Tanaffos (2010) 9(4), 9-21

Surgical Treatment of Post-Intubation Tracheal Stenosis

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ABSTRACT

Incidence of post-intubation tracheal stenoses is relatively high in Iran and the majority of tracheal surgeries are performed to treat these strictures. Therefore, it is important to become familiar with the nature of tracheal stenoses and know their treatment methods. Most surgeons learn different methods of tracheal surgery through operating on cases of post-intubation tracheal stenoses and apply these methods for surgical operation of tracheal tumors. We mainly focused on the technique of tracheal surgery, patient selection, and pre-op and post-op equipments required. Other related fields such as anatomy of the trachea, bronchoscopy, imaging, laser therapy and stenting are mentioned when necessary. ***(Tanaffos2010; 9(4): 9-21)***

Key words: *Surgical treatment, Tracheal stenosis, Resection and Anastomosis*

INTRODUCTION

Incidence of post-intubation tracheal stenoses is relatively high in Iran and the majority of tracheal surgeries are performed to treat these strictures. Therefore, it is important to become familiar with the nature of tracheal stenoses and know their treatment methods. Most surgeons learn different methods of tracheal surgery through operating on cases of post-intubation tracheal stenoses and apply these methods for surgical operation of tracheal tumors (1-6). Thoracic surgeons, otolaryngologists, and pulmonologists are three groups of specialists that are able to manage post-intubation tracheal stenoses.

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Received: 25 June 2010

Accepted: 28 August 2010

They usually have similar opinions regarding the treatment of malignant and benign tracheal lesions and can function well together as a team. However, disagreements and controversies always exist which can result in different treatment planning for patients. As a consequence, sometimes the proper treatment is not performed for patients or is done very late. This study aimed to evaluate and discuss different methods for surgical treatment of tracheal stenoses by focusing on the facts and considering the equipments present in medical centers all over the country. Special attention was paid to the present situation of these patients in the country and the strengths and weaknesses in this respect. We mainly focused on the technique of tracheal surgery, patient selection, and pre-op and post-op equipments required. Other related fields such as anatomy of the

trachea, bronchoscopy, imaging, laser therapy and stenting are mentioned when necessary. Our main discussion is about post-intubation tracheal stenoses. The surgical procedure used for such strictures can be employed for the treatment of other tracheal lesions or conditions (tumors, congenital diseases, trauma) as well. However, some differences exist in this respect which are briefly discussed in this review article. The author and colleagues' points of view are also presented. These opinions are based on the author's extensive clinical experience gained in the past 25 years (1993-2008) via operating on more than 1000 patients with tracheal lesions (7-14). The following subjects are discussed in this article:

- Pre-operative preparations
- Position of patient on the surgical operating bed and anesthesia considerations
- Selecting the type of incision and methods of accessing the lesion
- Releasing the trachea from adjacent tissues, dissecting the attachments and adhesions caused by tracheostomy or previous surgeries
- Determining a suitable location for circumferential dissection of the trachea for surgical resection of the stricture
- How to resect the lesion
- How to release the trachea in order to reach the two cut ends together after resecting the stricture
- Anastomosing the 2 cut ends of trachea after resecting the lesion
- Covering the site of anastomosis
- Inserting a drain and suturing up the wound
- Sutures securing the chin
- Extubation and insertion of tracheostomy tube or other stents post-operation
- Subglottic stenoses

Pre-operative Preparations

The field of operation in post-intubation tracheal stenosis surgery is usually confined to the neck and sometimes a small part of superior mediastinum. Therefore, there is usually no profound post-surgical effect on patients. Additionally, as the result of treating the stricture and opening the airway, the patients are usually in a much better condition post-operatively compared to their pre-operative status. Among 571 patients, we operated on 505 of them through a cervical incision (15). Similar statistics were reported by other researchers(16-18). Preparing a patient for surgical operation of post-intubation tracheal stenosis is simple and no complex procedure is needed. Also, most patients with this condition are young and therefore have a good cardiopulmonary status. They usually enjoy a fast recovery after the surgery. Important factors that should be evaluated as part of the pre-operative preparation are summarized in Table 1.

Table 1. Important factors that should be evaluated before resection of the tracheal stenosis.

1- Patient's cerebral status
2- Patient's laryngeal status
3- Evaluation of the tracheotomy wound (stoma) in patients with tracheostomy tube
4- Evaluation of the patient's current airway status
5- History of corticosteroid therapy
6- Choosing an appropriate time for the operation
7- Determining the length of stricture and see whether the resection of the lesion is feasible
8- Scheduling other surgical operations required (other than tracheal surgery)

- *Patient's cerebral status*: A considerable number of patients with post-intubation tracheal stenosis have been in a coma as the result of accidents, collisions, head trauma or brain injuries and have been under ventilator. Among our patients, 595 out of 901 patients (66.1%) had been intubated due to accident and head trauma (15). Complications related to primary head trauma stay with some patients

temporarily or permanently after recovery and discharge from the hospital. Some brain injuries aggravate with surgical resection of tracheal stenosis. Those include deglutition problems, hemiplegia, vocal cord paralysis, and jaw fractures. Before performing the surgical resection, these conditions have to be resolved or improved as well as can be expected.

- *Patient's laryngeal status:* Patient's larynx may have been injured as the result of intubation or head trauma. Some strictures extend to the subglottic area of the larynx and result in destruction, narrowing or deformity of cricoid cartilage, fixation and immobilization of vocal cords, translocation and dislocation of the arytenoids, and even narrowing or obstruction of the glottis. Treatment of such conditions is more complicated than that of strictures confined to the trachea. In our patients, one fourth of the post-intubation stenoses had involved subglottic area (19). In another study of 503 patients, 62 had severe laryngeal destruction requiring resection of the anterior segment of cricoid cartilage (20). Sometimes the larynx is so damaged that resection and anastomosis and maintaining an open airway is not possible. It mostly happens when primary lesions caused by intubation are aggravated as the result of improper or unsuccessful interventions. In fact, the author and colleagues did not meet any case of post-intubation stenosis resulted in this situation without further improper medical interventions. In all cases this condition had been caused iatrogenically. Laryngeal status should be evaluated comprehensively and meticulously. If a lesion is detected in the larynx, we should consult a laryngologist for its diagnosis and determination of its dimensions. If resection of the lesion requires laryngoplastic procedures, a teamwork operation should be performed. Evaluation of the laryngeal function in patients who do not have a tracheostomy tube is easy. In fact, a patient who speaks normally usually has a healthy larynx. If in such patients the appearance of the vocal cords and arytenoids and their movements are normal in bronchoscopy and laryngoscopy, no further action is required for evaluation of the larynx. But if a vocal cord was immobile or had abnormal movement, or anatomical deformities such as narrowing or dislocation of the arytenoids or a stricture close to the vocal cords were detected, then further evaluation and professional laryngological consultations are required. If patient's normal voice has changed but indirect laryngoscopy has reported a normal larynx, the patient should be locally anesthetized and a fiberoptic laryngoscope or bronchoscope is entered through the nose in order to precisely evaluate the vocal cords, arytenoids and mucosal folds during phonation. Intubation sometimes causes cartilaginous or mucosal injuries in arytenoids or vocal cords which are not detected or diagnosed during primary laryngological examinations with rigid bronchoscopy (21,22). In some patients, we noticed that their voice was apparently normal and primary laryngological examinations (direct laryngoscopy or rigid bronchoscopy) showed no abnormality. However, fiberoptic laryngoscopy detected bilateral paralysis of the vocal cords. In a patient who has a tracheostomy tube, it is not possible to evaluate the function of the larynx through simple clinical examinations. In such cases, direct laryngoscopy is required to be performed by an expert familiar with laryngeal injuries. In such cases, we enter a fiberoptic bronchoscope through the nose while the patient is awake (using local anesthesia along with the administration of analgesics and sedatives by an anesthesiologist to a level that laryngeal and vocal cord movements are not affected) in order to thoroughly evaluate the anatomy and movement of the larynx and the vocal cords. If the movement of the larynx and its anatomy were normal, no further evaluation is required. But if abnormal changes in the appearance or the movement of the larynx or the

vocal cords were observed professional laryngological consultations are required. For evaluation of post-intubation laryngeal and tracheal lesions, we mainly focused on using laryngoscopy and bronchoscopy, and imaging procedures did not play a significant role in diagnosis or treatment planning. Insisting on imaging studies is usually time consuming and increases patients' treatment costs. In some patients, the stricture has not directly involved the subglottic area but the vocal cord paralysis still occurs. If this condition is not detected and diagnosed prior to the operation, not only it may increase the post-op complications, but also can trouble the surgeon legally and the paralysis may be contributed to the operation and considered as a complication of the surgery. When we diagnose the unilateral paralysis of the vocal cords prior to the operation, we inform the patients and their family members and confirm and legalize it through laryngological consultations. During surgical resection, we should be extremely careful not to injure the intact side of the vocal cords. Unilateral or bilateral paralysis of the vocal cords although causes many problems but is not considered a contradiction for resection and anastomosis surgery. In such patients usually an adequate airway can be maintained without tracheotomy and after the operation we can help patients improve their vocal status with the help of laryngologists. We could perform resection and anastomosis of tracheal stenosis with no need to post-op tracheostomy and follow up in 5 patients who had bilateral vocal cord paralysis with adequate open glottic lumen during lyryngoscopy. In some cases, we need to perform reconstructive laryngological interventions such as arytenoidectomy, cordectomy and laryngoplasty before surgical resection of the stricture (23-25). In cases who require both laryngoplasty and tracheal resection, it is preferred that both procedures be conducted at the same time by 2 teams of surgeons unless it is not feasible for some other reasons.

-Examining the wound and tracheotomy stoma:

Some patients suffering from post-intubation tracheal stenoses have tracheostomy tube when referred to us and the stoma might be infected. This infection should be treated before the operation. Cause of infection in such patients can be presence of unabsorbed sutures, large over size tubes, secretions are not drained or the tube is obstructed by mucosal plugs. These conditions should be evaluated and treated before surgical resection. In our study, presence of infection at the site of tracheal anastomosis had resulted in recurrence of stenosis (26). The remaining sutures should be taken out. Size, shape and material of the tracheostomy tube should be appropriate. Some tubes are inappropriately shaped and put pressure on stoma, tracheal wall or the skin causing ischemia, necrosis and infection (Figure 1).

Figure 1. An example of improper stomal wound and bad-shaped scars.

Tracheostomy tube should be easy to remove and re-insert by the patient or his/her companions and they should be able to clean it every day. It is necessary to have similar or smaller size tubes handy so that they can be used as a substitute when patient's tube is removed for cleaning. If the patient or his/her companions do not exactly know how to do it, we should take some time to teach them patiently. This results in patient comfort and eliminates the

need for frequent visits to the hospital. It also decreases the risk of tracheostomy tube obstruction. Unfortunately, we witnessed the death of several patients as the result of tracheostomy or T-tube obstruction outside the hospital (27). In complex cases, metal or non-metal cannula tubes can be used (Figure 2).

Figure 2. Comparison of metallic and non-metallic cannulated tracheostomy tubes. Intraluminal diameter of metallic tracheostomy tube is rather bigger.

In such tubes, the internal cannula can be easily removed and cleaned. The only problem of the cannula tubes is that the internal tube through which the patient breathes is smaller than the external/actual diameter of the tube.

-Evaluation of the patients' current airway status:

Maintaining an adequate temporary airway for the patient is another important issue that should be addresed prior to the operation. As a matter of fact, most tracheotomies are preventable in patients with post-intubation tracheal stenoses (9). We can divide tracheotomy patients into 2 groups: the first group is patients who had intra-tracheal tube for a long time and then underwent tracheotomy selectively because of their continuous need for ventilator. The second group comprises of those who gradually developed signs of post-intubation stenosis after partial improvement and weaning off the ventilator. In these patients signs of tracheal stenosis worsened until they required emergency tracheotomy as the result of severe exacerbation of stenosis. In both groups, unnecessary Interventions can greatly damage the airway to an extent that sometimes treating the complication caused by the tracheotomy is harder than treating the primary condition itself. In the first group who underwent tracheotomy selectively, in spite of stenosis caused by the cuff, damage and narrowing of the stoma may also be expected. As a result, resection of all lesions will be hard if not impossible. In our study, a few cases of multi-segmental tracheal stenoses due to unnecessary, inappropriate tracheostomy were detected (27). Conduction of tracheostomy by expert physicians familiar with the technique is helpful in decreasing these complications.

In the second group (those who undergo emergency tracheostomy) tracheostomy can be prevented in most cases by performing bronchoscopic dilatation of the stricture temporarily. Based on the experience of the author and his colleagues in less than 5% of the cases who underwent emergency bronchoscopic dilatation, emergency tracheostomy was also required. Unfortunately, emergency tracheotomy is usually performed for patients who present to medical centers due to emergency severe tracheal stenosis. These tracheostomies are often performed in an intact location of the trachea far from the stenotic area. As a result, in addition to the previous stenotic area, another section of trachea is now injured which makes the reconstructive surgery very hard if not impossible.

Sometimes it is helpful to use a T tube instead of a tracheostomy tube especially for cases whose final operation (resection and anastomosis) is postponed for a long time and have an intact larynx (the larynx is unharmed and the stenosis is confined to the trachea) (20,28). When the stricture has involved the 3rd, 4th, or the 5th ring, T tube can be inserted through

the stenosis itself. T tube should be placed in a way that its upper arm is in a safe distance from the vocal cords (more than 5-6 mm) to make sure it does not interfere with their function. T tube irritates the airway mucosa less than the tracheostomy tube and causes less inflammatory reactions in the trachea. In patients who have an intra-tracheal tube and undergo tracheostomy, a severe stenosis or complete obstruction of the airway above the stoma may occur. We do not know why it happens but we think that it may be a complication of tracheostomy rather than being due to the existing intra-tracheal tube. Using a T tube instead of a tracheostomy tube can prevent this complication. However, the main problem with a T tube is that in case of obstruction with a mucus plug, it is much harder to clean or replace compared to a tracheostomy tube. If patients cannot be taken to the hospital immediately, they may suffocate due to the tube obstruction.

In patients who have undergone tracheostomy or have a T tube and are scheduled for surgical resection, we may be able to do decannulation before the surgery. This is especially important in patients who have a tracheostomy tube and the insertion site for the tracheostomy tube is far from the stricture. In such cases we can decannulate the patient before resection and anastomosis and wait for a few weeks until the tracheotomy wound is healed and then perform the resection. During this time interval, adequate airway is secured through repeated dilatations (if signs of severe stenosis exist). Decannulating the patient before surgical resection lifts up patients' spirit, and helps by evacuating the bronchial secretions, maintaining laryngeal function and decreasing the risk of wound infection after the operation. Also, this way a shorter length of trachea needs to be resected.

- Corticosteroid use:

If for any reason, the patient is under corticosteroid therapy, it should be gradually discontinued before the operation. It requires several weeks and should not be performed hastily. When anastomosing the 2 cut ends of trachea, there is always some tension on the sutures and using corticosteroids may delay the repair of anastomosis site and can result in its opening or other complications such as stenosis or malacia at the site of anastomosis (29). Although most tracheal surgeons emphasize on discontinuing the corticosteroid therapy before the surgery, some actually believe that it is helpful to use small doses of corticosteroid in the first 1-2 weeks after the surgery in order to decrease the risk of recurrence and formation of fibrosis at the site of anastomosis (30). We believe that administration of small dosage of oral prednisolone (10-20 mg daily for adults) for 2-3 weeks after tracheal resection and anastomosis is indicated in most patients. Such low dosage will probably not have an adverse effect on the healing of the anastomosis and will decrease the risk of fibrosis and recurrence. When laryngeal manipulation is performed during the operation, several doses of corticosteroids are administered in order to prevent post-op laryngeal edema. However, its usefulness is not well determined. Also, it is not determined whether long-term corticosteroid therapy after tracheal resection can prevent recurrence in cases when signs of recurrence exist at their anastomosis site.

- Choosing an appropriate time for the operation:
When a patient presents with post-intubation tracheal stenosis, is has been usually a few weeks to a few months after the intubation, and inflammation or infection of the trachea or around the tracheostomy stoma has subsided. Conditions and complications that required intubation in the first place have also been resolved. Presence of some complications can prevent or postpone the operation. Important factors that can postpone tracheal resection and anastomosis are summarized in Table 2.

Table 2. Factors that can postpone tracheal resection and anastomosis surgery

Factor	Treatment required before resection
Infection of the tracheostomy stoma	Taking care of stoma, using an appropriate tube or decannulating and maintaining an open airway with repeated dilatations
Inflammation of the tracheal mucosa over or below the stricture	Using an appropriate tube (if the patient has a tracheostomy tube), antibiotic therapy, wait until the inflammation subsides
Presence of other strictures other than the primary one	Evaluation of the feasibility of resecting all the strictures, try to decrease the factors aggravating inflammation and infection, resolving the 2nd stricture with non-surgical procedures if possible
Laryngeal malfunction and vocal cord paralysis	Laryngological consultations, try to maintain an open airway at the level of larynx before resection and anastomosis
Laryngeal destruction and stenosis	Providing the required conditions for performing reconstructive surgery by a laryngologist
Requiring other surgical operations	Performing other operations before tracheal resection
Time interval less than 3 months from the previous intubation	Postponing the surgery (if possible) until an appropriate time

-Determining the length of stricture and feasibility of the resection of the lesion (resectability):

This is performed through bronchoscopy. Rigid bronchoscopy under general anesthesia is better than other bronchoscopic methods for the evaluation of post-intubation stenoses and other obstructive lesions of the trachea. For better evaluation of lesions and noticing the details during rigid bronchoscopy, loupe magnification can be helpful. The main questions that should be answered via bronchoscopy are summarized in Table 2. In addition to answering the questions in Table 2, we usually draw a schematic picture of the trachea and larynx (31) (Figure 3).

Based on the length of stricture, location of stricture and length of trachea needed to be resected, it can be determined that the lesion is resectable or not and whether the outcome of surgery would be successful. The more the length of the resected lesion, the greater the tension required to reach the two intact cut ends of trachea together and the greater the tension on the anastomosis. However, it is not always possible to determine the length of the damaged area. We cannot determine the exact length of stenosis in cases in which part of their trachea is obstructed as the result of post-intubation stenosis or tumors or tracheotomy has been performed below the obstruction site. In such cases, an appropriate method is to determine the length of the intact tracheal segments and number of the intact remaining tracheal rings. Imaging studies such as MRI and 3-Dimensional CT-scans along with sagittal reconstruction of the airway can also be helpful (31) (Figure 4).

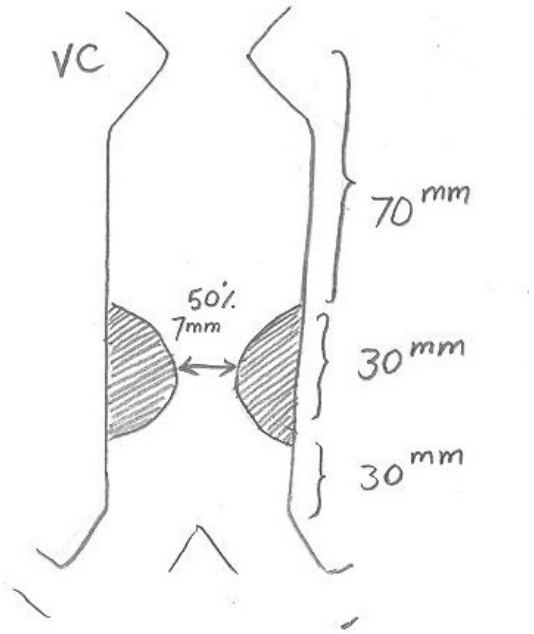

Figure 3. A simple schematic picture which is drawn in some notes during bronchoscopy of a patient with post-intubation tracheal stenosis.
VC: Vocal Cord
◄► = Diameter of lumen at stenosis site.
The length of stenosis is 30 mm, the length of intact trache below to stenosis site is 30 mm and the above distance from vocal cord to stenosis is 70 mm.

Figure 4. 3-dimensional computed tomography shows the site of stenosis well (arrow). In this patient, the presence of tracheostomy tube dose not help to maintain opening of the airway because the stenosis site is distal to the tip of tracheal tube .It is better to remove the tracheal tube and maintain opening of the airway with intermittent dilatation or replacement of T-tube.

- Scheduling other surgical operations if necessary:

In some patients with post-intubation tracheal stenosis, surgical operations other than resection and anastomosis are also required including reconstructive surgeries for limb fractures, reconstructive surgery for jaw fractures, cardiac surgery or plastic surgeries for facial injuries. In such patients, it is preferred that such surgeries be performed first and after those, tracheal resection and anastomosis would be performed. Especially if the patient has a tracheostomy tube, various surgeries can be performed with no concern regarding the intubation issues during anesthesia or dilatation of the stricture. But if the patient does not have a tracheostomy tube, intubation of patient during anesthesia and managing the airway during or after the operation can be troublesome. Presence of a tracheal surgeon in order to perform dilatation prior to anesthetic intubation might be required.

Patient's position on the operating bed and anesthesia considerations:

The patient is positioned on the bed based on the type of incision that is going to be applied. In most cases of post-intubation stenoses surgical access is through the anterior and the patient is in supine position. In another study conducted by the author and his colleagues on 571 post-intubation tracheal stenosis patients requiring resection, only in 6 cases the operation was performed through right posterolateral thoracotomy incision (15).

Releasing the trachea from adjacent tissues:

Releasing the trachea from the adjacent tissues is an important step in resection and anastomosis surgery. Usually scar tissue and fibrosis can be found between the trachea and the adjacent tissues due to the tracheostomy or previous surgical interventions. When releasing the trachea in the neck, there is always risk of injuring the trachea itself, esophagus or recurrent nerves. In the mediastinum, there is a risk of injuring the vasculature. The consistency of trachea and its location in the midline is a great help for the surgeon in this regard. The surgeon can successfully accomplish releasing the trachea without injuring adjacent structures (esophagus, recurrent nerves, vasculature or trachea itself) by frequent palpation of the trachea and staying in a dissecting plan next to it even when there is a great amount of scar tissue and adhesions. Releasing the trachea is

initiated from the anterior portion of the cervical trachea in the midline. If the patient has undergone tracheostomy, thyroid gland and strap-muscles around the stoma develop severe adhesions to the trachea. Trachea should be released from these adhesions gradually with utmost patience and precision. Then the surgeon has to move towards the thoracic cage and release the trachea at the thoracic level. The adhesions are usually decreased at the level of thorax and will end farther down. However, if the patient has been operated on before, adhesions would be seen at the thoracic level as well. Releasing the trachea in the mediastinum is also performed anteriorly and it would be better to be performed under direct vision. At the level of innominate artery, it is recommended that the attachments between the artery and the trachea be dissected under direct vision. If the patient has not been operated on before, no scar tissue would be found in this area. Therefore, if direct vision cannot be obtained, lower sections can be released under indirect vision (using finger). Trachea is released only anteriorly from the beginning of the trachea in the neck down to carina. Circumferential dissection of the trachea is only performed at the site of resection. The whole length of trachea can be anteriorly dissected through a cervical incision in most cases. If the patient has undergone tracheal surgery before and has scar tissue formation and adhesions in the mediastinal section of the trachea, it would be hard to release the trachea from such adhesions through a cervical incision and may endanger the great vessels. In such cases, when the surgeon senses that there is a risk of vascular trauma if operating through a cervical incision, he /she should open up the sternum (T incision).

How to resect the lesion

In order to resect the trachea, we have to release about 1 cm of its length from the adjacent tissues at the right location (in the middle of the stricture). This segment should be released circumferentially. However, there is a risk of injuring the recurrent nerves at both sides of trachea and perforating the esophagus posteriorly. To avoid such risks, the surgeons should only follow one rule. They have to stay in a path of dissection next to the trachea. Recurrent nerves are usually not attached to the trachea. In order to keep the dissection path next to the trachea, the surgeon has to use fine mosquito clamp and start from the anterior side of the trachea, moving gradually to the sides and then to the posterior segment (Figure 5).

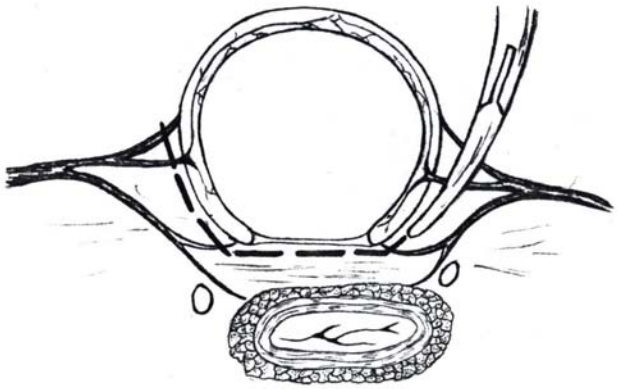

Figure 5. The dotted line shows the path of circumferential dissection of trachea at the site of resection. This path is next to the trachea. The dissected vasculature is cauterized and then resected using the cautery.

Tracheal release maneuvers

This is the most important part of tracheal resection and anastomosis and the surgeon should do it precisely and patiently. If releasing the trachea is performed correctly, one third of the length of trachea can be resected and the 2 cut ends can be anastomosed together without putting too much tension on the anastomosis. Table 3 demonstrates the maneuvers that are usually employed.

Table 3. Main maneuvers for releasing the trachea

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 up until the carina anteriorly
3-	Releasing the superior segment of trachea, cricoid and thyroid cartilages up until the hyoid bone anteriorly

In a small number of cases, there is still too much tension on the anastomosis after doing all the mentioned maneuvers. In such cases, more complex releasing maneuvers should be applied in order to mobilize additional trachea including mobilization of the (right) hilum by cutting the pericardium, releasing the larynx by dissecting the suprahyoid muscles and releasing the left main bronchus from the aortic arch by dissecting and re-implanting it to the middle bronchus (32).

Anastomosing the two cut ends of trachea after resecting the lesion:

Airway anastomosis should be performed using synthetic absorbable sutures. Knots should be placed extraluminally and interrupted sutures should be applied. 4-0 vicryl sutures are suitable for most tracheal anastomoses. 5-0 vicryl sutures are suitable for infants and children. Non absorbable sutures even fine nylon sutures cause granulation tissue at the site of anastomosis and should not be used. It should be mentioned that at first, all sutures are placed around the site of anastomosis without being tied. Then, 4 holding sutures (2-0 vicryl) placed equally on the inferior and superior cut ends are pulled towards each other until the 2 cut ends meet. Then the holding sutures are all tied at the same time by the surgeon and his assistant. By doing so, cut ends are placed end to end. At this time, the patient's neck should be repositioned from extension to straight/neutral or flexion in order to take the pressure off the anastomosis. Then, all the 4-0 vicryl sutures are tied starting from the anterior towards the posterior segment. In the end, the surgeon inspects the anastomotic site thoroughly to make sure it is done perfectly. There is no need to cover the anastomosis with special surgical flaps. The dissected strap muscles and thyroid isthmus can be used for this purpose and are sutured in the midline. There is no need to suture the muscles directly to the trachea. Following completion of the operation, the patient is extubated on the surgical bed and is transferred to the recovery room while breathing spontaneously without the tracheal tube. In patients with tracheal to laryngeal anastomosis (in case of subglottic strictures) especially in children, sometimes we cannot transfer the patient to the recovery room without the tracheal or tracheostomy tube because of the laryngeal edema. In such cases, we recommend placing a small tracheostomy tube a few centimeters below the anastomotic site and after 1-2 days when we made sure that the anastomosis is intact, the tube can be removed.

Sutures securing the chin:

At the end of the operation, most surgeons place heavy sutures to secure the chin to the chest (sternum). These sutures will prevent cervical extension. We did that as well and in the majority of patients, these sutures were removed 7-9 days after surgery. Unlike public opinion, these sutures are not that disturbing to the patients and our patients did not complain much about it. The significance of these sutures has not been studied. We did not place sutures securing the chin to the chest in cases in whom anastomosis was not under much tension or in the elderly patients and we did not encounter any problem in this respect.

Extubating the patient and using tracheostomy or other stents post-operatively:

In the majority of tracheal resection operations for benign lesions, the patient is extubated after the completion of surgery and is transferred to the recovery room while breathing spontaneously.

In cases of tracheal stenosis along with subglottic involvement, surgical incision is extended to the subglottic area as well but even in such cases we can usually extubate the patient after resecting the subglottic stenosis. However, when laryngeal

movement mechanism is affected or the anatomy of cricoid cartilage is deformed, placing a tracheostomy tube or other temporary stents is necessary.

Subglottic stenoses:

Operations routinely performed on subglottic stenoses include: 1- resection of the anterior arch of cricoid, 2- resection of the anterior arch of cricoid along with the inferior segment of thyroid cartilage anterior to it (to a few millimeters below the vocal cords), and 3- a longitudinal incision on the posterior arch of cricoid after resecting its anterior arch (posterior cricoidotomy) and placing a free cartilaginous graft from patient's rib at the site of cricoidotomy. After performing these resections, the intact trachea is anastomosed to the remaining larynx (33) (trachea is anastomosed posteriorly to the cricoid cartilage and anteriorly to the thyroid cartilage). In type 1 and 2 resections, the patient can usually be extubated on the operating bed and tracheostomy or other stents are not required. However, in type 3 resections the patient usually has to have a tracheostomy or another stent like a T tube for some time after the operation. A few weeks post-operation, when an adequate open upper airway is secured and laryngeal function is normal, the tracheostomy or T tube can be extracted. When posterior cricoidotomy is performed a cartilaginous graft taken from the rib is placed at the site of cricoidotomy in order to maintain an open airway at the subglottic area. In addition, an intra-tracheal stent can be inserted. For this purpose, a T tube can be used with its upper arm extended below (if necessary over)the vocal cords. However, if the T tube is obstructed, it is really hard and sometimes impossible to open it and evacuate the secretions in the first few weeks following the operation. In such cases, we use a piece of silicone tube (by cutting a piece of a T tube) and insert it inside the subglottic lumen as a stent and fix it with a non-absorbable suture to the skin and tracheal mucosa. Also, we place a smaller than usual tracheostomy tube distal to it. Two to 3 weeks post-operation, if the subglottic lumen was adequately open (to make sure of it we can cap the tracheostomy tube opening or remove it and then evaluate patient's breathing through larynx), the tracheostomy tube is extracted and the stent is remained for 6 months to a year (Figure 6).

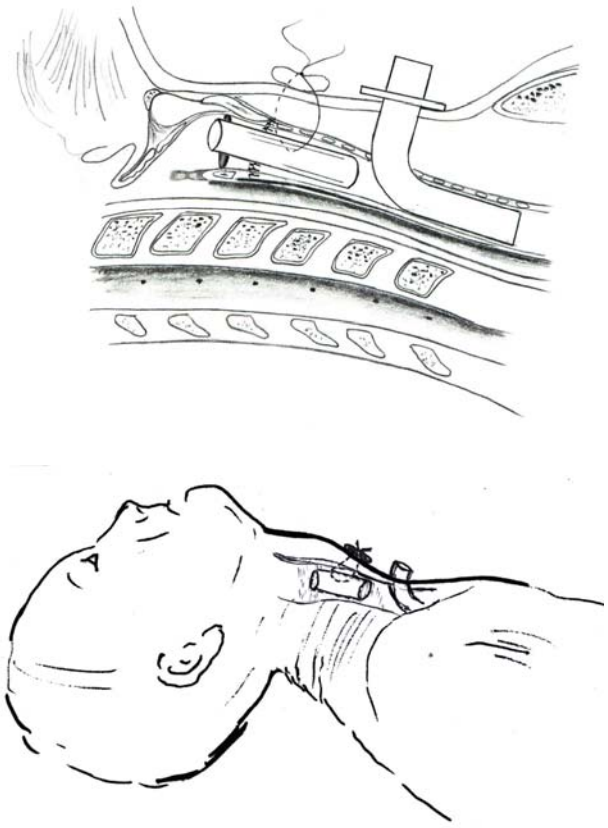

Figure 6. Using a silicone stent in order to secure an open subglottic lumen after resection and anastomosis

A: Anastomosis is below the vocal cords and the stent is placed above the level of the vocal cords

B: The stent is fixed to the skin and tracheal mucosa with nylon sutures

Sometimes after the operation, the patient cannot tolerate intubation for reasons other than mechanical obstruction such as low level of consciousness, temporary paralysis of the larynx due to anesthetic drugs or laryngeal edema (especially in children). In

these cases, there is no need to use a tracheostomy or a T tube. The endotracheal tube inserted through the mouth or nose (preferably nose) into the trachea can be remained and when the above conditions were resolved, it can be removed. In order to extract the endotracheal tube, the patient should be taken to the operating room and the equipments required for the induction of anesthesia (if necessary) and rigid bronchoscopy should be available and ready to use because after extracting the intra-tracheal tube, the patient may develop symptoms of severe airway obstruction. In patients in whom the endotracheal tube is maintained because of their low level of consciousness or temporary laryngeal paralysis as the result of anesthetic drugs, the tube can usually be extracted 6-12 hours post-operation but if the reason is laryngeal edema we should wait for 1-2 days before attempting to extubate the patient. If a patient could not tolerate extubation even after 1-2 days post-op, tracheostomy or T tube insertion should be considered. In such cases we prefer to use a smaller than usual tracheostomy tube 2-3 cm below or above the anastomosis (based on the location of the anastomosis).

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