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**Original Research Article**

# A clinical study on laryngotracheal injuries following endotracheal intubation

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## ABSTRACT

**Background:** Despite major advances in the design of endotracheal tubes and developments in the management of difficult airways, endotracheal intubation remains by far the most common cause of laryngotracheal injuries (LTI). These LTI are challenging to manage and are associated with significant morbidity and mortality. Hence, the present study was done to find out the incidence, types of LTI and to study the factors affecting the same.
**Methods:** A prospective study was conducted on patients who were intubated for more than 48 hours and admitted in medical intensive care units in a tertiary referral hospital, for a period of 1 year. All patients following extubation were evaluated for LTI by x-ray neck (antero-posterior and lateral view), rigid endoscopy and flexible naso-pharyngo-laryngoscopy.
**Results:** Thirty patients were included in the study. Majority of the patients (56.6%) were found normal while 43.2% patients were having LTI following extubation in the form of bilateral vocal cord fixation, subglottic stenosis, granulation tissue in the posterior commissure and in the trachea. Majority of these patients were aged less than 45 years, with duration of intubation for more than 10 days, with tube size more than 7 mm. Organo-phosphourous (OP) poisoning was the etiology for LTI in 69.2% cases.
**Conclusions:** A high incidence of LTI especially in cases of OP poisoning warrants one to be cautious in managing these intubated patients. Those patients requiring prolonged intubation should be considered for other alternative airway managements like tracheostomy in addition to using low pressure, high volume cuffed tubes. Adequate training of the emergency personnel in the intubation technique and its subsequent care is important especially in a tertiary referral center.

**Keywords:** Endotracheal intubation, Flexible naso-pharyngo-laryngoscopy, Laryngotracheal injuries

## INTRODUCTION

Endotracheal intubation is the optimum method for protecting the patency of the airway and maintaining oxygenation and ventilation in patients requiring advanced life support.[1,2] While the indications for intubation are varied, it is commonly used for ventilatory assistance, relief of upper airway obstruction and to aid in tracheobronchial toileting.[3,4] Although a lifesaving procedure yet can result in serious sequelae which can lead to a significant morbidity and mortality.[5]

Despite major advances in the design of endotracheal tubes and developments in the management of difficult airways, endotracheal intubation remains by far the most common cause of laryngeal trauma. Approximately 10% of patients have demonstrable laryngeal pathologies even a day after intubation for surgery.[6] With longer term

intubation and mechanical ventilation for critical illness, the incidence of LTI approaches 90%, with long-term sequelae occurring in 11% of patients.[7] The incidence of postintubation laryngotracheal stenosis that requires surgical correction is 1 in 204,000 adults and 4.9 in 100,000 in children per year.[8-10]

With the advent of high-volume low pressure cuffed tubes, patient can be ventilated through the endotracheal tube for up to 3 weeks.[3,11] The presence of endotracheal tube in direct contact with larynx and trachea can provoke injuries to its mucosa and submucosal layer which in turn can lead to ulcerations, granulation tissue and stenosis.[12] These injuries may be temporary in the beginning which can become a permanent sequelae later.[5]

LTI after prolonged intubations have varied incidence rates in the literature. The incidence of laryngeal stenosis after prolonged or repeated intubation range from 0.9-8% for both adults and children.[13] The incidence of arytenoid dislocation following intubation has been reported to be 0.023-0.1%.[14,15] Though the patients recover from the primary disease for which they were intubated, they may develop the problems due to intubation which are challenging to manage for an otolaryngologist. The primary complaints post intubation may be a voice change or difficulty in breathing of varying severity.

Majority of the intubating residents may not be aware of the consequences of intubation sequelae and they may be in different levels of training. In the last decade, there have been a significant number of cases of ventilator related recoveries due to the standardized management protocols followed in intensive-care-unit (ICU). In spite of all this, still one can land up with an unrelated complication (LTI) not related to the primary disease for which they were ventilated.

Hence, the study was undertaken to know the incidence of LTI, spectrum of the disease and the factors contributing to the same.

## METHODS

This prospective study was conducted on patients intubated for more than 48 hours and admitted in medical ICU at a tertiary referral care hospital in North Karnataka for a period of one year from January-December 2017.

### *Inclusion criteria*

All patients aged more than 14 years intubated for more than 48 hours were included in the study.

### *Exclusion criteria*

Patients with associated comorbidities which hamper examination, those taken for elective surgical procedures, pediatric age of less than 14 years which are admitted in pediatric ICU and those who underwent tracheostomy were excluded from the study.

History was taken from reliable patient attenders regarding the need for intubation and duration of intubation, medical history to rule out associated co-morbid conditions like chronic- obstructive-pulmonary-disease, bronchial asthma, pulmonary tuberculosis, or any pulmonary disease compromising the ventilation.

The objectives of the study were to find the incidence, types of injury and to study the factors influencing LTI following intubation. The pressure of the cuff used in the endotracheal tube was 20 cm of water. All patients were evaluated for LTI based on the x-ray neck-anteroposterior and lateral view, 70-degree rigid endoscopy and flexible naso-pharyngo-laryngoscopy (NPL) 15 days following extubation.

Informed consent was taken prior to the study and ethics committee clearance was obtained from the Institutional ethics committee.

## RESULTS

A total of 30 patients (Table 1) were inducted into the study of which 19 were males and 11 were females with age ranging from 15 to 70 years. Majority of patients (63.3%) were between 15-29 years. Endotracheal tube of size 7.5 and 8 were used in 83.3% of patients.

**Table 1: Characteristics and distribution pattern of patients with laryngotracheal injuries.**

| Demographics | | N (%) |
|---|---|---|
| **Age (years)** | 15-29 | 19 (63.3) |
| | 30-44 | 7 (23.3) |
| | >45 | 4 (13.3) |
| **Gender** | Male | 19 (63.3) |
| | Female | 11 (36.6) |
| **Endotracheal tube dimension** | | |
| **Size of tube (mm)** | 7 | 5 (16.6) |
| | 7.5 | 15 (50) |
| | 8 | 10 (33.3) |
| **Indication for intubation** | | |
| **Poisoning cases** | Organophosphorus poisoning | 15 (50) |
| **Non-poisoning cases** | Cerebro-vascular accidents | 3 (10) |
| | Hypoxic ischaemic encephalopathy | 3 (10) |
| | Acute respiratory distress syndrome | 3 (10) |
| | Metabolic disorders | 4 (13.3) |
| | Head injury | 2 (6.6) |
| **Length of intubation** | | |
| **Duration (days)** | 2-5 | 9 (30) |
| | 6-10 | 9 (30) |
| | >10 | 12 (40) |

Majority of the patients (50%) were cases of organophosphorus (OP) poisoning followed by metabolic disorders like diabetic ketoacidosis and chronic kidney disease with encephalopathy; each with 2 cases (13.3%). 40% of the patients were intubated for more than 10 days.

***Findings on various investigative modalities***

Patient were evaluated for LTI following intubation based on x-ray neck-antero-posterior view and lateral view, 70-degree endoscopy and flexible NPL. The x-ray was normal in 22 patients (73.3%) while the abnormality was picked up in 8 (26.6%) patients. On 70-degree endoscopy, 2 patients (6.6%) had granulation tissue in the posterior commissure and one patient had bilateral vocal cord fixation. Subsequently, when the flexible NPL was performed, additionally 9 cases (30%) of subglottic stenosis (Figure 1) and one case of granulation tissue in the posterior wall of upper third of trachea was picked up (Table 2).

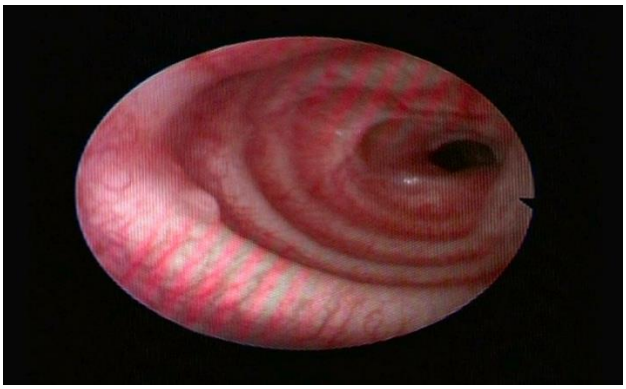

**Figure 1: Tracheal stenosis with 50%lumen obliteration.**

**Table 2: Laryngotracheal findings in various investigative modalities.**

| Investigation | findings | N (%) |
|---|---|---|
| **X-ray** | Normal | 22 (73.3) |
| | Abnormal | 8 (26.6) |
| **Rigid endoscopy** | Normal | 27 (90) |
| | Bilateral vocal cord fixation | 1 (3.3) |
| | Granulation tissue in posterior commissure | 2 (6.6) |
| **Flexible naso-pharyngo-laryngoscopy** | Normal | 17 (56.6) |
| | Sub-glottic stenosis | 9 (30) |
| | Bilateral vocal cord fixation | 1 (3.3) |
| | Granulation tissue in posterior commissure | 2 (6.6) |
| | Granulation tissue in posterior wall of trachea | 1 (3.3) |

***Factors influencing LTI***

All the patients who had LTI were aged less than 45 years and 10 of 13 cases affected were males. Among the cases of LTI, 10 (76.8%) out of 13 cases were intubated with endotracheal tubes of size more than 7. Eight (61.5%) of the total cases of LTI had intubation for more than 10 days. OP poisoning was the etiology for LTI in 9 cases (69.2%). However, none of the above factors were associated with the LTI statistically (Table 3).

**Table 3: Associations of laryngotracheal injuries with various factors of interest.**

| Factors | Sub factors | Injury | |
|---|---|---|---|
| | | **Present (%)** | **Absent (%)** |
| **Age** | 15-29 | 10 (76.9) | 9 (52.9) |
| | 30-44 | 3 (23) | 4 (23.5) |
| | >45 | 0 | 4 (23.5) |
| **Gender** | Male | 10 (76.9) | 9 (52.9) |
| | Female | 3 (23) | 8 (47) |
| **Size of tube** | 7 | 3 (23) | 2 (11.7) |
| | 7.5 | 7(53.8) | 8 (47) |
| | 8 | 3 (23) | 7 (41.1) |
| **Duration of intubation** | 2-5 days | 3 (23) | 6 (35.2) |
| | 6-10 days | 2 (15.3) | 6 (35.2) |
| | >10 days | 8 (61.5) | 5 (29.4) |
| **Cause of intubation** | OP poisoning | 9 (69.2) | 6 (35.2) |
| | ARDS and CVA | 1 (7.6) | 5 (29.4) |
| | Metabolic disorder | 0 | 4 (23.5) |
| | Others (head injury, hypoxic ischemic encephalopathy) | 3 (23) | 2 (12.5) |

## DISCUSSION

Patients requiring ventilation through artificial airways in the ICU is common. LTI following intubation have a reported incidence of 60% to 90% and permanent sequelae are reported to be about 15% in the world literature. The laryngeal injuries can be mucosal injuries like vocal cord erythema, edema, granulations or ulcerations to a more permanent sequelae like vocal cord palsy, arytenoids dislocation and subglottic stenosis.[6,11,16-28] In addition, the tracheal injuries can be granulations in the initial stages to tracheal stenosis in the later stages.[29] In the present study, LTI observed were subglottic stenosis, granulation tissue in posterior commissure, vocal cord fixation and granulation tissue in the tracheal wall.

The etiology of laryngeal stenosis following intubation is multifactorial. The mechanism of injury commonly associated with laryngotracheal intubation include duration of intubation, size of tube, pressure and rubbing of the shaft against the larynx, repeated intubation, foreign body reaction to the tube, use of a stylet during intubation, route of intubation, nursing care, and anatomic differences between the genders.[30] In the present study, majority of patients who sustained LTI were aged less than 45 years and were more common among male patients. Age of the patient plays an important role influencing site and degree of stenosis.

Neonates show predisposition for subglottic involvement but in our series, those cases have been excluded. It is an established entity that adults are more prone for posterior commissure lesions which is in concurrence with the present study. Nevertheless, combined stenoses account for about one-third of all laryngeal stenoses at any age.[31-33]

The inappropriate diameter of the endotracheal tube and the difficulty in keeping the patient immobilized for a longer period are well known predisposing factors to the development of airway injuries. The posterior part of larynx specially the posterior commissure comes in contact with endotracheal tube due to the configuration of glottis being in the shape 'V' and the friction is more in this portion when the patient moves frequently. This is largely responsible for injuries in this area. Additionally, the compression on the mucosa by the tube causes prolonged ischemia which leads to ulceration followed by granulation tissue formation and later stenosis.

The determination of tube size of an adult patient is usually based on the physicians assessment of neck morphology and external features of the larynx.[22] There is no standard formula to serve as a guide to appropriate tube size. A size of 8mm is generally used for adults and 7 or 7.5mm for thinly built adults.[22] Following these measurements may not be possible in an emergency like OP poisoning.

LTI were found more commonly among patients intubated for more than 10 days. Thus, the duration of intubation is also a factor contributing to LTI following intubation. The constant movements of the neck in an agitated state cause friction of the larynx and tracheal mucosa. In the patient without sedation, reflected movements of deglutition can incite tracheal injury. The longer the duration of intubation, more the risk of injury.

In the present study, it was found that OP poison consumption was the most common cause of intubation induced LTI. This probably could be due to atropine induced reduced secretions in larynx and trachea associated with increased vulnerability of the mucosa to frictional injuries caused by ventilator through the endotracheal tube.[34] Therefore, proper sedation and paralysis of these patients wherever required can reduce the incidence of LTI. Additionally, the appropriate dosage of specific antidote (atropine) will also minimize the risk of dryness and irritability of the patient.

In the study, LTI were evaluated based on the x-ray neck, 70-degree rigid endoscopy and flexible NPL. Flexible trans-nasal endoscopy is widely available in many oto-rhino-laryngology offices.[35] Flexible NPL is generally well tolerated in majority of the patients with the use of topical/nebulized local anesthetic which allows evaluation of vocal cord mobility and other signs of LTI.

**Table 4: Review of literature.**

| Author | year | No. of patients | Mean age (years), range | Duration of intubation | Investigative modality | Results | Types of LTI (%) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| **Rangachari et al[3]** | 2016 | 51 | 50.23 (17-85) | >24 hours | Rigid 70-degree endoscopy | 41 patients- laryngeal abnormality seen on the day of intubation. At the end of 3rd week after extubation only 10 patients had abnormal findings. | Vocal cord erythema (48), arytenoid edema (24), vocal cord granuloma (8) on the day of intubation. Vocal cord (16) granuloma was most common feature at 3 weeks | Laryngeal sequelae after extubation is directly associated with duration of intubation |
| **House et al[17]** | 2010 | 61 | 56 (19-80) | >48 hours | Flexible NPL | All patient had some degree of laryngeal injury. 41% patients had some degree of vocal fold immobility. | Arytenoid edema (95), vocal fold edema (65), subglottic edema (13), vocal fold immobility (39) | Duration of intubation, type and size of endotracheal tube do not affect the degree of laryngeal injury |
| **Esteller-Moré et al[9]** | 2005 | 654 | 54.5 (34-74) | >72 hours | Endoscopic examination | Endoscopic examination of upper airway 6-12 months after extubation revealed LTI in 11% patients. | Vocal cord granuloma (2.1), vocal cord immobility (4.6), subglottic stenosis (1.5), tracheal stenosis (3.2) | Development of LTI is influenced by duration of oro-tracheal intubation |
| **Lundy et al** | 1998 | 45 | 47.4 (NA) | 2 hours-37 days | Flexible fiberoptic video laryngoscopy | 19 Patients with vocal fold immobility, 12 with subglottic stenosis, 11 with granulomas, 3 with glottic webs | Vocal fold immobility, glottic web, subglottic stenosis, granuloma | Duration of intubation is directly associated with severity of injury |

Continued.

| Author | year | No. of patients | Mean age (years), range | Duration of intubation | Investigative modality | Results | Types of LTI (%) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| **Colice et al[22]** | 1989 | 82 | 64.3 (25-88) | >4 days | Direct laryngoscopy | 77 (94%) Patients founds to have laryngeal damage at the initial endoscopy. | Mucosal ulceration along the postero-medial aspect of both vocal cords and laryngeal edema | No relationship was found between laryngeal pathology seen at initial laryngoscopy and the development of adverse effects |
| **Whited et al[32]** | 1984 | 200 | Adult patients | 2-24 days | Fiberoptic laryngoscopy-bronchoscopy | Group I (50 patients, 2-5 days intubation): acute reversible laryngeal stenosis- 3 patients, Chronic posterior commissure stenosis- 1 Group II (100 patients, 6-10 days intubation), post extubation airway compromise: laryngospasm-edema- 2, Limited cord abduction- 3 Group III (50 patients, more than 11 days intubation), converted to tracheostomy: uneventful decannulation-9 Chronic laryngotracheal stenosis- 5, aspiration with pneumonitis - 2 | laryngeal stenosis, posterior commissure stenosis, laryngospasm-edema, Limited cord abduction. | Incidence, and severity of post intubation complications are more in group III patients (longer duration of intubation) |
| **Stauffer et al** | 1980 | 150 | 58 (17-88) | >24 hours | Flexible fiberoptic bronchoscopy, direct or indirect laryngoscopy | Prevalence of tracheal stenosis more with tracheostomy (65%) than intubation (19%). 95% patients with endotracheal intubation had LTI at autopsy. | Tracheal stenosis, Ulcers on the vocal cord, | No significant relationship between duration of endotracheal intubation or tracheostomy and amount of LTI at autopsy |
| **Present study** | - | 30 | 42.5 (15-70) | >48 hours | X-ray neck, 70-degree rigid endoscopy, flexible NPL | On flexible NPL, 43.2% patients had LTI following extubation. LTI were found among patients less than 45 years of age and more among males. LTI were found more among patients intubated with tube size more than 7 (76.8%) and with duration of intubation more than 10 days (61.5%). OP poisoning was the etiology of LTI in 9 cases (69.2%). | Subglottic stenosis (30), bilateral vocal cord fixation(3.3), granulation tissue in posterior commissure (6.6), granulation tissue in the posterior wall of trachea (3.3) | No significant statistical association found between duration of intubation, gender, age, size of tube, etiology of intubation with the incidence of LTI |

NPL- nasopharyngolaryngoscopy, LTI- laryngotracheal injuries

In the present study, flexible NPL was able to detect 75% of LTI in comparison to 70-degree endoscopy which detected only 25% of the lesions below the vocal cords. Thus, flexible NPL was found to be a more reliable modality in evaluating the LTI. As these lesions are intraluminal, a non-invasive modality like flexible NPL was preferred over Computed tomography or Magnetic resonance imaging. A basic investigation like x-ray neck was preferred prior to flexible NPL to assess the adequacy of airway which in turn would facilitate proceeding with the scopy.

A comprehensive review of literature was performed to compare and analyze the observations of the present study and is depicted in Table 4.

Limitations of the study are the difficulties faced during the intubation, the standardization of the qualification of

the personnel who intubated, and their skills could not be ascertained as those details were unavailable.

## CONCLUSION

A high incidence of LTI especially in cases of OP poisoning warrants one to be cautious in managing these intubated patients. Those patients requiring prolonged intubation should be considered for other alternative airway managements like tracheostomy in addition to using low pressure, high volume cuffed tubes. As the management of these LTI is challenging and associated with significant morbidity and mortality, an awareness of the same, adequate training of the emergency personnel in the intubation technique and its subsequent care is important especially in a tertiary referral center.

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