in number and percentage, 36 (75%) patients reported dysphonia, and it was the commonest complaint, followed by 32 (66.2%) patients reported dysphagia. Only 4 (8.3%) patients reported stridor and it was the least complaint.

Table 2: The laryngoscopic findings post extubation.

Laryngoscopic findings	Number of patients (Total =48)	Percentage
Edema	36	75%
Vocal folds mobility disorder	30	62.5%
Intubation granuloma	6	12.5%
Erythema	19	39.6%
Mucosal trauma	6	12.5%
Stenosis	3	6.25%
Ulcer	3	6.25%
Hematoma	3	6.25%
Dislocated arytenoid	3	6.25%

Table (2) shows the laryngoscopic findings post extubation presented in number and percentage, edema was found in 36 (75%) patients and it was the most prominent finding. The least findings were stenosis, ulcer, hematoma, and dislocated arytenoid; each one was found in 3 (6.25%) patients.

In this study: 10 cases were intubated for 1-3 days; 6 cases were intubated for 4- 6 days; 16 cases were intubated for 7- 9 days; and 16 cases were intubated for 10- 12 days.

Table 3: Post-extubation patients' complaints were divided into 4 stages according to different intubation periods.

Patients' complaint	Short term	Prolonged intubation		
	1-3 days	4-6 days	7-9 days	10-12days
	10 cases	6 cases	16 cases	16 cases
Dysphonia	2	5	15	14
Sore throat	4	2	6	7
Cough	1	2	3	7
Throat clearing	1	2	2	5
Sputum production	1	2	3	7
Stridor	-	-	1	3
Hemoptysis	-	-	2	3
Dyspnea	1	-	3	6
Dysphagia	-	4	13	15
Symptomless	6	-	-	-

Table (3) shows that most of the patients intubated for 1- 3 days were symptomless (6 patients). Dysphonia started early and increased after the 7th day of intubation. Most patients started complaining on the 4th day and increased after the 7th day of the intubation. Stridor and hemoptysis appeared after the 7th day of the intubation. Dysphagia appeared on the 4th day and increased after the 7th day of the intubation. Symptoms like sore throat, cough, and throat clearing had no special time to appear.

Table 4: Post-extubation laryngoscopic findings were divided into 4 stages according to different intubation periods.

Laryngoscopic findings	Short term	Prolonged intubation		
	1-3 days	4-6 days	7-9 days	10-12days
	10 cases	6 cases	16 cases	16 cases
Edema	6	4	13	13
Mobility disorder	-	4	12	14
Intubation granuloma	-	1	2	3
Erythema	3	2	6	8
Mucosal trauma	-	2	1	3
Stenosis	-	-	-	3
Ulcer	1	2	-	-
Hematoma	-	-	1	2
Dislocated arytenoid	-	1	1	1

Table (4) shows that during the short intubation period (1- 3 days): edema and erythema were only found and only one ulcer case was found, edema increased from 6 cases in (1-3 days) to 13 cases in (7- 9 days) and in (10- 12 days), granuloma appeared only when change from short term intubation to prolonged intubation. There was no specific duration for dislocated arytenoid, hematoma, or ulcers to appear; most cases of abnormal movement of vocal folds started after the 7th day of intubation, and no stenosis cases were detected before the 10th day of intubation.

Regarding mobility: 24 (50%) patients suffered from impaired mobility, 6 (12.5%) patients had immobility, and 18 (37.5%) patients had freely mobile vocal folds.

Regarding edema: 36 (75%) patients suffered from edema, 30 (83.3%) patients had arytenoidal edema which was considered the commonest site, 14 (38.9%) patients had vocal fold edema, 10 (27.8%) patients had ventricular edema, 8 (22.2%) patients of them had subglottic edema, 7 (19.4%) patients of them had epiglottic edema and it was considered the least site.

Regarding erythema: 19 (39.5%) patients suffered from erythema, 18 (94.7%) patients had arytenoidal edema, and it was considered the commonest site, 6 (31.6 %) patients had vocal fold edema, 5 (26.3%) patients of them had ventricular edema, 4 (21.1%) patients of them had subglottic edema, 3 (15.8 %) patients of them had epiglottic edema and it was considered the least site.

N.B: The total number of separate lesions (edema and erythema) exceeded the total number of cases as one patient might have more than one lesion either in the same anatomical site or in another one.

Regarding granuloma: 6 (12.5%) patients had intubation granuloma, 5 (83.7%) patients of them had arytenoidal granuloma, and 1 (16.7%) patient of them had subglottic granuloma.

Regarding hematoma: 3 (6.25 %) patients had laryngeal hematoma, 1 (33.3%) patient had vocal fold hematoma, 1 (33.3%) patient had arytenoidal hematoma, and 1 (33.3%) patient had subglottic hematoma.

Regarding stenosis: it was classified according to Stauffer J L *et al*.1981 (17). 3 (6.25%) patients had stenosis. According to the degree of stenosis: 2 of them were graded as 11-25%, and 1 patient was graded as 26-50%. According to the site of stenosis: 2 patients had subglottic stenosis and 1 patient had cuff site stenosis.

Table 5: The clinical grading of acute changes in the larynx and trachea after extubation.

Clinical Grading	No of patients (Total =48)	Percentage
Grade zero	3	6.25%
Grade one	8	16.6%
Grade two	6	12.5%
Grade three	1	2.1%
Grade 4	30	62.5%

The clinical grading of acute changes in the larynx and trachea after extubation was graded according to Thomas R. *et al*. 1995 (18). In this study: 3 (6.25%) patients were graded zero; 8 (16.6 %) patients were graded one; 6 (12.5%) patients were graded two; and 1 (2.1%) patient was graded three.

Table 6: The correlation between intubation duration and patients' complaints using Mann Whitney U test.

Patients' complaint	Mann-Whitney U test	Asymptomatic significance (2-sided test)
Dysphonia	354.000	.001*
Sore throat	294.500	.684
Cough	297.000	.102
Throat clearing	226.500	.360
Sputum production	297.000	.102
Stridor	143.000	.039
Hemoptysis	174.000	.022*
Dyspnea	253.500	.108
Dysphagia	458.500	.000*
No symptoms	25.000	.001*

(*) means a significant correlation. Significance level ≤ *0.05*.

Table (6) shows a significant correlation between intubation duration and some patients' complaints like dysphonia, stridor, hemoptysis, dysphagia, and no symptoms.

Table 7: The correlation between intubation duration and laryngoscopic findings post-extubation using the Mann-Whitney U test.

Laryngoscopic findings	Mann-Whitney U test	significance (2-sided test)
Edema	275.500	.150
Vocal folds mobility disorder	455.000	.000*
Intubation granuloma	140.000	.681
Erythema	347.000	.126
Mucosal trauma	160.000	.305
Stenosis	119.500	.020*
Ulcer	32.000	.143
Hematoma	108.000	.091
Dislocated arytenoid	65.500	.936

(*) means a significant correlation. Significance level ≤ *0.05*.

Table (7) shows a significant correlation between intubation duration and vocal fold mobility disorder and stenosis.

Fisher exact test (2-sided test) revealed a significant correlation between tube size change from 7.5 to 8 and vocal fold mobility disorder in male cases, also revealed a significant correlation between tube size change from 7.5 to 8 and dysphagia in male cases, and a significant correlation between tube size change from 7 to 7.5 and vocal fold mobility disorder in female cases.

DISCUSSION

Endotracheal intubation is the most common invasive procedure carried out for critically ill patients admitted to ICU[3]. It is commonly associated with varying degrees of changes to the laryngotracheal mucosa ranging from edema, erythema, and necrosis to slough formation. These changes may proceed to eventual laryngotracheal stenosis or abnormal vocal fold mobility[20].

In this study, the type of intubation was only orotracheal, and the intubation attempts mean was 1.65 ranging from 1-5 trials, previous studies stated that orotracheal type was the dominant type of intubation by 97.9%, nasotracheal type represents 2.2% and the intubation attempts ranged from 1- 4 times with a mean of 1.3[21]. The difference in the intubation attempts may be attributed to different emergencies in which, the more intubation attempts the more susceptibility to laryngeal injury.

In this study, the patients' most common complaint was dysphonia (75%), followed by dysphagia (66.2%), stridor was the least common at 8.3%, and 12.5% of patients had no complaint. The same results were reported by Megarbane Bruno *et al*. 2010 who stated that within 24 hours following extubation, persistent dysphonia, dysphagia, and pharyngeal pain were the main symptoms and were significantly associated with laryngeal injury[22], also Hernández-García *et al*. 2023 mentioned that the main post-extubation symptoms were dysphonia, dyspnea, and dysphagia in 87.8%, 34.7%, and 42.9%, respectively[21]; Stauffer J L *et al*. 1981 stated that 71% of the cases complained of dysphonia[17], moreover Saeg Ali and Haitham Alnori 2021 mentioned that 75% of patients who underwent intubation complained mainly of dysphonia and throat discomfort[20].

The presence of dysphonia could be attributed to mucosal edema and/or congestion which may be relieved within a few weeks by medical treatment and voice rest, also the presence of dysphagia following extubation may contribute to malnutrition, pneumonia, and decreased quality of life with a high risk of mortality. The development of dysphagia among such a group of survivors may be secondary to neuromuscular incoordination or sometimes sensory affection following prolonged intubation.

It was found that most patients intubated shortly were symptomless, on the other hand, patients complained of dysphonia started early and increased after the 7th day of intubation. Injury to vocal fold mucosa was common; Wallace S and B A McGrath 2021 reported that laryngeal trauma was responsible for dysphonia following intubation[13]. Recurrent laryngeal nerve injury was also reported by many studies as overinflation in the subglottis region can do compression between the cuff and the thyroid cartilage. However, this complication can be prevented by choosing the proper size of the tube and the right positioning of the cuff.

In this study, 62.5% of patients had vocal fold mobility disorder. The range of vocal fold immobility is very wide ranging from 0.5% to 79.6%; Saeg Ali and Haitham Alnori 2021 stated that only one case (0.5%) had vocal fold paralysis[20]; Campbell *et al*. stated that 7% of cases had mobility disorder[23]; Colton *et al*. 2011 stated that 41% of previously intubated patients had vocal fold immobility[24].Boggiano *et al*. 2022 stated that 75% of cases had mobility disorders[25]; Hernández-García *et al*. 2023 mentioned that 79.6% of cases had mobility disorder[21]. A previous study mentioned that the duration of intubation, the size of the endotracheal tube, and the type of endotracheal tube did not significantly affect the degree of laryngeal injury[24]. Generally, the causes of vocal fold immobility disorder may include myopathy, myositis of the intrinsic laryngeal muscles, or arytenoid dislocation and commonly leads to dysphonia, pharyngeal dysphagia, or even stridor in case of vocal fold immobility with limited respiratory chink.

The intubation granuloma resulted from prolonged intubation; in addition, it may be seen following short-term intubation. Many factors contribute to granuloma formation. In this study, intubation granuloma was found in 6 patients (12.5%), this result matched with previous studies which stated that granuloma incidence was 12.2%[21] and 19%[25]. The formed granulomas are typically found in the posterior glottis on the medial aspect of the arytenoids. Their size fortunately not cause airway obstructions, the excessive cuff pressure and injury cause laryngeal irritation and granulation tissue formation, and hence the granuloma appears.

In this study, the erythema incidence was 39.6%, the mucosal trauma incidence was 12.5%, the ulcer incidence was 6.25%, the hematoma incidence was 6.25%, the dislocated arytenoid incidence was 6.25% and the stenosis incidence was 6.25%. This study shows fortunately 0 % of cases had glottic stenosis and only 6.25 % had subglottic stenosis probably secondary to scar formation. This scaring may be in the form of fibrosis between the two vocal processes. The ulceration may result again in scarring and adhesions and subsequently breathing difficulty and airway problems. Also, 2 cases were found to have 11:25% stenosis, 1 case was found to have 26:50% stenosis, and no cases were more than 50% stenosis, also 2 cases had stenosis in the subglottic area and one

case had the stenosis in cuff site, these results matched with a previous study that found 3 patients had 11-25% stenosis, 2 patients had 26-50% stenosis and no patients had >50% stenosis[18].

Previously, Mehel *et al*. 2020 examined 40 patients studying their glottic and subglottic injuries and found that 22.5% of patients were graded one that included vocal fold edema, granulation tissue on the arytenoid, posterior glottis ulceration and granulation tissue in the subglottic area; 40 % were graded two that included arytenoid ulceration, ulceration and granulation at interarytenoid region; 37.5% were graded three that included circumferential granulation at glottic level and synechia in anterior part of vocal folds, deep ulceration at interarytenoid region, and circumferential ulcerated granulation tissue[12].

The previous studies declared that more than 3 days of intubation is considered prolonged intubation[26]. In this study, the intubation period was divided into short-term intubation and prolonged intubation, and we added a further classification, the prolonged intubation was divided into three stages: 4-6 days, 7-9 days, and 10-12 days. During the short intubation period (1-3 days): edema and erythema were only found and only one ulcer case was found, and the results were reasonable as this period is considered a short time intubation. Edema increased from 6 cases in 1:3 days to 13 cases in 7-9 days and 13 cases in 10-12 days, so these stages enabled us not only to distinguish laryngeal findings between short-term and prolonged intubation but also to detect the precise duration that causes each laryngeal lesion in the prolonged intubation.

The granuloma appeared only when changed from short-term intubation to prolonged intubation. There was no specific duration for dislocated arytenoid, hematoma, or ulcers to appear, as it may be due to intubation by less experienced healthcare personnel in emergencies.

In this study, abnormal movement of vocal folds increased after the 7th day of intubation. No stenosis was detected before the 10th day of intubation; it means that stenosis is commonly associated with prolonged intubation for more than 10 days.

In this study, mobility disorder was divided into impaired mobility 80% and immobility 20%; however, previous research declared that 11.75% suffered from impaired movement of the vocal folds and 88.3% suffered from complete fixation[27]. Either in case of vocal fold paresis or paralysis, patients may benefit from voice therapy which may last for 12 sessions. In this study, the mucosal edema and the erythema were found in most laryngeal parts, and the most common site was the arytenoids, the granuloma was mostly found on the vocal folds. Boggiano S. *et al*. 2022 stated that the most common pathologies were edema (75%); abnormal movement (75%); atypical lesions (69%); and erythema (38%)[25]. The laryngeal edema particularly the vocal fold edema is considered a common complication following intubation that directly results from the pressure and the inflammatory reaction triggered by the tube contact. In this study, although edema is reported in 75 % of the extubated patients, 12.5% of patients were asymptomatic, and it may be the cause of breathing difficulty and struggle. If edema persists and is severe, it may be the cause of stridor that may lead to re-intubation. This should be dealt with cautiously to avoid the increased risk of mortality.

Regarding the clinical grading of acute changes in the larynx and trachea after extubation, most patients were graded 4, which went against the previous study whose most cases were graded 2[17], the difference in this grading may be due to the different intubation periods between studies.

Generally, Saeg Ali and Haitham Alnori 2021 stated that five patients (2.5%) had intubation-related laryngeal injuries: left vocal fold mobility in 1 case, left arytenoid dislocation in 1 case, and right posterior third granuloma in 1 case, 1 patient had unilateral left fold hematoma, and 1 patient had bilateral vocal fold erythema and edema[20]. But in this study, 75% of cases had laryngeal injuries. The difference may be due to the intubation duration, the position of the patient, the difficulty of intubation, the presence of an emergency, the general condition of the patients, and the skills of the physicians.

Mann Whitney U test revealed that there was a significant correlation between intubation duration and many complaints like dysphonia, stridor, hemoptysis, dysphagia, and no symptoms. Also, there was no significant correlation between intubation duration and some complaints like sore throat, cough, throat clearing, sputum production, and dyspnea.

In addition, the Mann-Whitney U test added that there was a significant correlation between intubation duration and some laryngoscopic findings like vocal fold mobility disorder and stenosis. Also, there was no significant correlation between intubation duration and some laryngoscopic findings like edema, intubation granuloma, erythema dislocated arytenoid, hematoma, mucosal trauma, and ulcers.

Although edema shows no significant correlation with intubation duration as it started from the first day of intubation, prolonged intubation can lead to increased trauma and inflammation in the airway, potentially causing more severe edema upon

extubation. The administration of methylprednisolone as a pre-treatment has shown potential in reducing the risk of post-extubation laryngeal edema[28].

Fisher exact test revealed a significant correlation between tube size change from 7.5 to 8 and the vocal fold mobility disorder in male cases, a significant correlation between tube size change from 7 to 7.5 and the vocal folds mobility disorder in female cases, also there was a significant correlation between the tube size change from 7.5 to 8 and the dysphagia in male cases, these results matched with Santos P M *et al*. 1994 who stated that increasing size of an endotracheal tube from 7.5 to 8 was a significant risk factor for vocal fold erythema, ulceration, and immobility of vocal folds[25], also Fan Tao *et al*. 2008 and Wittekamp Bastiaan *et al*. 2009 stated that tube size is indeed recognized a risk factor for post-extubation laryngeal edema[29-30]. However, Colton House, Joyce, *et al*. 2011 stated that neither the duration of intubation, the size of the endotracheal tube, nor the kind of endotracheal tube had a significant impact on the severity of laryngeal damage, also none of the collected demographic information age, gender, height nor weight significantly affected the degree of laryngeal injury[24].

Finally, the selection of an appropriate tube size is crucial to minimize this risk. It is generally recommended to use a 7- or 7.5-mm tube for males and a 6.5-mm tube for females to reduce the incidence of laryngeal complications. However, it is important to consider the potential drawbacks of using smaller-diameter tubes. Using smaller tubes may result in a weaning delay from the mechanical ventilation, as the narrower diameter can increase airway resistance and make it more difficult for patients to breathe spontaneously. Additionally, smaller tubes may impede certain bronchoscopic procedures that require larger instruments to be passed through the endotracheal tube[29-30].

CONCLUSION AND RECOMMENDATIONS

Post-extubation laryngoscopic examination is recommended for early detection of the laryngeal lesions. In this study, the presence of endotracheal tubes causes various degrees of laryngeal injury ranging from mild to severe lesions depending mainly on intubation duration, tube size, and comorbidities, these lesions -arranged from most to least prominent- edema, abnormal movement, erythema, granuloma, mucosal trauma, ulcer, hematoma, stenosis, dislocated arytenoid.

Endotracheal tubes also cause some post-extubation complaints -arranged from most to least prominent- like dysphonia, dysphagia, sore throat, cough, sputum production, dyspnea, throat clearing, hemoptysis, and stridor.

Although the duration of intubation is life-saving and the size of the tube gives better weaning strategies, it is recommended to take into consideration the laryngeal injuries, especially irreversible ones.

CONFLICT OF INTEREST

There are no conflicts of interest.

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