Montgomery tracheal t-tube stenting as a single first-line treatment in postintubation laryngotracheal stenosis

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Objective
The aim was to evaluate the use of Montgomery tracheal T-tube stenting as a single first-line treatment for postintubation laryngotracheal stenosis (LTS), addressing the outcomes, its main complications, and how to manage them.

Materials and methods
From March 2012 to April 2017, 25 patients with postintubation LTS had contraindication(s) for laryngotracheal surgery and were treated by Montgomery tracheal T-tube stenting as a single first-line treatment. The preoperative, operative, and postoperative follow-up data were collected retrospectively and analyzed.

Results
Successful outcome was reported in 16 (64%) patients, whereas seven (28%) patients had recurrent stridor after T-tube removal. It was reinserted in two of them, and the rest were subjected to other surgical procedures. Mortality was reported in two patients. Complications of different nature, severity, and durations were reported, and most of them were detected and managed successfully by applying close follow-up protocols.

Conclusion
Montgomery tracheal T-tube stenting is a very valuable modality in the treatment of LTS as a single first-line treatment when surgical option is contraindicated. It has a relatively low incidence of treatable complications; however, false sense of security must be avoided to ensure good outcome.

Keywords:
laryngotracheal stenosis, Montgomery T-tube, tracheal stents

Introduction

Iatrogenic airway injury after tracheostomy and endotracheal intubation continues to be a serious clinical problem [1,2]. For laryngotracheal stenosis (LTS), laryngotracheal resection along with end-to-end anastomosis is now accepted as the procedure of choice, with excellent results reported in many large series in the literature [3–7]. Surgery may, however, be temporarily or permanently contraindicated in patients with airway stenosis because of the excessive length of the lesion, severe acute inflammation of the airway, or associated comorbidities. In these cases, tracheostomy or airway stenting may be indicated as a temporary procedure or as a definitive treatment [8–11].

To overcome the disadvantages of tracheostomy, Dr. Montgomery [12] from Harvard Medical School introduced silicone T-tubes in 1965. Since then, several articles have been published regarding the indications, advantages, complications, and outcomes of managing tracheal stenosis with T-tubes.

In this retrospective study, the main objective is to evaluate the use of Montgomery tracheal T-tube stenting as a single first-line treatment for postintubation LTS, addressing the outcomes, its complications, and how to manage them.

Materials and methods

From March 2012 to April 2017, 45 patients were treated for postintubation LTS at the Department of Otorhinolaryngology, Assiut University Hospital, Egypt. The study was conducted as a retrospective analytic study after obtaining institutional review board approval from the committee of medical ethics, Faculty of Medicine, Assiut University Hospital, and a written informed consent from the patients or their health caregivers. Montgomery tracheal T-tube (Invotec Products, Florida, USA) was inserted 36 times in 32 patients for different indications. In 25 of them, it was used as a first-line treatment because of local or general contraindication for laryngotracheal surgery. They were 19 (76%) males

Table 1 Myer–Cotton grading system for subglottic stenosis [13]

Grades	Percentage of obstruction
I	0–50
II	50–70
III	70–99
IV	100

Table 2 Causes of ICU admission and intubation

Causes		n (%)
Trauma		
Road traffic accident	18	21 (84)
Falling accident	1	
Firearm injury	2	
Suicidal attempt	1	
Post-thyroidectomy stridor	1	
Postpartum hemorrhage	1	
Guillain–Barre syndrome	1	
Total	25	

and six (24%) females, with mean age of 27 years (range: 12–55 years).

All of the patients had a rotine preoperative evaluation in the form of medical history, physical examination, and workup for preoperative fitness (laboratory investigations, ECG, and chest radiography). Additionally, diagnostic workup using multislice computed tomography scan of the head, neck, and mediastinum and rigid bronchoscopy with telescopic examination under general anesthesia was done to determine the site(s) of the stenosis and its grade according to Cotton–Mayer grading system [13] (Table 1), to measure the length of the stenotic segment and to examine the mucosal lining (the nature of the stenosis and the maturity of fibrosis).

The main cause of admission to the ICU and intubation was trauma [n=21 (84%)] (Table 2). The mean duration of endotracheal intubation before either extubation or tracheostomy was 15.6 days (range: 7–30 days).

The main indication for Montgomery tracheal T-tube placement was incomplete cicatrization of the stenotic segment which was present in 21 (84%) patients. Among them, one patient had long stenotic segment (5.8 cm) and another one had ischemic heart disease. Complete cicatrization of the stenotic segment was present in four (16%) patients, but performing a laryngotracheal surgery for them was contraindicated because they were recumbent, three of them owing to neurologic affection and the last one owing to multiple skeletal fractures.

Surgical technique
Rigid bronchoscopy under general anesthesia was done for all patients. The length of the stenotic segment, the distance of its proximal end to the vocal fold (VFs) and its distal end to carina, as well as the size and location of tracheostome (if present) in relation to the stenotic segment were all precisely determined followed by dilatation of the stenosis. The T-tube was trimmed based on previous measurements.

When there was a tracheostomy, the stoma was dilated by endotracheal tubes of increasing sizes or a small incision. Nontracheostomized patients were intubated transorally, and conventional tracheostomy was performed with vertical slit incision in the stenotic segment.

Before T-tube insertion, spontaneous respiration of the patient was ensured by the anesthesiologist. Forceps were used to grasp the distal end of the tube for insertion through the tracheal stoma into the tracheal lumen below the stoma. Then the transverse limb was forced to enter the stoma and lower trachea until the upper end is completely introduced to the tracheal lumen above the stoma. The transverse limb is then withdrawn from the stoma.

After tube placement, its proper position was confirmed by laryngoscope or fiberoptic bronchoscope. In some cases and in spite of precise bronchoscopic measurements, the tube had to be removed one or more times and cut more and more either proximally or distally for a better adjustment. The transverse limb was capped and the patient recovered from anesthesia.

Postoperatively, care was taken for the T-tube by keeping the external limb capped and frequent suctioning through it. Three to four daily sessions of humidified air inhalation using nebulizer and instillation of one to two cc of normal saline in the external limb were also done.

Patient follow-up was done during hospital stay and after discharge in weekly visits in the first month, and then in monthly visits, which included clinical evaluation, laryngeal examination using rigid 90 degree or flexible laryngoscope, examination of the T-tube through its external limb using flexible laryngoscope, and bronchoscopy under general anesthesia, if needed. The reported parameters were presence of difficulty in breathing or stridor, voice and

Figure 1
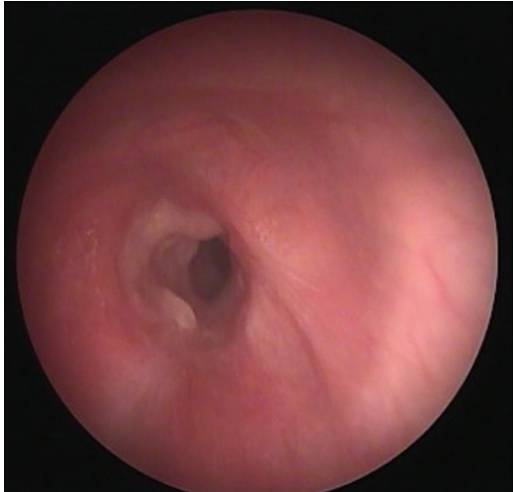
Bronchoscopic view showing grade III tracheal stenosis with partial cicatrization.

its quality, and presence of glottic or subglottic abnormalities, for example, granulations or adhesions. Other reported data included position of the T-tube in relation to the VFs, the ability to keep the external limb of the T-tube capped, incidence of the T-tube obstruction, and the need to remove it under general anesthesia.

Montgomery T-tube removal was done under general anesthesia and was followed by rigid bronchoscopy with telescopic tracheal examination to assess the subglottic region and trachea and remove any polyps or granulations. All patients were discharged 3–4 days after tracheal T-tube removal.

After Montgomery T-tube removal, all patients were followed up as previously described. Additional reported data included the need for bronchoscopic intervention(s) or for tracheostomy or tracheal T-tube reinsertion or other surgical procedure(s) and the presence of other complications, for example, scar complications and tracheocutaneous fistula.

The patient was considered cured if he/she was symptom free without dyspnea or stridor for at least 6 months after tracheal T-tube removal or the last bronchoscopic intervention.

Results

From March 2012 to April 2017, Montgomery tracheal T-tube was used as a single first-line treatment in 25 patients. All of them had a residual tracheal lumen, and the stenosis was either grade II or grade III [18 (72%) patients and seven (28%) patients,

Table 3 Distribution of different criteria of stenosis

Patient (stenosis) criteria	*n* (%)	Total
Tracheostomy		
Tracheostomized	14 (56)	25
Nontracheostomized	11 (44)	
Site of the stenosis		
Tracheal	18 (72)	25
Subglottic	3 (12)	
Combined tracheal and subglottic	4 (16)	
Degree of cicatrization		
Incomplete cicatrization	21 (84)	25
Complete cicatrization	4 (16)	
Stenosis grade		
Grade II	18 (72)	25
Grade III	7 (28)	

Table 4 Postoperative complications and their incidence

Complications	*n* (%)	Total
Dysphonia		
Yes	6 (24)	25
No	19 (76)	
Opening the T-tube		
No need	17 (68)	25
Occasional	7 (28)	
Most of time	1 (4)	
Need for frequent suction		
Yes	8 (32)	25
No	17 (68)	
Complete tube obstruction		
Yes	5 (20)	25
No	20 (80)	
Subglottic granulations		
Yes	2 (8)	25
No	23 (92)	

respectively] (Fig. 1). The site of stenosis was tracheal in 18 (72%) patients. The length of the stenotic segment ranged between 1.5 and 5.8 cm (mean 2.36 cm) (Table 3).

During follow-up after tracheal T-tube placement, 16 (64%) patients had neither problems nor complications, and the tube was always capped in 17 (68%) patients and was opened most of time in only one patient (Table 4). Nine (36%) patients had one or more complication(s), which varied in nature, severity, and duration. Six (24%) patients had dysphonia, in spite of appropriate positioning of the tracheal T-tube and normal VF mobility. Frequent accumulation of secretions inside the tube and need for frequent sessions of saline instillation and suctioning were present in eight (32%) patients. Three of them needed less sessions after a mean duration of 1.1 months (Table 4).

Complete tube obstruction with stridor occurred in five (20%) patients. Obstruction was caused by secretions in

Figure 2

Laryngeal examination using 90° endoscope showing granulations above the upper end of tracheal T tube.

three of them and by subglottic granulations in the other two patients (Fig. 2). Urgent bronchoscopy under general anesthesia was done in these cases, and the tube was removed, cleaned and reapplied in all of them. Subglottic granulations were removed by microlaryngosurgery in two patients. In these five patients, bronchoscopy was done once in four patients and twice (with 20 days interval in between) in one patient (Fig. 3).

The tracheal T-tube was removed after a period that ranged from 1.5 to 12.5 months (mean: 6.9 months). The shortest period (1.5 months) was in the patient who had two times of complete tube obstruction by subglottic granulations. Bronchoscopic examination at time of tracheal T-tube removal revealed presence of granulations and/or polyps which were at the level of the tracheostome in 18 (72%) patients and in the subglottic region at the level of the upper edge of the tracheal T-tube in seven patients (Figs 4 and 5).

Extubation was done safely in the operative theater in 21 (84%) patients. Four patients had decreased oxygen saturation after extubation, and tracheostomy tube had to be inserted. Decannulation of the tracheostomy tube was done 2–3 days later.

After stent removal, successful outcome in the form of normal breathing without stridor for at least 6 months after the last intervention was reported in 16 (64%) patients with mean duration of stenting 8.3 months (range: 6.5–12.5 months) (Fig. 6). No further interventions were needed in 13 of them (52%), whereas bronchoscopic dilatation with or without

removal of granulations were performed in three (12%) patients before they were cured. This was done twice in two patients and three times in one patient.

Unsuccessful outcome in the form of recurrent stenosis and stridor necessitating frequent bronchoscopic interventions was reported in seven (28%) patients. The mean number of bronchoscopic interventions was six and revealed recurrence of stenosis with or without granulations and polyps (Fig. 7). After each bronchoscopic intervention in these patients, stridor recurred after a mean duration of ten days (range: 5–14 days). The length of the stenotic segment before stenting in these patients was 3 cm or more in six of them (85.7%), and the stenosis recurred in the four (57.1%) patients who had combined tracheal and subglottic stenosis. Four (57.1%) patients had fully cicatrized stenosis, and the stenosis was grade III in four (57.1%) patients (Table 5).

Unsuccessful cases were managed by reapplication of the tracheal T-tube in two (8%) patients who were unfit for laryngotracheal surgery, one patient owing to ischemic heart disease and the other was recumbent because of neurological problems. The other five (20%) patients were fit for laryngotracheal surgery, and tracheostomy tube was applied to allow for full cicatrization of the stenosis. Resection and anastomosis was done in four patients and laryngotracheal reconstruction (LTR) with cartilage graft was done in one patient (Fig. 8).

Mortality was reported in two (8%) patients who had recurrent stridor after the third bronchoscopic intervention and they came from a remote area to our hospital in late stage. One of them died from hypoxia and after urgent tracheostomy and failed trial of resuscitation. In the other patient, tracheostomy and resuscitation were done, but she died 2 days later in ICU owing to hypoxic brain insult (Fig. 8).

Discussion

The study was conducted on 25 patients with age and sex distribution that differs noticeably from that present in most of the literature [4–6]. More than three-quarters (76%) of the patients were males and 72% were less than 30 years old. These results can be explained by the commonest cause of ICU admission and endotracheal intubation in these patients which was trauma in 84% of cases. Bruns and Hauser [14] reported that trauma is more common in males and in adolescents and middle age.
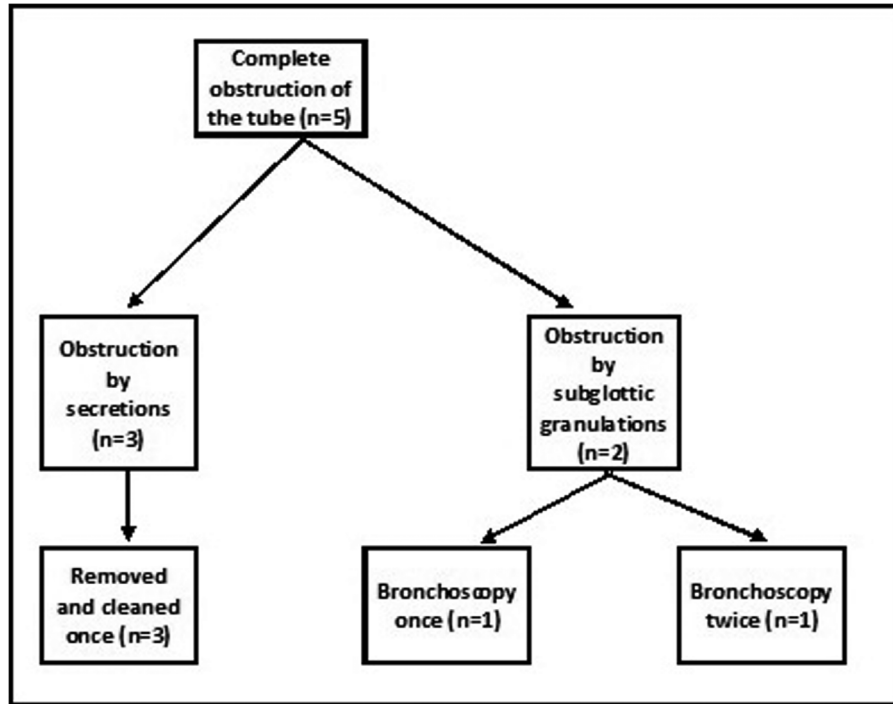
Figure 3

Chart showing number of patients, causes and management of complete tracheal T tube obstruction.
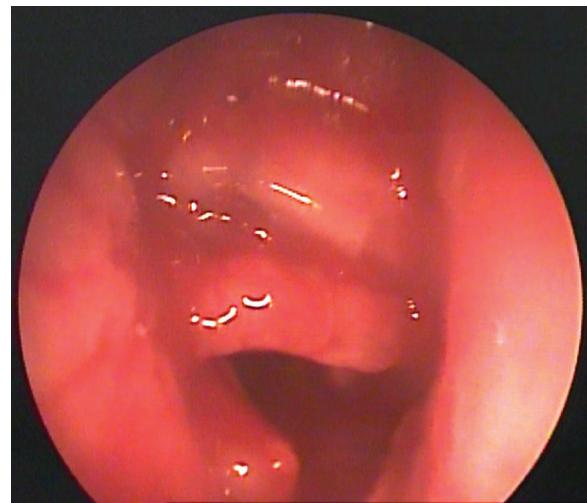
Figure 4

External view showing granulations around the stoma and hypertrophic scar.

Figure 5

Bronchoscopic view showing granulations at the level of stoma at time of T tube removal.

In this study, stenting was done in 25 cases with incomplete cicatrization of the stenotic segment and in patients who were unfit for laryngotracheal surgery. These two factors have been discussed in literature as an indication for temporary or permanent stenting [8–11,15]. According to Carretta *et al.* [8], tracheal stent should be placed and removed easily, has low incidence of migration and obstruction, is inexpensive, and is biocompatible. The silicon tracheal T-tube was used in all cases of this study. It was devised in 1965 by Montgomery [12]. However, its main disadvantages are that it

requires tracheostomy and it has an external limb which may carry a social problem.

In this study, it was observed that tracheal T-tube has advantages that may not be present in the totally endoluminal stents, for example, Dumon stent. Its external limb allows suction and cleaning of secretions and has a stabilizing effect, which reduces the risk of migration. They are less expensive and do not need special equipment or instruments for its
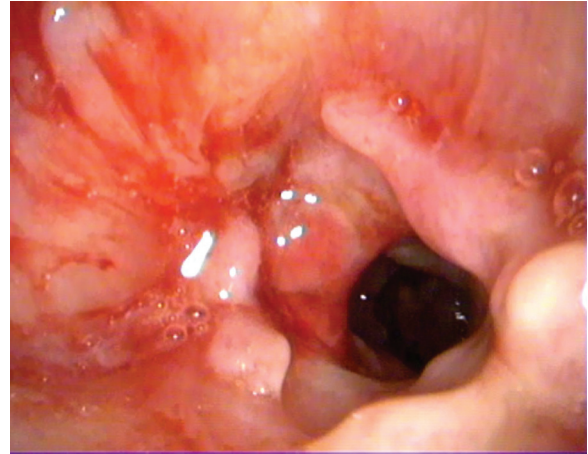
Figure 6
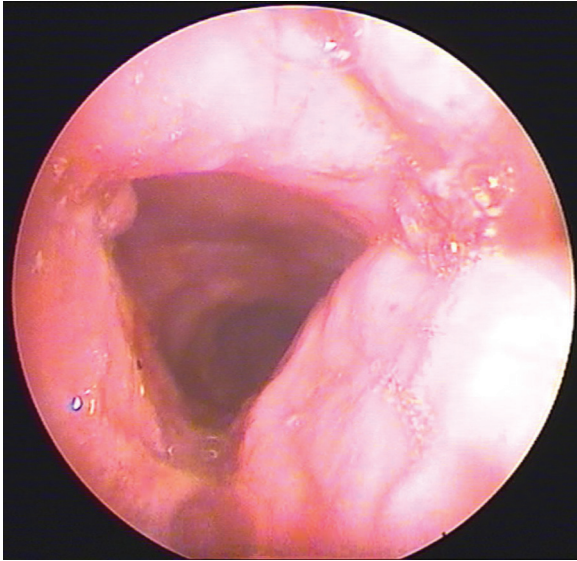
Flexible endoscopic view in a successful case three months after tracheal T tube removal.

Figure 7

Bronchoscopic view showing recurrent stenosis and granulations.

application. The possibility of examination of stent patency during follow-up with a flexible bronchoscope through the sidearm of the T-tube is an additional advantage. These advantages were documented in a number of reports [15–17]. Lee [16] reported that the T-tube acts as both a medium and a support during re-epithelialization of the tracheal wall, and squamous metaplasia occurs along the prosthesis, creating a smooth mucosal surface over the stenotic area. Thus, the T-tube decreases the formation of granulation during the recovery stage.

Choosing the appropriate diameter of the T-tube and its correct positioning is very important to prevent complications and for a successful outcome. The diameter of the tube was selected according to the age of the patient and radiological or endoscopic measurements. The T-tube size 12 mm was used in patients aged 15 years or less and size 14 mm was used in older patients. The T-tube was trimmed to cover to the length of stenosis completely and extend for a small distance above and below it. It was ensured that the trimmed edges were smooth to reduce inflammation and granulation formation.

Various techniques have been proposed to facilitate T-tube placement. Cooper *et al.* [15] described the use of a tracheostomy tape passed through the sidearm and the upper part of the T-tube and then grasped with endoscopic forceps during rigid bronchoscopy to ease the insertion of the proximal arm of stent. The same authors also described a translaryngeal placement technique [15].

Table 5 Different criteria of stenosis in successful and unsuccessful cases and their percentage in each of them

Criteria	Successful cases [n (%)]	Unsuccessful cases [n (%)]
Number of cases	16	7
Length of stenosis		
Mean length (cm)	1.9	3.2
Length 3 cm or more	1 (6.25)	6 (85.7)
Site of stenosis		
Combined subglottic and tracheal stenosis	No cases	4 (57.1)
Tracheal stenosis	13 (81)	3 (42.9)
Grade of stenosis		
Grade II	14 (87.5)	3 (42.9)
Grade III	2 (12.5)	4 (57.1)
Complete cicatrization of stenosis	1 (6.25)	4 (57.1)
Mean duration of stenting (months)	7.5	5.8

In this study, placement of the T-tube was done through the tracheal stoma using forceps to grasp the tube and force it gently at first into the trachea distally and then the proximal limb was forced into the stoma and allowed to expand within the trachea proximally. Endoscopy was done to ensure appropriate positioning in relation to the VFs. This technique was found to be less complicated and easily applicable. Ko *et al.* [18] reported that the distance between the stent and VFs should be 10 mm or more to decrease the incidence of granulation formation.

Liu *et al.* [11] described the use of a T-tube in a group of 53 patients with benign LTS and reported five postoperative deaths, with a success rate of 71.8%. They also discussed complications of tracheal T-tube and different methods of its management. Carretta *et al.* [8] described that nine of 43 patients with

Figure 8
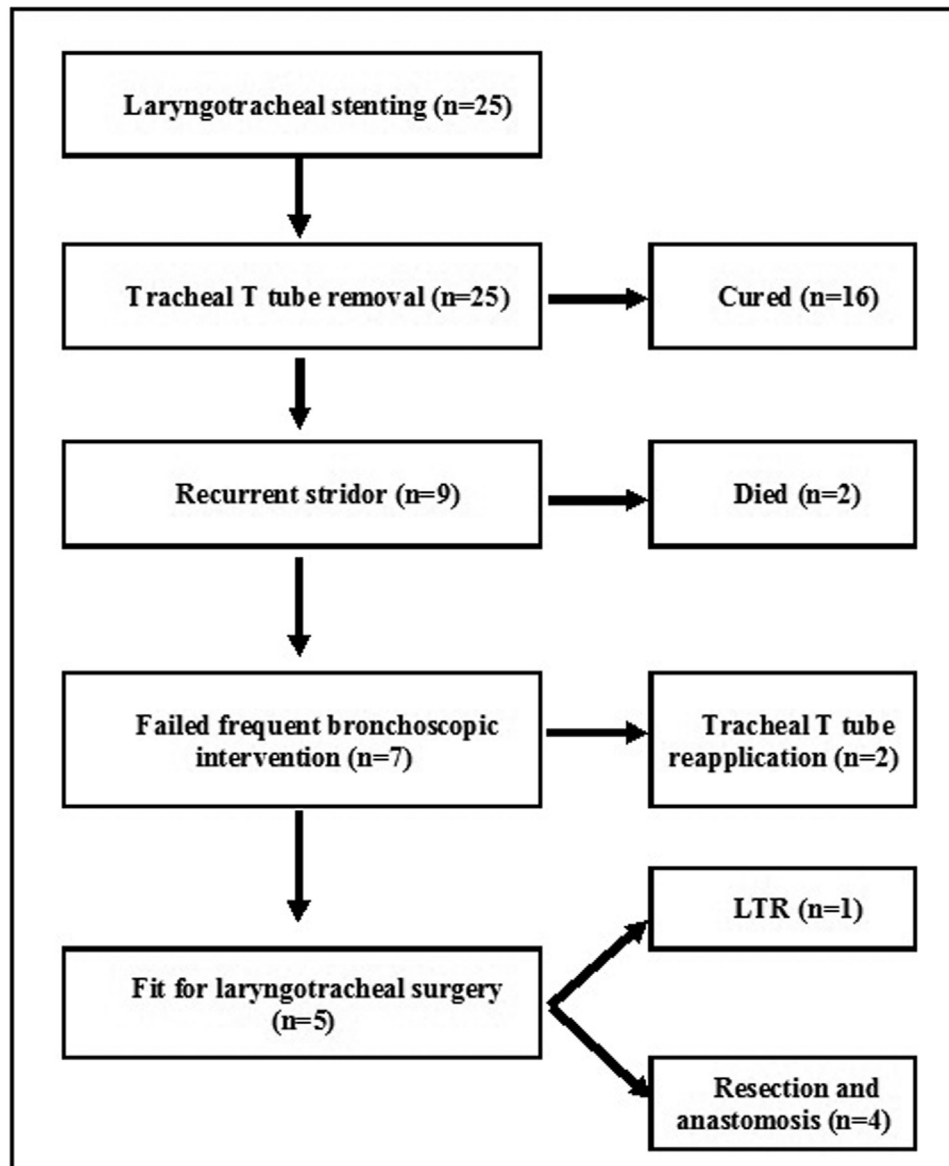
Flowchart of management and results.

postintubation lesions (21%) healed after conservative treatment using T-tube.

In this study, the tracheal T-tube was found to be successful in the treatment of 16 (64%) patients. The most common observed complications were stomal granulations (72%), recurrent stenosis (28%), subglottic granulations (24%), and tube obstruction (20%). Some of these complications were managed successfully and did not recur. Mortality was reported in two patients and was owing to recurrent respiratory obstruction and stridor, and they could not be saved in spite of trials of resuscitation.

In this study, it was observed that recurrent stenosis after T-tube removal was reported in cases with combined tracheal and subglottic stenosis and stenosis extending over the whole tracheal circumference. Gaissert *et al.* [17] have described the same factors that affect the outcome of treating stenosis with T-tube placement, and they reported the absence of cartilage support as an additional factor.

No standard time for T-tube removal has ever been established in literature, as it must be decided on a cases-by-case basis; however, the minimal time suggested is 7 months. Usually, after several months of stenting, infection is unlikely and airway secretions will decrease as the laryngotracheal lesion heals, allowing for long time of stenting [11]. Saghebi *et al.* [19] could not confirm in their work that keeping the T-tube in place for more than

6 months may increase the chance of successful decannulation.

The duration of stenting was variable between the patients in this study, and its effect on the success rate was not assessed owing to limited number of cases. However, it was observed that, in the two patients who had duration of stenting less than 6 months, incomplete healing of the stenotic site was found and airway obstruction recurred shortly after T-tube removal.

In conclusion, we found that Montgomery T-tube is a very valuable modality in the treatment of LTS as a single first-line treatment when the surgical option is contraindicated. It has a relatively low incidence of treatable complications; however, false sense of security must be avoided to ensure good outcome.

Conflicts of interest
There are no conflicts interest.

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