

Management of Post-traumatic Laryngotracheal Stenosis: Our Experience

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Received: 1 September 2014 / Accepted: 24 November 2014 / Published online: 3 December 2014
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Abstract To describe our experience in management of post-traumatic laryngo-tracheal stenosis by study of various surgical methods. To compare our results with different studies. To find out best surgical procedure. Retrospective study. 13 patients of LTS were analyzed within the period of 2009–2013 highlighting the important causes of stenosis, management based on type and severity of stenosis and outcome following the treatment given. Cases were diagnosed in detail with help of flexible laryngoscopy. Finer details of stenosis like site, length, associated injuries were studied with help of CT scan. Various modalities of treatment were used and outcome was assessed. There were 13 patients 9 males and 4 females. Of these 54 % had iatrogenic stenosis and 46 % had traumatic stenosis. 46 % had true stenosis, remaining cases suffered from either soft stenosis or had associated injuries rendering the stenosis as a complex one. The patients underwent a combined surgical approach which included treatment modalities like T-tube insertion, endoscopic dilatation, laser, and open surgical intervention (tracheal resection and anastomosis). Of all the patient treated 69.2 % were successfully decannulated and recovered well with a satisfactory airway outcome, (23.07 %) cases remained T-tube dependent, 8 % case died due to septicemia. It was evident that prolonged intubation remained most common cause of tracheal stenosis and the management varied depending on the type of stenosis. Simple soft stenosis could be managed well by endoscopic dilatation and laser while complete, complex stenosis required surgical intervention in form of T-tube stenting or open surgical intervention. Tracheal stenosis is a life threatening complication and difficult to manage. It

requires multiple approaches and the successful outcome is assessed by patent airway and voice quality.

Keywords Laryngotracheal stenosis · Postintubation · T-tube · Laryngofissure approach · Tracheal resection

Introduction

Laryngotracheal stenosis is narrowing of central airways at different sites (larynx, trachea, carina, main bronchi and may often involve more than one site). This becomes a serious condition as it compromises central airways and result in respiratory emergency. Central airway, a vital and delicate structure needs to be handled with expertise. These make management of Laryngo-trachealstenosis a highly skilled job and often requires equipped tertiary centre for fruitful outcome. In the following study patients suffering from Laryngotracheal stenosis were studied from period between 2009 and 2013 in terms of cause, severity, management of stenosis and following outcome of the treatment.

Materials and Methods

In this study retrospective analysis was done of 13 patients suffering from laryngo-tracheal stenosis in the year between 2009 and 2013. The patients included both male and female of varied age group and consisted of patients suffering from stenosis which was iatrogenic, or traumatic (suicidal, homicidal or accidental). Stenosis due to infection and malignancy are excluded from the study. They underwent a detailed clinical examination involving a descriptive history taking and physical examination.

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All patients were subjected to flexible laryngoscopy and CT scan to determine the severity, site, consistency and length of stenosis. It also aided in planning the management of the disease. The patients were treated with various approaches involving more than one approach. The various modalities included tracheostomy, T-tube stenting, endoscopic dilatation, laser, and for cases following trauma the treatment consisted of laryngofissure approach with repair of fractured cartilage. Postoperative outcome of patients was assessed by number of patients decannulated.

The final statistics of various approaches used is depicted in Table 1.

Of all the cases treated 9 (69 %) cases were decannulated and recovered well, 3(23 %) cases became T-tube dependent for life time while 1 (8 %) case died due to septicemia.

Result

Of 13 patients 9 were male and 4 female between age group of 12 to 60 year with mean age being 31 year. Of the 13 cases 6 cases (54 %) had history of prolonged intubation following organophosphorus poisoning, 6 cases (46 %) cases suffered from trauma (3 cases had blunt trauma neck and the other 3 cases had penetrating neck injury) and remaining 1 (8 %) case had prolonged intubation following head injury. Of the cases suffering from trauma 4 were accidental and 2 were homicidal. As per the study prolonged intubation was found to be commonest cause of tracheal stenosis. This is in contrast to study of Bent III et al. [1] and Cohen et al. [2] where traumatic injury was the main cause of tracheal stenosis (Table 4).

Of the 13 patients 6 (46.1 %) suffered from complete stenosis, 3 (23.07 %) had stenosis due to bowing of unilateral vocal fold resulting from fracture of ipsilateral thyroid lamina, 2 (15.3 %) had stenosis due to mucosal fold partially occluding the tracheal lumen, 1 (7.69 %) due to collapse of anterior tracheal wall due to fracture of 1–6 tracheal rings. All patients went through flexible bronchoscopy and CT scan to assess the site, severity and wherever possible length of stenosis. The CT scan provided additional information regarding any associated injuries referring the stenosis as a complex one and hence altering the management protocol.

Table 1 Showing various modalities used for management of tracheal stenosis

S. no	Type of stent	Indication
1	Soft hollow stent	If phonation is desired
2	Firm stent	If splinting is required
3	Solid stent	If aspiration is a problem

Of the 13 patients length of stenosis could be measured in 3 cases the mean length being 2.33 cm.

Most common site affected with stenosis was 2nd tracheal ring. This was evident from the study in which about 3 cases had stenosis at 1st–2nd tracheal ring, 2 had stenosis involving 1st–3rd tracheal ring 2 cases had only involvement of 2nd tracheal ring with soft stenosis, 1 had involvement of 1st tracheal ring with fracture of cricoids while 1 case had involvement of all 1st–6th tracheal rings inclusive of fracture of cricoid cartilage.

Stenosis above tracheostomy site was seen in 5 cases, soft stenosis at 2nd tracheal ring in 2 cases and subglottic stenosis in 1 case. Most common site of stenosis was above the stoma in post intubation stenosis.

Different approaches were used to treat the stenosis. 6 (46 %) cases underwent tracheostomy, 7 (54 %) cases had T-tube stenting done, 8 (61 %) cases were treated with endoscopic dilatation and 5 (38 %) cases experienced laser treatment while open surgical intervention consisting of laryngofissure approach with suturing of fractured segment was done in 31 % of cases, tracheal resection with end to end anastomosis in 1 (8 %) case and repair of tracheoesophageal fistula was done in one case of accidental strangulation who developed complex stenosis due to dislocated left arytenoid with left vocal cord palsy and had subsequently developed Tracheoesophageal fistula.

Out of 7 cases of post intubation stenosis 5 (71 %) underwent tracheostomy followed by T-tube stenting and later were treated with endoscopic dilatation, while 2 (29 %) cases having soft stenosis with mucosal fold partially occluding tracheal lumen were treated with endoscopic dilatation followed by excision of fold by laser. The case of post intubation stenosis following head injury had repeated endoscopic dilatation and in absence of fruitful outcome was later treated with laser for removal of the fibrosed area was followed by resection of the fibrosed tracheal segment and end to end anastomosis after which patient could be decannulated and recovered well. Another case of post intubation stenosis with complete subglottic stenosis also underwent laser treatment after repeated endoscopic dilatation could not achieve the decannulation, this patient however remained T-tube dependent. Table 4. The remaining 6 cases which suffered from complex stenosis due to associated injuries were treated with open surgical intervention. Of these 3 cases which involved stenosis due to bowing of unilateral vocal cord following fracture of thyroid lamina of ipsilateral side had replacement and suturing of fractured segments through laryngofissure approach while 1 case involving fracture of 1st–6th tracheal ring resulting in collapse of anterior tracheal wall underwent tracheostomy followed by T-tube stenting, the case died due to septicemia. One case of traumatic

stenosis at subglottic region with fracture of cricoid and 1st tracheal ring had open surgical intervention with repair of fracture but also had to undergo endoscopic dilatation after which case recovered well and the remaining 1 case of 12 year old female who had dislocated left arytenoids with left vocal cord palsy with CT showing fracture of thyroid and cricoid cartilage resulting into subglottic stenosis and complications like emphysema and trachea-esophageal fistula, was treated with tracheostomy, T-tube stenting, repair of Tracheo-esophageal fistula and she remained T-tube dependent (Table 4).

Discussion

Laryngotracheal (LTS) stenosis is abnormal narrowing of central airways. May occur at larynx, trachea, carina or main bronchi. Many a times may involve more than one site. LTS can be classified on basis of site of stenosis [3].

Subglottic stenosis was classified by Cotton and Myer's [4] for grading circumferential subglottic stenosis.

Grade I: <50 % luminal obstruction.

Grade II: 50–70 %.

Grade III: 70–99 %.

Grade IV: complete obstruction.

Tracheal stenosis was classified into three types: cicatricial, anterior wall collapse and complete tracheal stenosis.

Etiopathogenesis

Causes of Laryngotracheal stenosis are divided depending on site of stenosis (Table 5).

Pathological considerations Tracheal stenosis most commonly caused by inflammatory complications of prolonged intubation and tracheostomy. The stenotic process begins with trauma and ulceration of tracheal mucosa with superimposed local infection leading to perichondritis of tracheal cartilage and increased fibroblastic activity which causes circumferential scarring resulting into narrowing of the tracheal lumen and stenosis.

In our study the most common cause of stenosis was postintubation. According to Grillo, Mathesien, Wain study the two most common causes are post intubation and post tracheostomy [5]. Trauma was the most common cause of stenosis was proved in study reported by Bent III [6] and Cohen and Larsen [7].

The site and mechanism of stenosis depends on whether the patient has had tracheostomy or endotracheal intubation.

1. Post intubation: commonest site is site of endotracheal tube [5, 8] and stenosis is longer and uniform.

2. Post tracheostomy: common sites are the stoma, supra stomal, cuff site. Here stenosis is extension of granulation tissue from injured anterior wall of trachea.

In a study by Zeis et al. [9] the length of stenosis was 2.6 cm in postintubation stenosis compared to 3.57 cm in posttracheostomy. In our study average length of tracheal stenosis was 2.33 cm in both postintubation and post tracheostomy.

Clinical presentation Symptoms of tracheal stenosis can present after an acute injury to the trachea and include dyspnoea (on exertion or rest depending on severity of stenosis), noisy breathing (stridor), recurring pneumonia, wheezing, Cyanosis (blue-spells), apnea (breathing pauses), chest congestion. In initial stages patient presents with increased cough and difficulty in clearing secretions till lumen is compromised above 50 % after which patient present with increasing dyspnoea and later stridor [10].

Evaluation is done by clinical features, flexible laryngoscopy, rigid bronchotracheoscopy radiological methods (X-ray, CT scan).

According to clinical features A high index of suspicion is warranted with the onset of respiratory symptoms following intubation or tracheostomy regardless of the duration. Early presentation of TS may include the patient being unable to be weaned off the ventilator, unable to be decannulated from the tracheostomy or patient presents with progressively worsening dyspnoea beginning 6 weeks to 2 months from successful extubation or decannulation [11].

Laryngotracheoscopy Flexible is used for the assessment of anatomical abnormality, presence of pooling of secretions, vocal cord mobility, degree of stenosis at different sites. Rigid has the advantage of direct visual assessment and helps in simultaneous performance of diagnostic and therapeutic procedure. *Considered gold standard method for intraluminal assessment of upper airway* [12]. But the endoscopy has limitations as it is subjective and dependent on the endoscopist's skills, unable to evaluate the airway caliber and morphology beyond a high-grade stenosis of the bronchial lumen and gives limited information about extraluminal disease.

Radiological X-ray Plain AP and lateral view of upper airways is done; it provides preliminary or definitive information about foreign bodies, trauma, and other types of acute and chronic airway obstruction, demonstrates soft-tissue swelling, alterations of the cartilaginous framework (if it is sufficiently calcified) and the position of the air column.

CT scan has proved very helpful in diagnosing stenosis, judging its level and severity. The acquired images provide detailed information regarding the tracheobronchial tree and its associated pathology. Moreover, 2-D and 3-D

images that are generated by CT scan data provide additional information regarding airway pathology. Conventional coronal CT scanning allows visualization of the frontal view anatomy without a superimposed spine. This technique enables satisfactory analysis of the vertical extent of the tracheal stenosis or stricture. It is useful for those patients who have mild to moderate injury with no airway compromise, judicious use of CT can guide proper management and avoid unnecessary surgical exploration [13, 14]. Axial CT scan images can sufficiently evaluate the majority of airway abnormalities, but there are some limitations like limited ability to detect subtle airway stenosis, underestimation of the craniocaudal extent of disease, difficulty in displaying the relationships of the airway to the adjacent mediastinal structures and assessing the interfaces and surfaces of airways that lie parallel to the axial plane, inadequate representation of the airways that are oriented obliquely to the axial plane.

Treatment The most common treatment options for tracheal stenosis include

1. Observation: Milder forms of tracheal stenosis not significantly affecting the patient may be monitored with close observation and regular doctor's visits. Patient advised avoidance of smoking and heavy work.
2. Medical management: Bed rest with head end elevated at 30° with soft liquid diet. Voice rest given to reduce edema, humidified air to reduce crusting and improve ciliary function, supplemental oxygen for airway, corticosteroids in form of intravenous dexamethasone and hydrocortisone to reduce inflammation and fibrosis, antibiotics are useful in associated complications to prevent local infection and perichondritis and if open exploration needed they should be given 5 days prior to operation and also post operatively. Antireflux medicines prevent granular tissue formation and subsequent stenosis. Mitomycin C is antimetabolite with antineoplastic and antiproliferative activity used for local application to prevent restenosis. It inhibits human fibroblasts thus inhibiting vigorous granulation response noted after airway injury [15].
3. Surgical management: Various studies indicated open surgical treatment as treatment of choice whereas rigid bronchoscopy and other procedures like stenting, laser and dilatation as intermediary procedures [5, 16–18]. Rigid bronchoscopy and dilatation or excision is useful for treatment of true web like stenosis [19]. This obtained excellent result in 100 % cases of simple stenosis [19–21]. While recurrence was seen in 90 % cases of complex stenosis [16] Tracheostomy depends on clinical condition of patient [22]. Usually done at site lower than the usual site that is below 2nd tracheal

ring to avoid further injury to larynx and supporting structures.

Laryngeal stents are used to maintain lumen following reconstruction if cartilage support is inadequate, provide support to cartilage and bone grafts, separate opposing surfaces during healing and prevent adhesion formation and maintain scaphoid shape of anterior commissure, useful for vocalization. Complications depend on duration of stent used [23]. Different stents have different uses and require varied amount of time for action (Tables 2, 3). Stents may be Aboulker stent, Montgomery stent, Sialistic sheets. Tracheobronchial stents may be silicone or metal. Silicone stents are easier to remove, can be left in place for years but have migration tendency. Metal stents are more distensible, used for distal trachea and bronchi as they do not obstruct primary or secondary bronchi, Difficult to remove and cause metal toxicity. Metallic stents are used for palliation of patients with malignant stenosis [24].

Laser bronchoscopy is used to remove the scar tissue causing the stenosis. This provides immediate relief but is a temporary procedure due to recurrence of granulation tissue and stenosis. The laser may have adverse effect as it increases the length of stenosis [16]. CO₂ laser are widely used. It enables mucosal preservation, allows for control resection and achieves haemostasis. KTP laser is useful in cases of minimal granulation, soft stenosis, post surgical web.

Bronchoscopic tracheal dilation is widening of the trachea, either with a balloon or surgical instruments called tracheal dilators, provides temporary relief of symptoms and allows to determine how much of the trachea is affected by the stenosis. In our study 8 patients underwent endoscopic dilatation with 6 cases being successfully decannulated (75 % success) in comparison to study of Simpson et al. [25] with success rate of 80.6 % (Table 4).

During tracheal resection and reconstruction the constricted section of the trachea is removed and upper and lower sections are rejoined. This is usually a successful treatment for stenosis, with excellent long-term results. It is indicated in cases with complex stenosis, restenosis after multiple other techniques and in conjunction with associated conditions like TEO fistula closure. This technique has 90 % success rate as described in literature [5, 16, 18]. In our study only one patient underwent this procedure and was successfully decannulated. In long-segment tracheal stenosis, a slide tracheoplasty is required. In this surgery, the narrow part of the trachea is cut horizontally. Then a vertical incision is made in the back part of one segment and the front part of the other tracheal segment. Finally, the two sections are slid together and sutured so that they overlap, providing a wider tracheal airway (Table 5).

Table 2 Showing uses and duration of stents

S. no	Method	%
1	Tracheostomy + T-tube stenting	8
2	Tracheostomy + T-tube stenting + endoscopic dilatation	31
3	T-tube + endoscopic dilatation	8
4	Tracheostomy + T-tube + endoscopic dilatation laser	15
5	Laryngofissure approach + endoscopic dilatation	8
6	Laryngofissure approach only	23
7	T-tube + endoscopic dilatation + laser + end to end anastomosis	1

Table 3 Showing various stents and their indication

S. no	Indication of stent placement	Duration required to be kept in situ
1	Only for mucosal healing or taking of graft	2–3 weeks
2	Used for splinting	6–8 weeks
3	If scar formation needs to develop around the stent due to deficient laryngeal frame work	>12 months

Table 4 Showing comparison of various studies with our study

S. no	Our study and the result	Other studies and result
1	Most common cause of tracheal stenosis was post intubation	As per Bent III et al. & Cohen & Larson et al. the most common cause of tracheal stenosis was trauma (inclusive of both blunt and penetrating trauma)
2	Of 8 cases who underwent endoscopic dilatation (with or without stenting) 6 were decannulated well i.e. 75 % cases	Simpson et al. reported 80.6 % success rate with endoscopic dilatation
3	Of 4 cases who were treated with laser therapy 3 recovered well with successful decannulation with success rate of 75 %	Shapsay et al. had a success rate of 100 % while Osoff et al. had only 57 %
4	All the 4 cases treated with laryngofissure approach with replacement of cartilage and suturing of fractured fragments were decannulated and recovered well	The success rate was 91 % in study of Pena et al. 76 % in study by Mc Caffrey et al and 64 % in study by Duncavago et al.

Most common complications after any treatment modality is relapse and restenosis with recurrence within 1–3 months [11].

Table 5 Causes of LTS on basis of site of stenosis

At the level of the larynx (glottis)	At the level of subglottis/trachea	At the level of carina or main bronchi
Blunt/sharp laryngeal trauma. Foreign body inhalation	Intubation/tracheostomy-related (most common cause)	Foreign body inhalation
Bilateral vocal fold mobility impairment	Tracheobronchomalacia	
Crico-arytenoid joint fixation	Relapsing polychondritis	
Intubation-related joint fixation	Tracheal ring damage due to COPD	
Inter-arytenoid scarring	Tracheal ring weakness	
Intubation-related	Tracheal trauma/rupture	

Conclusion

Laryngo-Tracheal stenosis is a dangerous and difficult to manage condition. It often requires multiple surgical approaches for management. The management is guided by the site, length and type of stenosis and associated complications if any. Simple uncomplicated stenosis are easily managed with close observation. Soft and simple tracheal stenosis are managed with tracheostomy, endoscopic dilatation and laser ablation. Such types often have a healthy outcome with patients having good respiration and voice quality. End to end tracheal resection anastomosis is gold standard single procedure for true tracheal stenosis. The stenosis with more severe nature and associated complications like TEO fistula or cartilage fractures often need an additional open surgical exploration. Such patients have high morbidity both pre operatively and post operatively.

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