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Management of post intubation tracheal stenosis

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***Abstract*---**Background: Postintubation tracheal stenosis (PITS) is caused by a number of etiologies demanding mechanical ventilation and application of endotracheal or tracheostomy tubes which in turn conflict regional ischemic necrosis of the airway at various levels, presenting the characteristic signs and symptoms of airway obstruction. The incidences of PITS have been decreased with the recognition of the causes, and modification of endotracheal tubes and methods of management. Patients and Methods: Fifty four patients were identified between June 2017 and June 2019. Those patients were treated for tracheal stenosis which developed after prolonged endotracheal intubation. The study was done in Cardiothoracic Surgery departments at Kasr-Alainy Hospital (Cairo University). Patients were managed by rigid bronchoscopic dilatation, airway devices (as Montgomery t-tube or metallic stent) and/or primary

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tracheal resection and end to end anastomosis. Results: Out of the 54 patients: Three (5.5%) were planned for tracheostomy from the start. Fifty-one (94.4%) were subjected to rigid bronchoscopic examination & dilatation. Three patients (5.5%) were fully improved after bronchoscopic dilatation. The rest of the patients (48) were directed to the next stage in our management, either staged management or resection anastomosis. Forty five (83.3%) patients were submitted to tracheal resection and end to end anastomosis, which was successful in 41 (91.1%) patients. Twelve (22.2%) patients were subjected to airway appliances; Montgomery tube airway was used in 11(20.3%) patients and metallic stent was used in one (1.9%)patient Thirteen (24%) patients were subjected to Tracheostomy. In 3 (5.5%) patients tracheostomy was applied due to restenosis after resection anastomosis surgery. The rest of the cases (10) (18.5%) tracheostomy were planned 1st upon arrival of the patient to the ICU either as an emergency plan or due to an anticipated long stay on mechanical ventilator support.

***Keywords*---**Trachea, Post-intubation tracheal stenosis, benign tracheal stenosis, Bronchoscopic dilatation, tracheal airway devices. Tracheal resection and anastomosis, Trache ostomy.

Introduction

Post tracheal stenosis is a relatively uncommon problem with variety of etiologies and presentations from mild dyspnea to a catastrophic airway obstruction requiring cardiopulmonary support and resuscitation. Dyspnea is the most common presentation classified as: a) Dyspnea on exertion when 50% of the airway is normal (about 8 mm airway diameter), b) Dyspnea at rest occurs when 75% of the airway is stenosed (about 5 mm airway diameter) . **(Geffin *et al.*,1971)**

When stenosis is suspected, a variety of investigative methods are carried out. Chest radiographs together with simple tracheal radiographs are obtained first. These include anteroposterior filtered tracheal views and lateral soft tissue views of the neck. Tracheal fluoroscopy be helpful in identifying areas of tracheal malacia associated with the stenosis. Tracheal tomograms provide additional information bu in general, conventional CT scans are not as helpful in the evaluation of tracheal strictures as modified types of CT scans, since they onl provide axial views **(Taha et al 2009).**

The best imaging tool to date is the CT with 2D planar or curved reconstructions and 3D imaging including volume rendering (virtual endoscopic views). The scan time ranges from 20 to 25 s during one breath hold. The patients are scanned in the caudo-cranial direction to reduce motion artifact to a minimum. The acquired images are then reconstructed in 1 mm slice thickness **(Taha et al 2009).**

MRI, on the other hand, can be extremely useful in assessing the length and width of the stenotic region with coronal and sagittal views. The main advantage

of the MRI is its ability to give multiplanar images of the airway as well as the definition of the state of peritracheal tissues and the state of the mucosa. Imaging should start from the level of the tongue base down to the level of the carina. The scan should be oriented parallel to the ventricle or true vocal fold. Typical image parameters for a standard examination are Slice thickness 3-4 mm with a 0-1 mm intersection gap **(Vogl et al 1993).**

Endoscopy is critically important not only for evaluation of the tracheal but also for evaluation of the larynx. Laryngoscopy should be performed prior to undertaking a definitive procedure to detect the presence of glottic or subglottic stenosis or to detect the presence of vocal cord dysfunction. Likewise, rigid bronchoscopy is essential for evaluating stenotic lesions in the trachea. The length and width of the stricture and the degree of tracheal inflammation should be assessed, and areas of malacia and granulation tissue should be identified. In addition, if granulation tissue alone is causing stenosis, endoscopic removal may be the only treatment necessary. Flexible bronchoscopy under topical anesthesia should be avoided since secretions, edema, and the bronchoscope itself can precipitate sudden, complete airway obstruction. Also, accurate tracheal measurements with the flexible bronchoscope are virtually impossible to calculate. **(Caretta e al 2006)**

Management of PITS differs according to location, severity, response to the initial therapy and comorbid conditions. In symptomatic benign tracheal stenosis the gold standard is surgical reconstruction (often after interventional bronchoscopy). Tracheal stenting for symptomatic cicatricial stenoses is reserved for patients with lesions that are deemed inoperable, due to local or general conditions **(Puma et al., 2000)**. When stenting is decided, silicone stent insertion is considered the treatment of choice in the presence of inflammation and/or when removal is desirable **(Phillips, 1998**). The treatment of choice is surgical resection with primary reconstruction (**Grillo and Donahue, 1996, Wain, 2003**). Special techniques are required if the subglottic larynx is involved. Best results are achieved at an initial corrective operation **(Grillo and Donahue, 1996)**.

Aim Of The Work:

This work aimed to investigate the management outcomes of patients who developed tracheal stenosis after tracheostomy or intubation

Patients and Methods

Our study was done in Cardiothoracic Surgery departments at Kasr Al Ainy Hospital, Cairo University on 54 patients who were mechanically ventilated due to several etiologies and identified with tracheal stenosis between June 2017 and June 2019. Inclusion citeria included patients were treated for tracheal stenosis developing after prolonged endotracheal intubation. Most of the patients were subjected to several forms of management according to the extent of the lesion.

The current study included patient demographics, clinical presentation, etiology of the laryngotracheal pathology, the location of the stenosis, the stage of the stenosis using various grading systems appropriate to the topography of lesion,

the type of corrective or reconstructive procedure performed, the type and duration of stent if used, the post-reconstruction complications, and the duration of follow-up.

Patient criteria

-Demographic data was obtained for each patient:

Age, sex, body mass index (BMI), co-morbid conditions.

-The following data regarding the tracheal stenosis were also obtained:

- post extubation symptoms, Days in ICU, duration of endotracheal intubation, diameter of tube during intubation. Symptoms such as dyspnea, stridor and dysphagia were recorded according to **the MRC Breathlessness Scale (Stenton, 2008)** , **Stridor grades (Shah et al 2007)** and dysphagia **scoring system** (**Mellow and Pinkas 1985**)

-Each patient underwent a standard pre-operative assessment, including physical examination, Routine laboratory tests, chest radiography to exclude other causes of dyspnea and stridor

Computed tomography of the neck/chest ± 3D reconstruction of the tracheobronchial tree was ordered to study the extent of the lesion prior to further evaluation in the operating theater. Direct bronchoscopy was then undertaken for a final and direct mapping of the lesion.

Mangment:

Rigid bronchoscope:

In 51 patients, rigid bronchoscope (KARL STORZ NDTec Walsdorf , Germany), was performed to evaluate vocal cords, glottis, cricoid and tracheal mucosa and wall. Rigid bronchoscopy was performed under general anesthesia in an operating room.

If the severity of stenosis was mild and the length of the stenotic segment was less than 1 cm, bronchoscopic treatment including repeated dilations, were applied. In the patients, who had a severe or moderate stenosis, resection was performed. Dilatation was done serially, by means of dilators starting from rigid infantile bronchoscopes to adult size. If the dilatation procedure was inadequate or in the patients who had a severe or moderate stenosis, surgical resection was considered. The classification of stenosis was done according to Cotton–Myer staging system **(Myer *et al* 1994)**

The lesion was also classified depending on its location (cervical vs. thoracic), length (1–3 cm vs. > 3 cm) and severity of obstruction (mild, moderate or severe).

We assessed the symptomatic relief as interviewing the patients in the next morning of the bronchoscopic intervention. Patients were followed at 1, 3, 6, 9 and 12 months after intervention with chest radiography and three-dimensional computed topography (3D CT).

Tracheal reconstruction:

Pre-operative Preparations

Among the 54 patients, we operated on 45 (resection and end to end anastomosis). The field of operation in post-intubation tracheal stenosis surgery was usually confined to the neck and sometimes a small part of superior mediastinum. Preparing a patient for surgical operation of post-intubation tracheal stenosis was simple and no complex procedure was needed. Most patients with this condition were young and therefore have a good cardiopulmonary status.

Important factors such as **Patient's cerebral status, Patient's laryngeal status and the patient's current airway status** were evaluated as part of the pre-operative preparation **(Abbasi et al., 2010)**

Operative procedure

Preoperative Preparation and Anesthesia

All surgical procedures were performed under general anesthesia, and with the use of standard techniques for airway operations. A rigid bronchoscope was used for assessment of the lesion and if dilatation was an option of management. Dilation was done serially, by means of dilators starting from rigid infantile bronchoscopes towards the adult sized bronchoscope. If the dilatation procedure was inadequate, surgical resection was considered.

Tracheal surgery

Out of 54 patients, 45 were subjected to tracheal reconstruction. Collar incision was applied in 30 cases (66.7%) because the stenosis level was in the cervical region; collar incision and ministernotomy were done in 14 cases (31.1%) the stenosis level was in the cervical region and thoracic mediastinum; one case (2%), a ministernotomy incision was used as the stenosis was in thoracic trachea. We followed the techniques described by **Pearson et al. (1975) and Grillo et al. (2004).**

In all patients, the orotracheal tube was placed, and dilation was performed using rigid bronchoscopy to allow a small caliber tube to pass below the vocal folds. After resection, the distal trachea was intubated to allow anastomosis of the posterior suture line and removed with the passage of the orotracheal tube while performing the anterior suture line.

The patient was placed in supine position with his neck extended by placing cushion under shoulder. The operative procedure is very similar to that described by **Mohsen et al (2018)** In all patients, a transverse collar incision was made; however, a manubriotomy was added if the impacted region was in the lower cervical down to the mediastinum.

Through a collar incision, the superior flap was elevated in the subplatysmal plane to the level of the hyoid bone, and inferior flap was elevated to expose normal trachea below the level of stenosis. The cricoid and the trachea were exposed with a division of the thyroid isthmus if needed. A midline incision at the level of stenotic segment was performed to identify the upper and lower limits of the stenosis, avoiding unnecessary resection of unaffected trachea or cricoid cartilage. Injury of the recurrent laryngeal nerves was avoided by confining sharp dissection to subperichondrial plane of the lateral wall of the trachea. Sharp dissection was used to separate the esophagus and the membranous parts of the trachea at the level of the stenotic segment. In cases where cricoid involvement was present, the anterior arch and rim of the lateral parts of the posterior lamina of the cricoid were removed to expose healthy mucosal edges.

Upward mobilization of the distal tracheal segment was achieved through blunt dissection of the anterior surface of the cervico-mediastinal trachea.

Two Vicryl VR 2/0 stitches were placed at the lateral edges of the distal trachea, the anesthesiologist flexes the neck, bringing the proximal end of the trachea downward, while the operator uses the previous 2 stiches to bring the distal end up, approximating the anastomotic line. During this maneuver, the proximity and tension at suture line was evaluated, and the need for a release procedure was determined.

Main maneuvers for releasing the trachea included:

1. Releasing the trachea from adhesions, and scar tissues of previous tracheotomy or surgical operations
2. Releasing the mediastinal trachea from the base of the neck down to the carina anteriorly
3. Releasing the superior segment of trachea, cricoid and thyroid cartilages up until the suprahyoid or infrahyoid bone anteriorly

To prevent cervical extension, .at the end of the operation, we placed heavy sutures to secure the chin to the chest (sternum) in the majority of patients. These sutures were removed 7-9 days after surgery.

Following completion of the operation, the majority of the patients were extubated on the surgical bed and were transferred to the recovery room while breathing spontaneously without the tracheal tube.

The outcome was judged good if patients had no limitation in activity and good voice. Outcome was deemed satisfactory if the patients had symptoms of dyspnea

on exertion and an adequate voice. Failure was determined by the need for reoperation or a permanent tracheostomy tube.

Patients were considered cured when free of symptoms for at least one year after the initial intervention (the last treated patient was followed for 11 months). If re-stenosis occurred, a follow up bronchoscopy (usually every 4 to 6 weeks for the first 6 months) then another intervention was applied. In most cases no more than 3 interventions were needed.

Tracheostomy methods:

Tracheostomy was process of creating an opening in the anterior wall of trachea.ST refers to placement of a tracheostomy cannula under direct vision after dissection of pretracheal tissues and incision of tracheal wall. In open surgical technique, a 2–3 cm long incision was made in the anterior neck midway between the cricoid cartilage and the sternal notch, the skin and platysma were dissected **(Zollinger** 2011**, Cameron 2016).** Strap muscles were then retracted laterally to expose the thyroid isthmus, which was then mobilized or divided. After adequate hemostasis was achieved, a cricoid hook or lateral stay sutures were used as needed to expose the trachea and then a small opening was made on the trachea. Often a Bjork flap was created, where part of a tracheal cartilage was incised, folded and sutured to maintain patency of the stoma. The tracheostomy tube was then inserted through this stoma.

Results

The present study was done in Cardiothoracic Surgery departments at Kasr Al Ainy Hospital, Cairo University on a total of 54 patients who were mechanically ventilated due to several etiologies and identified with P.I.T.S. between June 2017 and June 2019. Those patients were treated for tracheal stenosis developing after prolonged endotracheal intubation **Fig (1)**.

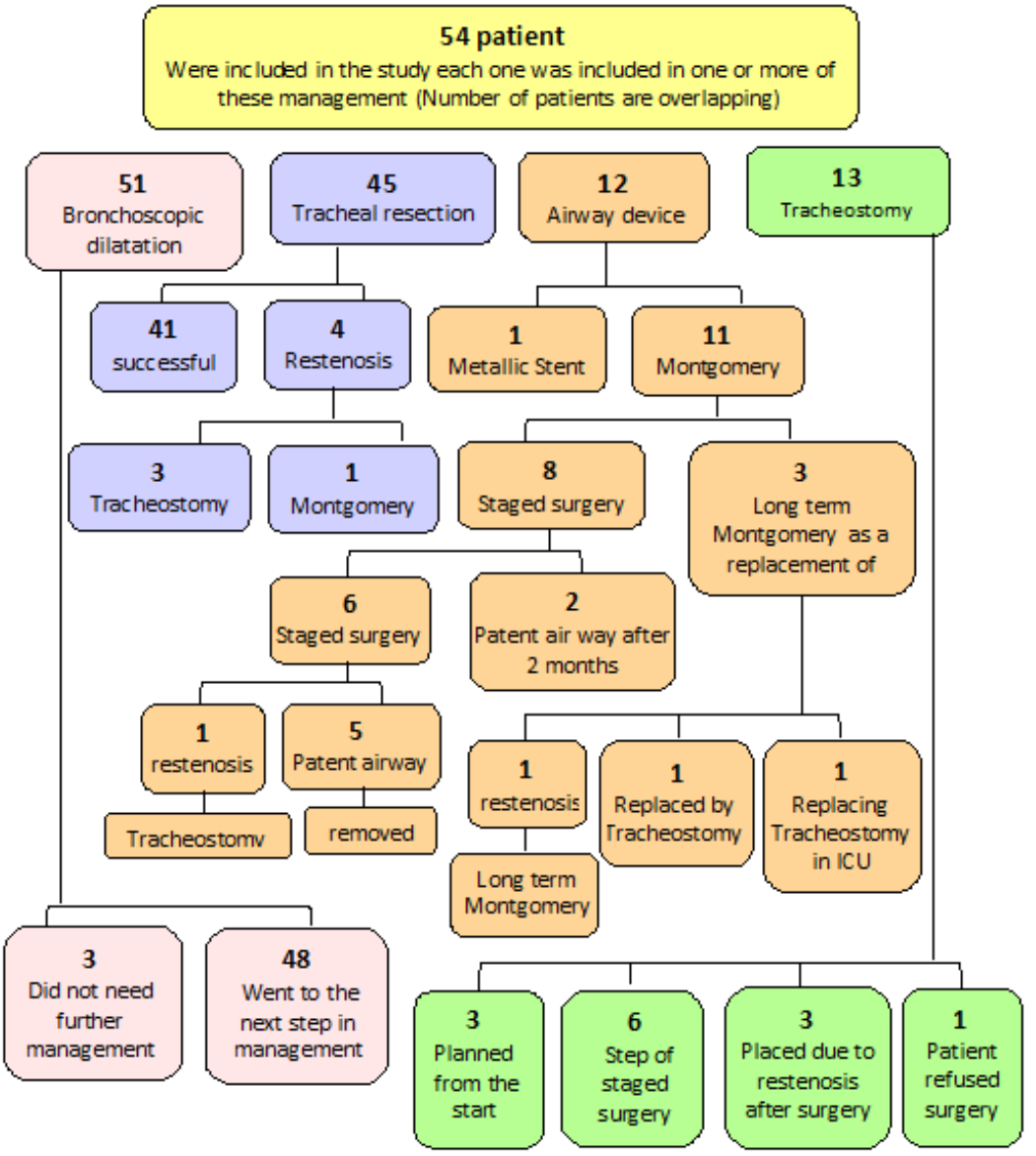


Fig (4) Number of patients included in the study and subjected to several forms of management according to the extent of the lesion

Demographics and clinical findings (Table 1)

Of the 54 patients, 42 (77.8%) were males and 12 (22.2%) were females with mean age (M± SD) of 29.2±12.13 years (range: 7 to 59 years). Their mean Body Mass Index (mean ± SD) was 27.71±3.07 ranged from 22-34 unit. The cause of intubation included: Trauma (Motor car accident and fall from height) 35 (64.4%), Postoperative 7 (12.9%) chest infection 7 (12.9%), neurological 4 (7.4%), and organophosphorous poison 1 (1.9%). Most of the trauma patients where males

(97%). Their time in ICU was 37.07±31.97 (range: 5 to 165 days). The mean duration of endotracheal intubation 22.61±20.79 days (range: 3 to 150 days)**.** The mean diameter of the tube was 6.76±0.50 cm with range of 5.5-8 cm.

After extubation, symptoms of tracheal stenosis (dyspnea and stridor) appeared within a range of one week up to one month. Most patients were with class III and class IV dyspnea and grade II and III stridor as shown in these symptoms appeared after a period ranged from 7-30 days

X ray and CT:

X ray and CT were done to all patients to exclude extra luminal compression and to locate size and length of stenosis. By CT, the location of stenosis ranged from 0.5 to 7 cm from the vocal cord with mean distance of 2.70±1.46 cm, and 2 to 10.01 from the carina with mean distance of 5.80±1.67 cm. The mean length of stenotic segment was 2.47±1.04 cm (range: 0.6 to 5 cm). The stenosis occurred subglottic in 23 patients (42.6%), in upper 1/3 trachea in 19 patients (35.2%), in the Mid 1/3 trachea in 8 patients (14.8), in the lower 1/3 trachea in 3 patients (5.6%).One case had double stenosis in the upper 1/3, middle 1/3 trachea (1.8%). (**Fig.2, 3,4,)**.

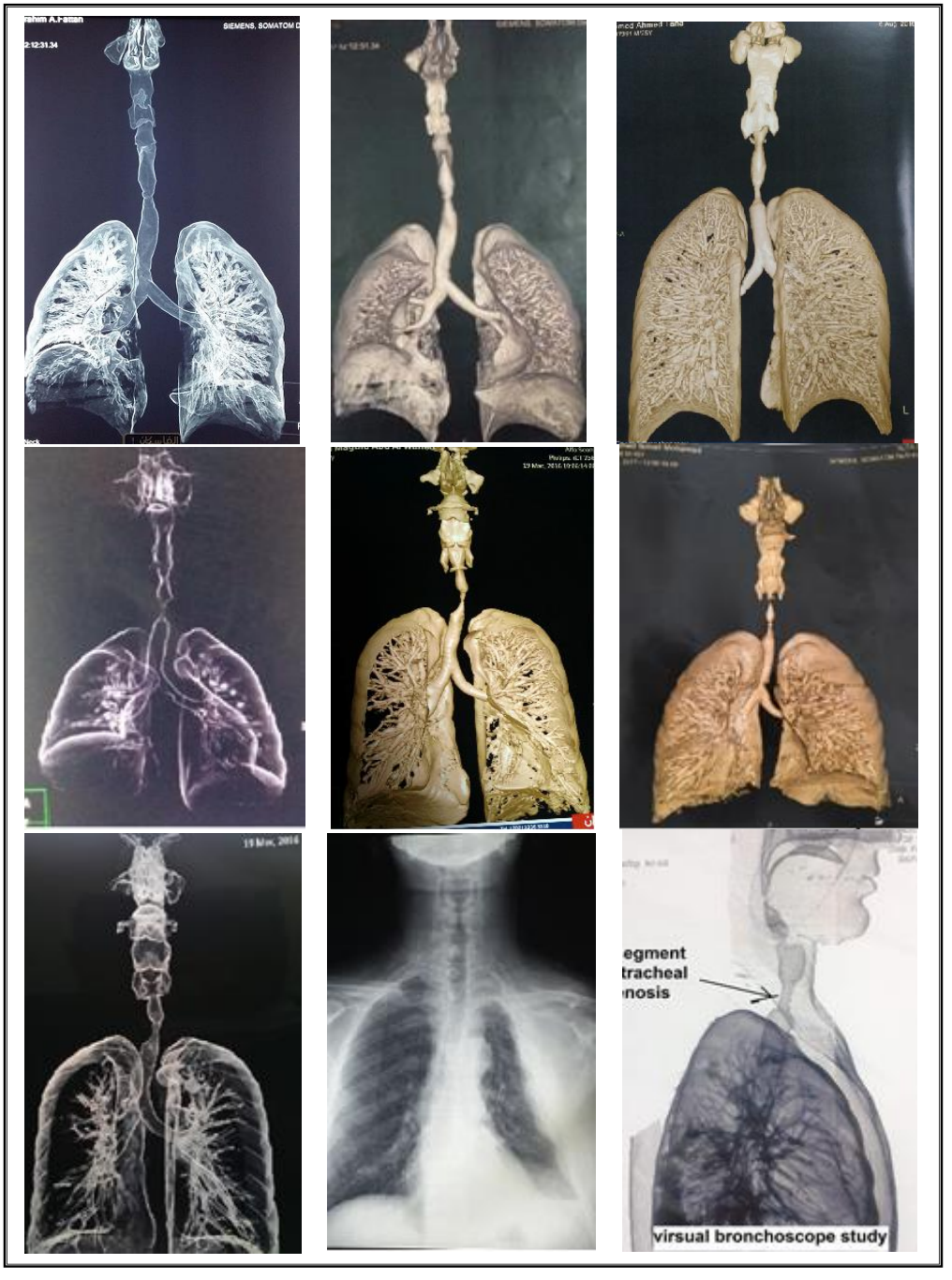
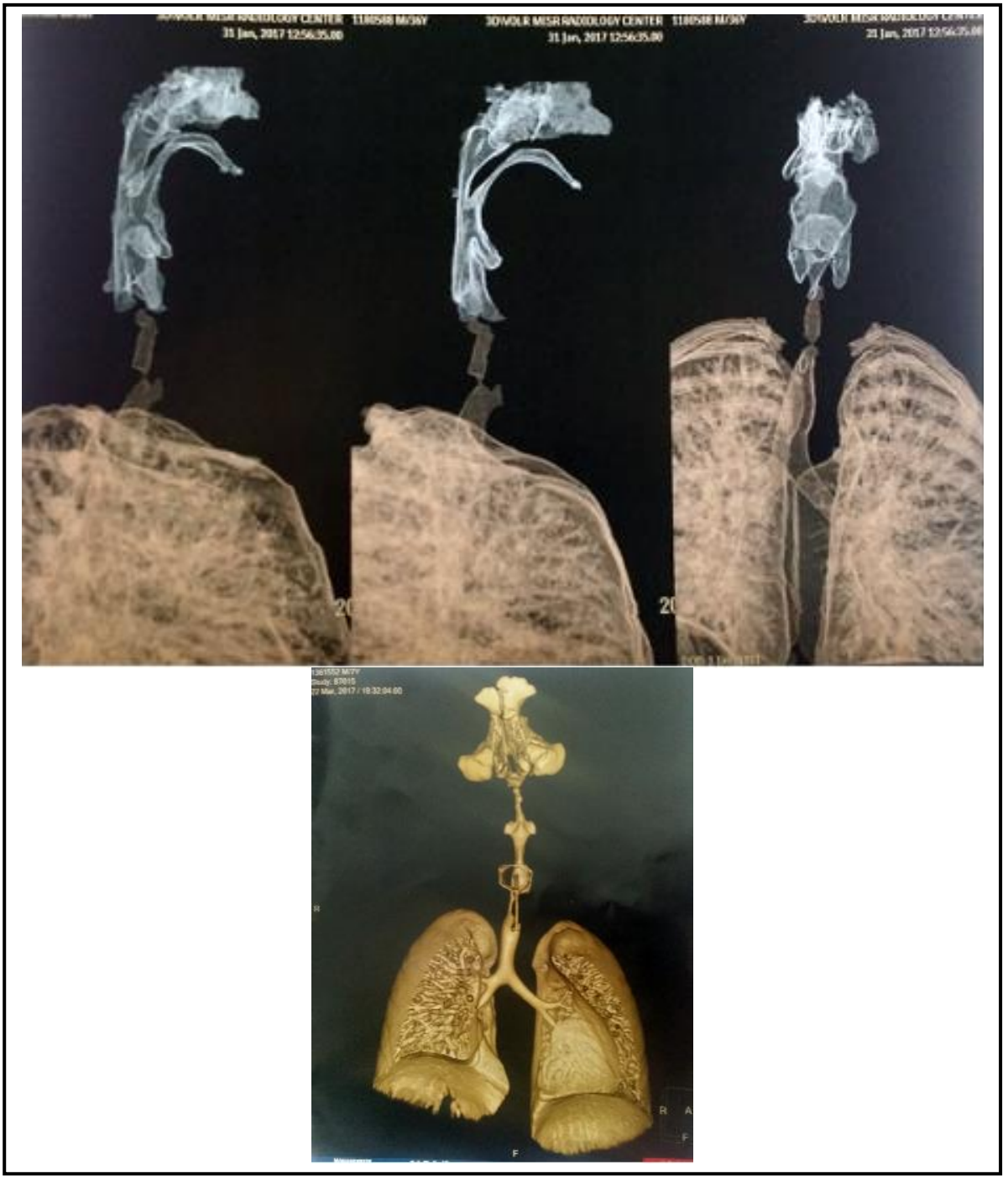


Fig (2): CT. slides of tracheal stenosis showing stenosed area in the subglottic upper 1/3 of the trachea.

Fig (3): Tracheal stenosis in the middle 1/3 of the trachea



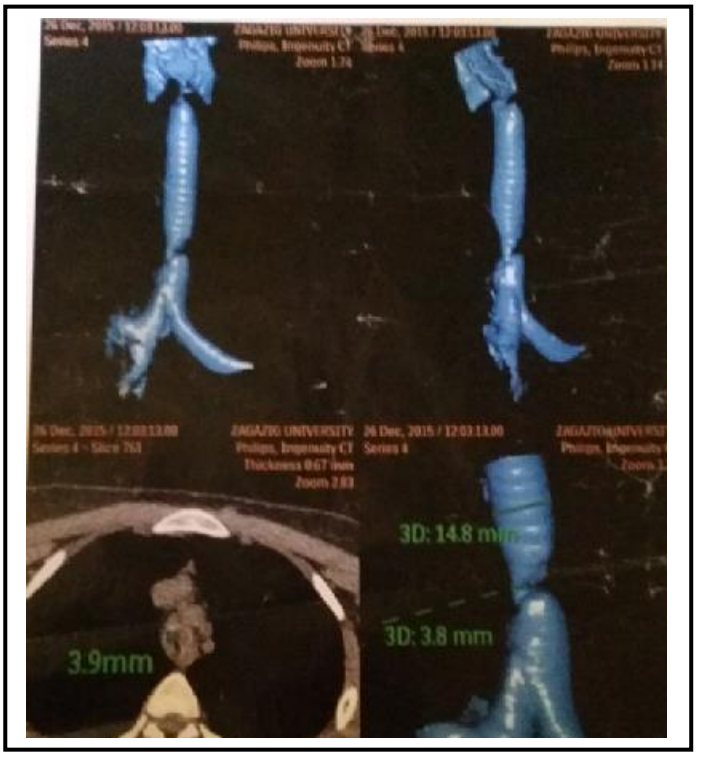


Fig (4):Tracheal stenosis in the lower 1/3 of the trachea.

The vocal cord Mobility:

Vocal cord mobility was evaluated upon removal of the bronchoscope and confirmed in the 51 patients who underwent rigid bronchoscopic procedures. Three (5.9%) patients did not undergo rigid bronchoscopy as they presented to us with impaired airflow and required and emergency tracheostomy. Bilateral VC paralysis was confirmed by the ICU intensivist during his trial to insert an endotracheal tube. Three (5.9%) patients showed unilateral VC mobility, and 1 (1.9%) patient showed sluggish mobility in both vocal cords.

Table 1: Preoperative patient data		
Item		**No. (%)**
Sex Male Female		**N=54** 42 (77.8) 12 (22.2)

Age Range Mean ± SD		5-65 29.2±12.13
Body Mass Index Mean ± SD		29.2±12.13
Reason of intubation Trauma Post-operative PO Chest infection Neurological Organophosphorous poison		35 (64.8%) 7 (12.9%) 7 (12.9%) 4 (7.4%) 1 (1.9%)
Diameter of tube during intubation 5.5 6 6..5 7 7.5		2 (3.7%) 4 (7.4%) 18 (33.3%) 24 (44.4%) 6 (11.1%)
Symptoms after extubation: **DyspneaMRC classification** Grade II Grade II Grade II Grade II **Stridor** Grade II Grade II Grade II Grade II		 0 (0%) 1 (1.9%) 11 (20.4%) 42 (77.8%) 6 (11.1%) 18 (33.3%) 30 (55.6%) 0 (0%)
Endoscopic assessment, n (%) **Anatomical site of stenosis:** Subglottic Upper1/3 trachea Mid 1/3 trachea lower 1/3 trachea Multiple (upper 1**/**3, middle 1/3)		 23 (42.6%) 19 (35.2%) 8 (14.8%) 3 (5.6%) 1 (1.8%)
Mobility of vocal cords Bilateral mobile vocal cords Unilateral immobile vocal cord Sluggish mobility of vocal cords		**N= 51** 47(87%) 3 (5.9%) 1(1.9%)

Mangment

Bronchoscopic diagnosis and dilatation: (Table 2)

Out of 54 patients, 51 subjected to bronchoscopic diagnosis. Size of bronchoscopes varied; Suckling to infant 0 child (0%), suckling to child 6 (10%). suckling to adolescent 23 (46%). Suckling to adult 22 (44%).

Three patients didn't undergo Bronchoscopic dilatation as one patient 59 years male entered the ICU with a stroke (a total of 90 days in the ICU) with a 25 day on mechanical ventilation. The patient left the hospital with a permanent tracheostomy. The second patient, was a 7 year old child, with a fall from height (FFH) trauma, who underwent urgent tracheostomy. The third patient, a 24 yr. old male, with a FFH trauma, who had an urgent tracheostomy, during a 15 day mechanical ventilation and a 5 month stay in the ICU. The patient then replaced the tracheostomy with a Montgomery

Bronchoscopic findings and interventions are summarized in table 2. The luminal narrowing was classified by the Cotton Myer grading system. Grade I was observed in 1 patients (1.9%), grade II was evident in 20 patients (37%), grade III in 22 patients (40.7%), and grade IV in 8 patients 15.7% (Fig 5)

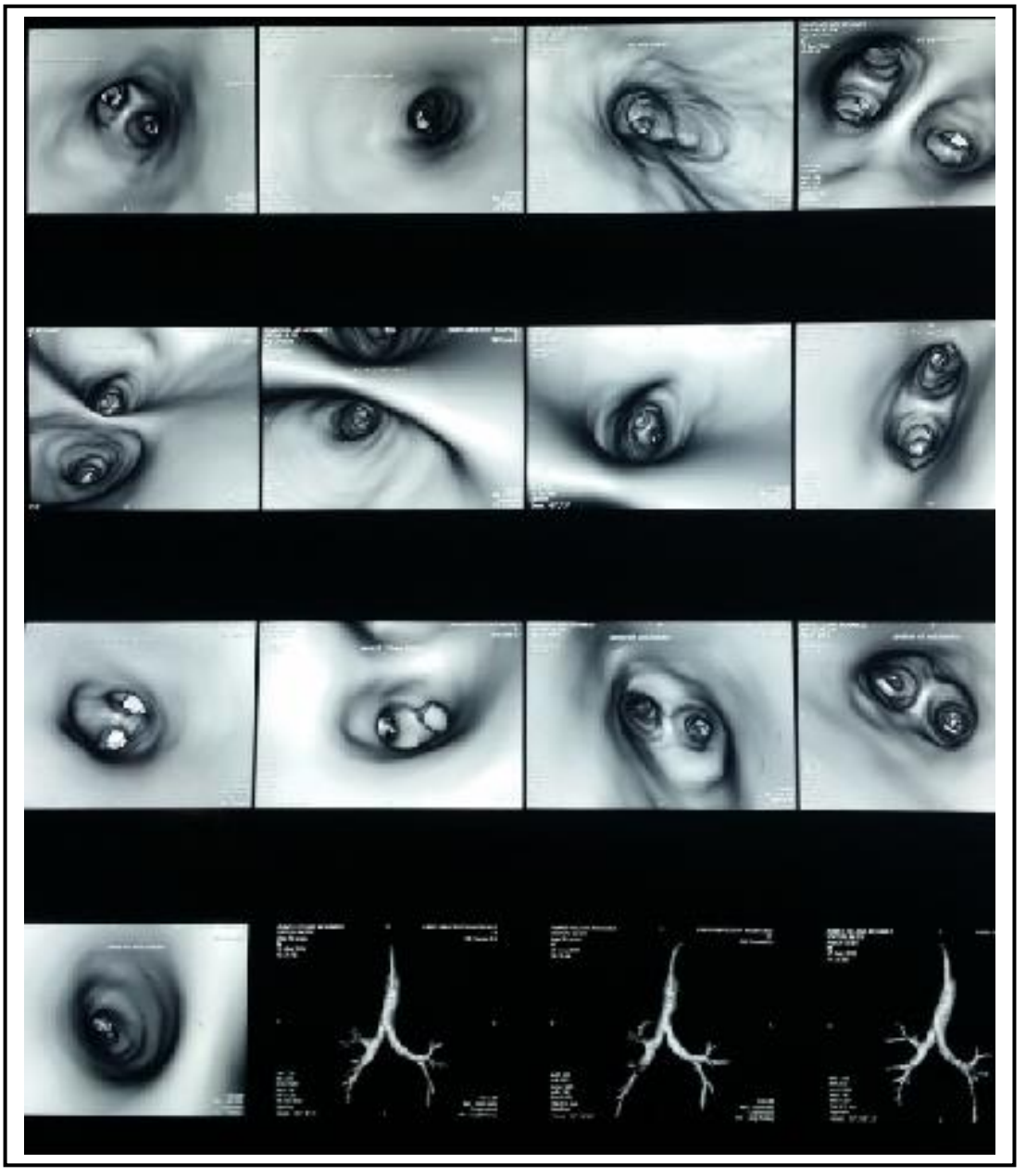


Fig (5): Diagnostic virtual bronchoscopy showing areas of stenosis

Thirty four patients (67%) developed recurrent tracheal stenosis after the first bronchoscopic intervention, and repeated from 1 to 7 times according to the case with time interval range from 1 week to 6 month.

Bronchoscopic dilatation was successful in **3** cases, 7 cases showed mild improvement and 41 failed where they went to the next stage in our management,.

Mucosa was normal in 6 patients (11.8%), congested in 23 patient (45%), and with irregular circumferential in 22 patients (43%).

Table 2: **Bronchoscopy**

Item	**No. (%)**
Size of bronchoscopes:	**N=51**
Suckling to infant	0 (0 %)
Suckling to child	6 (10 %)
Suckling to adolescent	23 (46 %)
Suckling to adult	22 (44 %)
Characteristics of the lesion at bronchoscopy	
Cotton Myer grade:	
I	1 (2 %)
II	20 (39.2 %)
III	22 (43.1%)
VI	8 (15.7 %)
Mucosa:	
Congested	23 (45.7 %)
Irregular circumferential	22 (43.7 %)
Normal	6 (11.8%)
Number of repetition of bronchoscopy:	
1	17 (33.3 %)
2	11 (21.5 %)
3	16 (31.4 %)
4	3 (5.9 %)
6	2 (3.9 %)
7	1 (2 %)
Multiple	1 (2 %)
Interval between each dilatation	
0	17 (33.3 %)
1 week	11 (21.5 %)
2 weeks	11 (21.5 %)
3 weeks	9 (17.6 %)
4 weeks	1 (2%)

The outcome of bronchoscopic dilatation:		
Successful		3 (6%)
Mild improvement		7 (14%)
Failed		41 (80%)

Stent / Airway: (Table 3)
Twelve out of 54 patients (22.2%) were subjected to stenting/airway. In Eleven patients (20.3%) we used Montgomery tube, while metallic stent was applied only to one patient (1.8%). In one (1.8%) of the 11 patients, Montgomery tube was left long term for very close follow-up with precautions to be kept dry with regular use of a nebulizer due to restenosis.

In 8 patients (14.8%) Montgomery tubes was applied after resection anastomosis surgery to ensure tracheal patency. The other 3 (5.5%) patients Montgomery tube was planned as a replacement for the unavailable metallic stent.
Two of the twelve patients (16.7%) had Montgomery tube for 2 months. Six patients (50%) had it for 6 month, in which 5 of those 6 patients resulted in a patent airway after removal, and one patient had the Montgomery tube replaced by a permanent tracheostomy due to restenosis.

Three patients (5.5%) had long term Montgomery tubes. One of the three patients applied a long term Montgomery due to restenosis after surgical resection anastomosis, the other one out of the three patients applied a permanent tracheostomy due do tracheomalacia after repeated trials of dilatation, and last one of the three patients had a Montgomery tube applied as a replacement of an urgent tracheostomy which was inserted upon patient arrival in the ICU, as part of a plan for future surgical resection. One out of the twelve patients had tracheal stent for 1 year and 4 month where the stent was removed after an incidence of sliding, and surgical resection anastomosis was done. (8.3%) **(, Fig. 8)**

Table 3: **Stent / Airway**		
Item		**No. (%)**
Stent duration:		**N=12**
Montgomery tube 2 month		2 (16.7 %)
Montgomery tube 6 month		6 (50 %)
long term		3 (25 %)
Tracheal stent for 1 year and 4 month		1 (8.3 %)

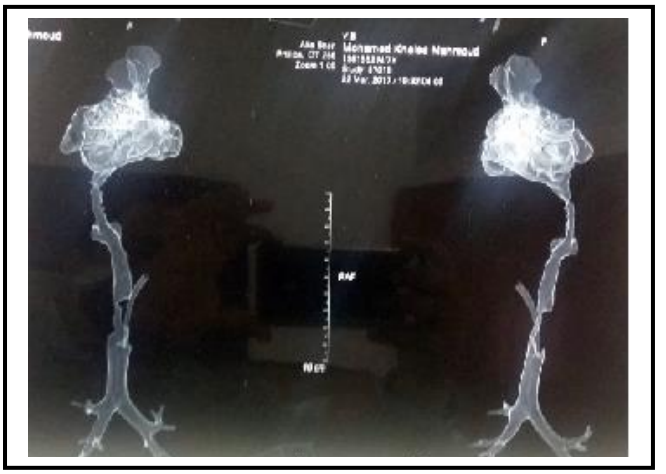


Fig (8): Radiological appearance of Montgomary tube inserted in the stenosed area

Tracheal reconstruction: (Table 4)

Operative and postoperative findings

Out of the 54 patients, 45 patients (83.3%) were submitted to tracheal resection and primary anastomosis. It was successful in 41 (91.9%) patients with a patent airway and failed in 4 (8.8%) due to restenosis. The rest of the 9 (16.6%) patients out of the 54 patients who didn't have a chance for resection anastomosis are as follows:

Three out of the 9 patients had a patent airway after successful bronchoscopic dilatation trials.

Three out of the 9 patients had a long term Montgomery tube, one of which was due to tracheomalacia after repeated bronchoscopic dilatation where surgery couldn't be applied, the other as a replacement of tracheostomy as explained before. And the last one applied a long term Montgomery as a replacement of metallic stent (as it was not available) for a patient who refused surgery.

Three of the 9 patients had a permanent tracheostomy, one of which 59 yr. patient presented to us with a stroke, and tracheostomised upon arrival in the ICU, and the other was a 7 year old patient that applied a tracheostomy as his surgery was delayed till puberty. And the last patient was a 13 yr. old MCA trauma patient that had an urgent tracheostomy applied upon arrival in the ICU.
Collar incision was applied in 30 cases (66.7%) because the stenosis level was in the cervical region collar incision and ministernotomy were done in 14 cases (31.1%) the stenosis level was in the cervical region and thoracic mediastinum; one case (2%), a ministernotomy incision was used as the stenosis was in thoracic trachea. (Fig. 26)

A variety of release procedures were used to achieve tension- free anastomosis in 26 out of the 45 patients, as described in Table (15). In the 26 patients, the anterior wall of the trachea was bluntly dissected to the level of the carina, and no additional maneuver(s) were necessary in 14 (31.1%) patients. Additional suprahyoid release was performed in 4(8.9%) patients, Mediastinal release in 3 (6.7%) patients, Supra & Infrahyoid release in 1(2.2%) patient and supra & infra hyoid, and mediastinal in 1 (2.2%) patient. Mediastinoscopic tracheal and bilateral bronchial release MTBBR maneuver was used in 3 (36.5%) Patients **(Table 15)**. The decision for the type of release depends on the tension at the suture line during surgery. The mean length of the resected segment was 2.6±1.02 cm ranging from 0.6- 4.2 cm.

All patients were extubated on table and taken to the intensive care unit. They were followed up in the intensive care unit for approximately 1 day. The suture holding the lower end of the chin to the anterior chest wall, and were removed on day 3 postoperatively on average.

Out of 45 patients subjected to tracheal reconstruction, the surgery was successful in 41 patients where they got patent airway (91.1%) and 4 failed due to restenosis (8.9%). 3 of which applied with a permanent tracheostomy and one continued with a long term Montgomery tube.

Table 4: **Tracheal reconstruction surgery**

Item		**No. (%)**
Type of incision:		**N=45**
Collar incision		30 (66.7 %)
Collar incision + manubriotomy		14 (31.1 %)
Manubriotomy		1 (2.2 %)
Type of release		
No release		19 (42.2 %)
Anterior release		14 (31.1 %)
Anterior release + suprahayoid release		4 (8.9%)
Anterior release Mediastinal		3 (6.7 %)
Anterior supra & infra hyoid Mediastinal		1 (2.2 %)
Mediastinoscopic tracheal and bilateral bronchial release MTBBR		3 (6.7%)
Outcome of tracheal reconstruction:		
Patent airway		41 (91.1 %)
Failed (restenosis)		4 (8.9 %)

Tracheostomy:

Out of 54 patients 13 (24%) subjected to tracheostomy.

Three (23.1%) patients out of the 13 patients, tracheostomy was applied due to restenosis after resection anastomosis surgery.

Out of the 13 cases subjected to tracheostomy, 10 (76.9%) patients were planned for tracheostomy directly upon arrival to the ICU due severe dyspnea and stridor. Six (60%) out of the 10 patients later on underwent Tracheal resection anastomosis with a patent airway outcome **(Fig. 9)**

Four (40%) out of the 10 patients were planned with a permanent tracheostomy, and divided as follows:

- The 1st patient was planned for tracheal resection anastomosis but delayed till puberty.
- The 2nd patient was a 59 years old presented to us with a stroke with no other choice of management but a permanent tracheostomy.
- The 3rd patient was an inoperable 13 years old road traffic accident victim.
- The 4th patient, a 30 year old female with post-operative tracheal stenosis, refusing surgery. The tracheostomy was later on replaced by a long term Montgomery tube working as a tracheal stent.

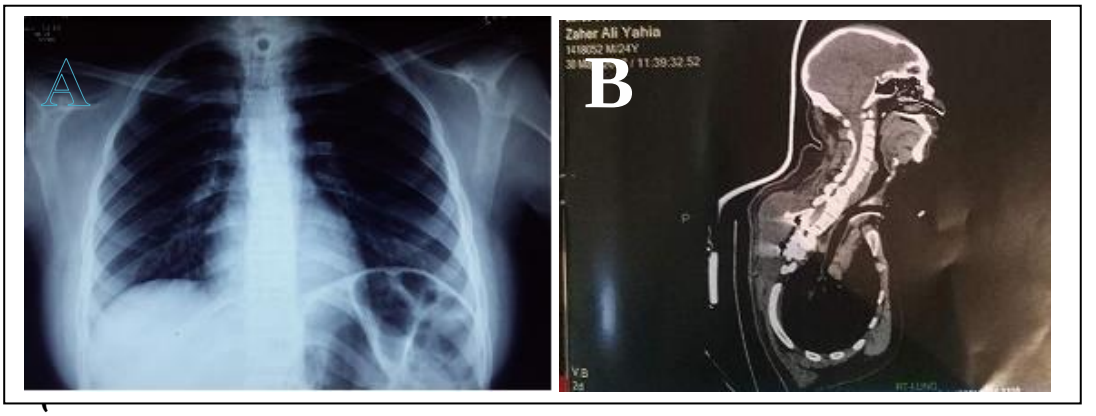


Fig (9): (A) X ray showing site of insertion of tracheostomy.

(B) CT sagital section lateral view showing tracheostomy tube and the site of insertion at the stenotic segment.

Complications: (Table 5).

The main complication statistically appeared to be **recurrent tracheal stenosis (restenosis)**, commonly found after trials of bronchoscopic dilatation, with a number of 48 out of 51 patients to develop restenosis and which were in turn prepared for the next step in our management.

Surgical emphysema in 5 patients, **hematoma** in 1 patient, **vocal cord paralysis** in 6 patients, 3 with unilateral paralysis, and 3 with bilateral paralysis which in turn couldn't undergo surgery.

Dysphagia (Grade 2) in a number of 26 patients was found to occur more in patients having Montgomery or tracheostomy tubes, which was cured in a time interval of 2 weeks.

Mild **Wound infection** occurred in 7 patients, treated easily by antibiotics and anti-inflammatory drugs.
There was no **mortalities** among our patients.

Table (5): Outcome and complications according to management

Management	**No**		**No**	**Outcome**		**Complications**	**No**
Bronchoscopic dilatation	51			Asymptomatic without R. stenosis	3	Restenosis	48
				Asymptomatic with R. stenosis	6		
				Failed	41		
Stent	12	Montgomery tube 2 month	2	Asymptomatic with R. stenosis Asymptomatic without R. stenosis	1 1	Dysphagia Dysphagia Restenosis Hematoma	1 4 1 1
		Montgomery tube 6 month	6	Asymptomatic with R. stenosis Asymptomatic without R .stenosis	2 4		
		Long term	3	Permanent tracheostomy	3		
				Slipped stent followed by resection anastomosis	1		
Tracheal resection	**45**	without release	19	Asymptomatic with R. stenosis Asymptomatic without R. stenosis	4 15	Surgical emphysema Dysphagia Wound infection Restenosis	1 4 3 4
		with release	26	Asymptomatic with R. stenosis Asymptomatic without R. stenosis	1 25	Surgical emphysema Dysphagia Wound infection	1 4 2
Tracheostomy	13	Couldn't undergo surgery Applied after surgery	3 9 1	Asymptomatic with R. stenosis 12	12	Surgical emphysema Dysphagia Wound	3 3 2

		Delayed till puberty				infection	

R. stenosis = Radiological stenosis

Discussion

The present study was done on 54 patients who were mechanically ventilated due to several etiologies and identified with tracheal stenosis Inclusion criteria included patients were treated for tracheal stenosis developing after prolonged endotracheal intubation.

The diagnosis of the included patients was confirmed with plain radiography, computed tomography (CT), 2D/3D virtual bronchoscopy, and/or flexible/rigid bronchoscopy. The lenghth of stenosis ranged from 0.5 to 7 cm from the vocal cord with mean distance of 2.70±1.46 cm, and 2 to 10.01 from the carina with mean distance of 5.80±1.67 cm**.** This is more or less similar to the study of **(Herrak et al., 2014)** who recorded that the location of stenosis in relation to the vocal cords was in average 2.8 cm and from 1 cm extreme to 7 cm. Its distance from the carina was on average 5.12 cm and extremes of 2–8 cm. The mean distance of stenosis to vocal cord by **(Ulusan et al., 2017)** was 3.41 cm (range, 1.50 to 8.00 cm). The mean length of the stenosis was 2.14 cm with a median of 2.00 cm. These measurements were important to be taken into account for the various therapeutic indications.

The mean length of stenotic segment was 2.70±1.46 cm (range: 0.5 to 7cm). Although the mean length of the stenotic segment in our study was higher than that in the other published studies **(Abouarab et. Al 2017, Salloum et .al. 2021)** (2.7 compared to 2 cm) which is mainly due to the long duration of intubation in the ICU, this in no way affected the feasibility of surgery, as tracheal resection and anastomosis remained the first line of surgical management for all patients in our study, even in stenotic segments longer than 3cm also gave comparable successes in the form of resolution of symptoms with no postoperative radiological stenosis.

Tracheal stenosis most commonly occurs at the level of the stoma or above the stoma (suprastomal) but below the vocal cords (subglottic). The site of stenosis in the present study was localized subglottic in 23 patients (42.6%), in upper 1/3 trachea in 19 patients (35.2%), in the Mid 1/3 trachea in 8 patients (14.8), in the lower 1/3 trachea in 3 patients (5.6%).One case had double stenosis in the upper 1/3 and middle 1/3 trachea (1.8%) in agreement with **Sue and Susanto (2003)** who mentioned that tracheal stenosis occurs at the site of tracheal tube cuff or at the site of the tube's distal tip.

Bronchoscopic diagnosis and dilatation

A study conducted by **(Carretta et al., 2006)** suggested that the most reliable methods for diagnosing PITS were rigid bronchoscopy and fiber optic

bronchoscopy. In our work we used rigid bronchoscope with several sizes according to the case in a trial of dilatation of the stenotic part, sizes used in dilatation passed as follows Suckling to infant and couldn't dilate more 0%, suckling to child in 10%, suckling to adolescent in 46%, and suckling to adult where all the sizes of the bronchoscopes used passed though the stenotic segment 44% of the patients, The size of the bronchoscope can be used as a gauge of the stenosis.

Considering restenosis in our present study, 48 patients (88%) developed recurrent tracheal stenosis after the first bronchoscopic intervention. Stenosis repeated from 1 to 7 times according to the case with time interval ranged from 1 week to 6 month. Bronchoscopic dilatation failed and restenosis occurred Most of these cases had stenotic segment ranged from 2 to -4.2 cm.

Herrak et al (2014) believed that if the treatment is limited to a single meeting of dilation, the risk of expansion of restenosis is close to 90%. If restenosis take place, further medical treatment is the alternative a transitional or permanent tracheal restorative surgery.

Conservative treatments may be carried out for stenosis smaller than 1 cm in length with no circumferential scarring and no loss of cartilaginous support **(Sharpe et al., 1996**).

Re-stenosis at the site of the intervention (is a result of an abnormal healing process) or a stent "event" (obstruction, migration or halitosis) were the most common reasons of a multiple procedure. After the first bronchoscopy, the treatment depends on the profile of the development of the stenosis (stabilization or recurrence), also on the case and the equipment of the stricture by endoprothesis.

Airway Devices:

In this study, airway devices were applied to 12 patient, where Montgomery tube airway was used in 8 patient to ensure tracheal patency after surgical resection anastomosis, and in 3 patients as a replacement device for the unavailable metallic stent in cases of restenosis after tracheal surgery, tracheomalacia, or in the case of a patient refusing surgery.

In our study we had only used one metallic stent which was complicated by sliding down on the carina after 16 monthes of placement and received surgical management. In similar study by **Lim et al (2012)** Montgomery tube was successfully removed in 40% of patients. In 60% of patients, the stent could not be removed and they received surgical management. These results demonstrate that the stent can be removed successfully only in a limited number of patients. The poor prognosis reflects not only the need for advances in bronchoscopic intervention, but also the shortage in the pathophysiological understanding and early diagnosis of PITS. Airway Devices proved valuable in the management of airway stenosis, both malignant and benign, being indicated for symptomatic relief of severe dyspnea **(McGrath et al., 2012).**

Resection and anastomosis

The observed results in our study showed a total favoring tracheal resection and end to end anastomosis in 45 out of 54 patients (83.3%). This is almost similar to the results published by many authors including **Grillo et al (1996), George et al (2005), Marques el al (2009) Elsayed et al (2016).**

Surgical reconstruction is the gold standard in the management of benign postintubation tracheal stenosis **(Tsakiridis et al., 2012). The definitive** treatment after tracheal intubation strictures is based on resection anastomosis thick segment. The achievement of the anastomosis is facilitated by lowering laryngeal or when an important mobilization is necessary just to free the tracheobronchial bifurcation (stenosis particularly long) **(Ciccone et al., 2004)**.

In our study, 57% of patients needed some form of a release incision and mobilization to have a safe tension-free anastomosis where anterior release was done alone in 31.1% of the patients. This is lower than the percentage recorded by **Mohsen et al. (2018)** who found that 85% of patients needed release incision and mobilization However their study was done only on patients with long segment tracheal stenosis more than 4 cm but in our study the stenotic tracheal segment was variable short & long segments, ranging from 0.6- 4.2 cm.

The surgery was successful in 41 patients (91.1%), they had patent airway which is more or less similar to results of **Sarper et al (2005)** (96%) and **Mohsen et al. (2018)** (86%)

A chin stitch has been proposed to protect against disruption of the suture line due to hyperextension during the early postoperative period. In the current study, all patients were extubated after the operation and taken to the intensive care unit. They were followed up in the intensive care unit for approximately one day. The suture holding the lower end of the chin to the sternum of all was removed on day 3 postoperatively on average.

Tracheostomy:

There are many reasons for performing a tracheostomy in ICU patients. Amongst the most important are the need for a long-term airway, the need for less sedation and analgesia, easier weaning, presence of an upper airway obstruction and secondary to trauma or surgery in the face/neck region. **Flaatten et al (2006)**

In the present study out of the 54 patients, 13 patients subjected to tracheostomy. Ten patients were planed from the beginning due severe dyspnea and stridor, with an anticipated long stay on a mechanical ventilator, in the ICU where other forms of management were impractical. Three patients had undergone tracheostomy due to failure of the other methods of management as tracheal stenosis and restenosis after surgical resection and anastomosis of the trachea. One patient couldn't undergo staged surgical techniques as the operation was delayed till puberty. Our results go with the results of Flaatten **et al (2006)** who said that the main clinical indications for tracheostomy were anticipated

prolonged endotracheal intubation and ventilation, or to secure the upper airway in trauma and acute upper airway obstruction.

There was no mortality in our study including the tracheostomy patients, which differs from some other reports. *Walz et al (1998), Engoren* **et al (2004)** *and* Flaatten **et al (2006)** who repored a morality 64.1%, 51.3%and 37.2% respectively in patients with tracheostomy.

Regarding the complications observed, wound infection was observed in seven patients (12.9%) following resection anastomosis, surgical emphysema in five patients (9.2%), dysphagia in 16 patients, restenosis in nine patients (16.6%), and hematoma was observed in one patent (+1.8%). Putting in consideration that one patient may suffer from multiple complications, the complications were not statistically different according to the type of definitive management (Fisher's exact p=0.46).

Wound infections in the seven patients were observed with continuous change of dressing in the ward, and were managed conservatively with in the ward with no recurrence or major adverse effects.

Surgical emphysema was observed almost immediately after discharge from the operating room, was non progressive and resolved within 48 hours. It was managed conservatively in all affected cases with no recurrence or major adverse effects.

Dysphagia was by far the most common complication and was particularly observed in resections involving the higher segment of the trachea (Laryngotracheal and subglottic). All cases where managed conservatively and dysphagia resolved within the duration of hospital stay.

Restenosis, observed in 48 patients who were managed by bronchoscopic dilatation, and was due to granulation overgrowth at the anastomotic site. Excessive granulation overgrowth required re-intervention and staged repair.

Restenosis was observed in 4 patients out of 45 patients who underwent resection anastomosis, due to excessive overgrowth of granulation tissue, which were in turn adequately managed using staged repair for one year. This particular adverse event was described by **Abouarab et al (2017).** And its incidence could be reduced by using absorbable sutures such as polydioxanone as employed in our study.

Hematoma appeared in one patient with during the insertion of a permanent tracheostomy, and was treated conservatively during his hospital stay.

Conclusion and Recommendations

In conclusion tracheal resection and end-to-end anastomosis are the most efficient of all techniques in cases without medical contraindications. Rigid bronchoscopy and tracheal dilation, possibly with placement of a stent, may be the only treatment required for less serious lesions and can be used to provide

time to plan a definitive procedure in more severe cases. Montgomery tubes are efficient airway devices in maintaining the patency of the trachea in pre/ post-operative cases.

Tracheostomy is usually the first and last plan of management applied in the ICU where all the other methods of management are not available.

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