Laryngotracheal Blunt Trauma

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Core Messages

- Laryngotracheal trauma is probably underestimated but the consequence of such trauma can range from mild hoarseness to complete airway compromise
- Narrowing of the airway results in breathing difficulty. We find this by looking through the patients registered in emergency archives. Complication rates among these patients are as high as 15–25%. The team in charge of the patient must keep in mind that the airway compromise will become worse with time as the edema increases.
- The elasticity of the cartilage framework contributes to airway's recoil, saving the airway even if the external pressure or the blow is strong enough to exceed the resistance of this structure.
- The larynx and trachea are vulnerable only to direct blows to the anterior neck. For damage to occur the object of contact has to approach the larynx in a horizontal manner. If the object is in vertical position relative to the body, the impact is blocked by the facial skeleton and/or sternum and clavicle heads.
- Fiberoptic laryngoscopy has become the initial evaluation tool for laryngeal injury. In case the endolarynx cannot be assessed with flexible laryngoscopy due to laryngeal edema, direct laryngoscopy should be carried out under general anesthesia. All of the upper aerodigestive tract mucosa should be examined
- Cartilage frame fractures are rare in the pediatric group, but soft tissue edema and hematoma are more common. In elderly people, the cartilage framework is usually calcified and has undergone osseous transformation. The laryngotracheal fractures in this age group are more common and usually more severe.
- Posterior or lateral dislocations of the arytenoids may occur at this stage when the thyroid cartilage is pressed against the vertebra by external pressure. Posterior dislocation of the arytenoids is reported to be more common. It is usually associated with traumatic orotracheal intubation rather than external trauma. Arytenoid dislocations can be confused with vocal cord paralysis during examination. Electromyography is an important tool to differentiate the two conditions.
- In the rare case of complete disruption between the cricoid cartilage and the trachea, the strap muscles and the surrounding fascia can serve as a temporary airway until the patient is managed by intubation or tracheotomy.
- Once the injuries are addressed and the patient is stabilized and assessed, the larynx and cervical trauma should be repaired surgically as soon as possible. A patient with minimal soft tissue edema, mobile vocal cords, and no difficulty with breathing can be observed closely without any surgical intervention.

Laryngotracheal trauma, including blunt and penetrating trauma, is one of the common causes of airway compromise. This type of injury is probably underestimated but the consequence of a laryngotracheal trauma

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can range from mild hoarseness to complete airway compromise. In the United States 1 in 14,000 to 1 in 30,000 emergency room visits is due to laryngotracheal trauma [1, 2]. Many more go undiagnosed because the injured person does not take mild hoarseness seriously and does not go to the emergency department.

The most common causes of laryngotracheal trauma are motor vehicle accidents and sports injuries [3, 4]. A decrease in the incidence of laryngotracheal injury was observed after the automobile safety belt use was mandatory and other safety features of motor vehicles were developed. The presence of airbags should eliminate sudden, savage blows to the anterior neck due to collision with the steering wheel or other hardware on the dashboard as well as injuries caused by misplaced safety belts. However, there is no objective study demonstrating this beneficial effect. Laryngotracheal trauma due to sports injuries are common in contact sports such as football, basketball, baseball, and soccer.

The degree of injury may vary from mild soft tissue edema to severe laryngeal framework fractures and to complete separation between the larynx and trachea. Mild injuries that result in temporary voice changes or throat pain probably go unregistered in medical archives. This degree of injury is temporary due to the extreme flexibility and resistance of the laryngotracheal framework. More severe trauma may cause injury to the framework and severe soft tissue edema or hematoma. Narrowing of the airway results in breathing difficulty. These are the cases that are registered in emergency department archives. Among these patients complication rates are as high as 15–25% [5, 6].

Complications include chronic airway obstruction and chronic voice changes. Injury to the laryngotracheal structure can be lethal because of airway compromise. Severe injuries with complete airway obstruction necessitate immediate airway management with orotracheal intubation or, more commonly, emergent tracheotomy. Many of these patients may not survive the time interval between the accident and arrival of medical assistance. Mortality rates are reported to be 2–35% among those with severe laryngotracheal injury [5, 6]. The principles of immediate airway management and long-term management of complications are discussed in this chapter.

8.1 Injury of the Cartilage Framework of the Larynx and Cervical Trachea

The airway is well protected as it passes through the neck. Thyroid cartilage and tracheal rings provide a framework that protects the airway from external compression. The elasticity of the cartilage framework contributes to its recoil, saving the airway even if the external pressure or the blow is strong enough to exceed the resistance of this structure. The larynx, and more pronouncedly the trachea, can be almost completely compressed and can recoil back to the original structure once the external pressure subsides. The optimal balance of strength and elasticity of the cartilage network is achieved by the time of early adulthood. During childhood the cartilage is much more elastic and lacks structural strength. At this period in life the airway is more vulnerable to external pressure that results in complete airway obstruction. However, the recoil effect is more pronounced as well. Once the external pressure is removed, the recoil is almost complete. Therefore, cartilage frame fractures are rare in the pediatric age group, whereas soft tissue edema and hematoma are more common [7, 8]. In elderly people the cartilage framework is usually calcified and has undergone osseous transformation. The airway is more resistant to external pressure. This increased resistance does not necessarily serve as airway protection. Loss of elasticity results in fractures with less forceful blows. Laryngotracheal fractures in this age group are more common and usually more severe [6, 8].

Surrounding the cartilage framework are the strap muscles, subcutaneous fat, and skin. These extralaryngeal soft tissues offer a buffer between the impact and the laryngotracheal cartilage framework. Sternocleidomastoid muscles protect the larynx from lateral blows. The mandible often blocks the impact that comes from the superior to inferior angle. Likewise, the clavicles and sternum may block an impact that comes from the inferior direction. The larynx and trachea are vulnerable only to direct blows to the anterior neck for damage to occur. The object of contact—whether a bat, a steering wheel, a dashboard, or a rope—must approach the larynx in a horizontal manner. If the object is in a vertical position relative to the body, the impact is blocked by the facial skeleton and/or sternum and clavicle heads [8].

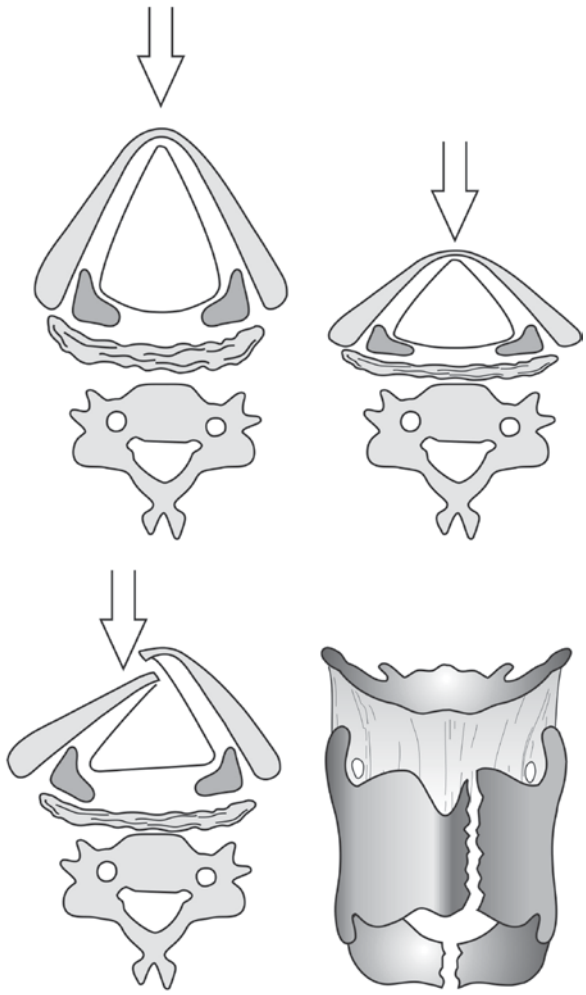

Fig. 8.1. The first impact is taken by the thyroid prominence, and thyroid cartilage is compressed against the vertebra, displacing the thyroid alas laterally. When the point of maximum compressibility is reached, the thyroid cartilage fractures in the vertical axis either medially or more commonly paramedially

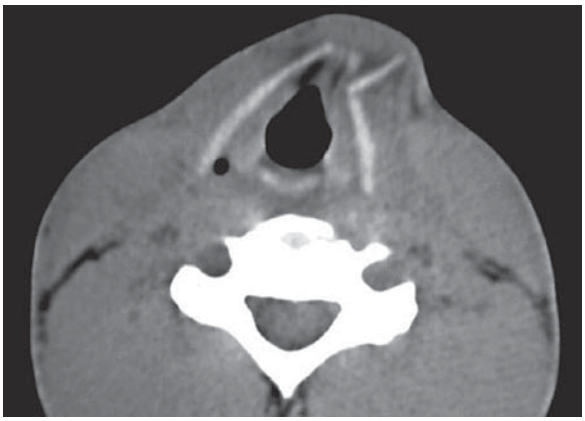

Fig. 8.2. Computed tomography (CT) image of a patient with a paramedian fracture of the thyroid cartilage. A fragment of cartilage is displaced laterally. The airway appears to be patent

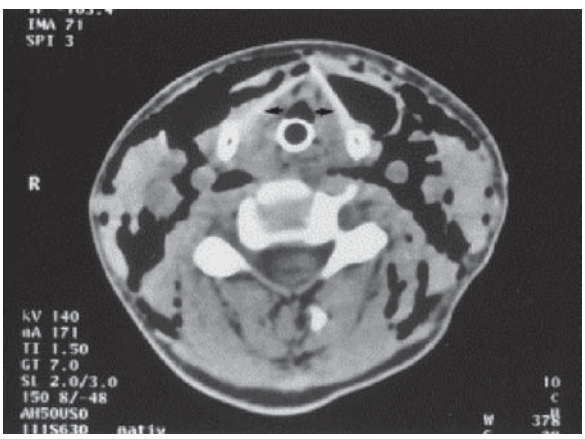

Fig. 8.3. CT image of a patient with a median fracture of the thyroid cartilage. There is extensive subcutaneous emphysema in the neck, suggesting soft tissue injury to the larynx. There is an endotracheal tube in the larynx

The most common blunt trauma to the larynx and cervical trachea is caused by motor vehicle accidents. The steering wheel and dashboards are located at the correct angle to produce an injury to the larynx and trachea. Collision of the vehicle causes sudden deceleration, throwing the body into the steering wheel and dashboards. Safety belts help slow the velocity of the impact, and airbags help prevent the contact totally. In the case where no seatbelt or airbag is present, the upper body is thrown violently against the steering wheel and dashboard. Even in this situation the head is usually flexed, and the mandible serves to protect the larynx. If the larynx comes into contact with hardware, the first impact is taken by the thyroid prominence; in this case the thyroid cartilage is compressed against the vertebra, displacing the thyroid alas laterally. When the point of maximum compressibility is reached, the thyroid cartilage fractures in the vertical axis either medially or more commonly paramedially [8, 9] (Figs. 8.1, 8.2, and 8.3). The point of maximum compressibility varies greatly with age and from person to person. Young victims may experience a single line of fracture, whereas older people may have multiple fractures.

If the impact is more inferior, the cricoid cartilage may be affected (Fig. 8.4). The cricoid cartilage is a complete cartilage ring with more rigidity than tracheal

Fig. 8.4. CT image of a patient with a cricoid fracture. The cricoid cartilage is fractured in two places. There is an endotracheal tube in the airway

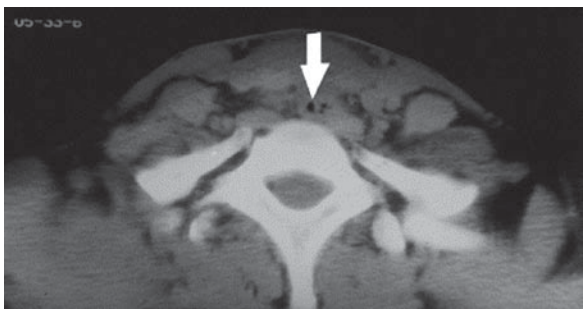

Fig. 8.5. CT image of a patient with almost complete collapse of the airway

rings or thyroid cartilage. Whereas the thyroid ala can spread laterally with the advantage of being an incomplete circular structure, the cricoid cartilage cannot displace laterally but, is rather, compressed into an oval shape [8]. This can result in a median fracture. More severe blows can cause fragmentation of the cricoid cartilage and loss of the airway (Fig. 8.5). This fragmentation can also cause the injury to one or both recurrent laryngeal nerves at the region of the cricothyroid joint, with subsequent vocal cord paralysis and further narrowing of the airway.

If the impact is on an area lower than the cricoid cartilage, complete separation of the larynx and trachea may occur. The usual site of separation is between the cricoid cartilage and the first tracheal ring [10] (Fig. 8.6). The separation may be accompanied by cricoid cartilage

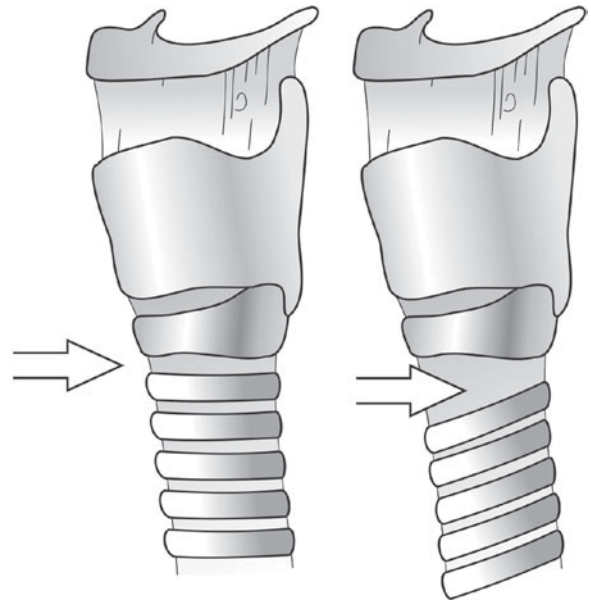

Fig. 8.6. Horizontal trauma at the level of the cricoid and first thyroid cartilage usually results in cricotracheal separation. The posterior tracheal wall may still be attached

fracture or may occur without a fracture. This type of injury is more commonly associated with the neck coming into contact with a fixed cable or rope while riding a motorbike, jet ski, snowmobile, or a similar vehicle where the neck is not protected against outside objects.

Two vectors of force cause laryngotracheal separation. The first is compression of the cricoid cartilage and the trachea against the vertebral bodies, as described above. The second vector is the "telescoping effect." When the neck comes into contact with a fixed wire or a rope while traveling fast, it comes to a complete stop while the body still moves forward. This pulls the trachea from the fixed larynx, causing separation [11]. The separation can be complete or incomplete. The posterior membranous portion of the trachea may remain attached while the anterior cartilaginous trachea is separated from the larynx. In that case, the trachea does not retract completely into the chest. An intubation or a tracheotomy are easier in case of incomplete separation of the airway, the posterior wall serving as a guide for airway management.

If the trachea is completely separated from the larynx, it retracts into the chest. This most often results in complete and sudden loss of airway, which is fatal. Rarely, the strap muscles and surrounding fascia serve as a temporary airway until the patient is managed by intubation or tracheotomy.

Another mechanism of injury is falling onto the handlebar of a bicycle or onto any horizontally positioned hard object. This kind of impact may cause the cricoid cartilage to be displaced superiorly under the thyroid cartilage [12, 13], resulting in the soft tissues doubling onto themselves and severe soft tissue edema. Frequently, this injury is seen in young children with flexible cartilage. Fractures do not occur with this kind of trauma in young children, whereas adults who experience this sort of impact present with cricoid fractures. This displacement may cause injury to one or both of the recurrent laryngeal nerves with subsequent vocal cord paralysis [11–14].

8.2 Injury of the Cricoarytenoid Joint

Arytenoid cartilages are in relation with the cricoid cartilage via a joint, and with the thyroid cartilage via the vocal ligament and the thyroarytenoid muscle. Arytenoid cartilages are located deep to the thyroid cartilage and the hyoid bone. In case of external laryngeal trauma, fracture of arytenoid cartilages is prevented by the thyroid cartilage but, most importantly, by the extreme mobility of the cricoarytenoid joint [15]. When the thyroid cartilage is pressed against the vertebra by external pressure, the arytenoid cartilages are displaced laterally and posteriorly. Posterior or lateral dislocation of the arytenoids may occur at this stage. With the sudden release of pressure, the thyroid cartilage springs back to its original shape. This sudden springing motion pulls the arytenoid cartilage by its muscular attachments anteriorly to the thyroid cartilage [9, 16]. This motion may result in anterior luxation or subluxation of the arytenoid cartilage. Posterior dislocation of the arytenoids is reported to be more common, but it is usually associated with traumatic orotracheal intubation trauma rather than external trauma [16]. Dislocation of the arytenoid cartilages is usually associated with severe soft tissue trauma, which can cause edema, masking the larynx and making the diagnosis of dislocation difficult [17]. Dislocation of the cricoarytenoid joint impairs vocal cord movement. Arytenoid dislocations can be confused with vocal cord paralysis. Electromyography (EMG) is an important tool to use to differentiate the two conditions. EMG would detect muscle contraction potentials in case of arytenoid dislocation. These potentials would be absent in the case of vocal cord paralysis.

8.3 Laryngeal Soft Tissue Injury

External blunt trauma to the larynx almost always results in soft tissue injury. The loose submucosal connective tissue is prone to fluid collection and edema. Even the mildest trauma results in some degree of swelling of the endolarynx. This may manifest as a change in voice or more seriously as breathing difficulty. As the impact of the trauma increases, the likelihood of having a mucosal laceration increases as well. Lacerations may cause bleeding and contribute to airway problems. Laryngeal framework fractures are usually associated with mucosal injuries [9]. Mucosal injury may range from mild tissue edema to large lacerations. The mucosa can be crushed or caught between cartilage fragments. In the case of laryngotracheal separation, the mucosa cannot withstand the pulling forces and is separated as well. Large lacerations of the mucosa may cause emphysema due to air leakage into the soft tissues of the neck. Air can accumulate around the strap muscles as well as in the subcutaneous plane. Extensive ecchymosis and crepitation of the skin makes the diagnosis of emphysema easily recognizable. Soft tissue emphysema may contribute to airway compromise (Figs. 8.7 and 8.8). After repair of the larynx, air in the soft tissues is gradually resorbed.

A distinct soft tissue injury is rupture of the thyroarytenoid muscle and ligament. As the thyroid cartilage is pressed against the vertebra and springs back, the muscle and the ligament relax and undergo

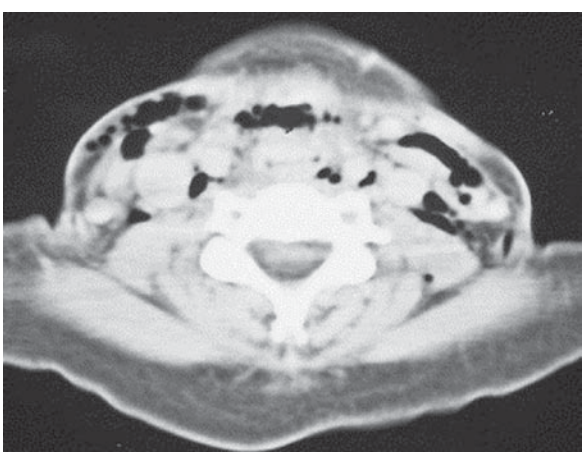

Fig. 8.7. CT scan shows that there is extensive subcutaneous emphysema, and the airway cannot be identified

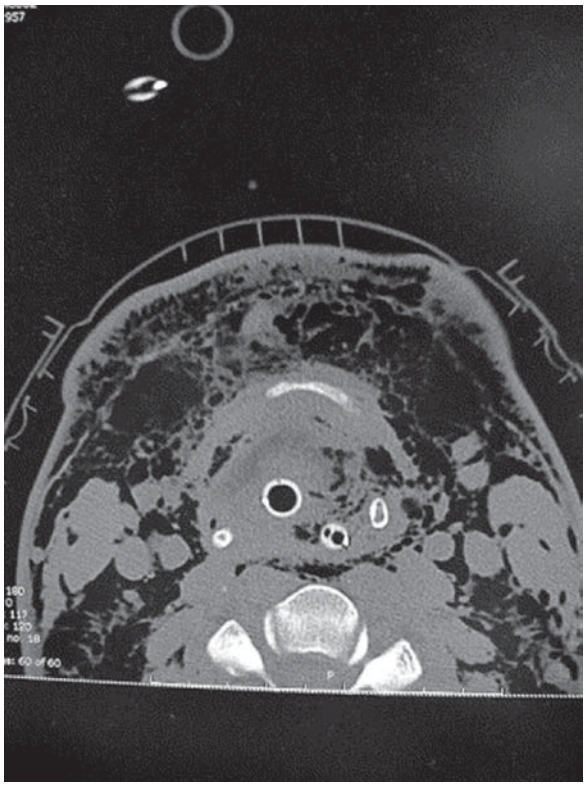

Fig. 8.8. CT scan at the level of the hyoid bone demonstrates subcutaneous emphysema. The airway can be identified only by the presence of an endotracheal tube

tension within a short period of time. This may result in rupture or detachment of the ligament from the thyroid cartilage at the level of the anterior commissure. As the ligament detaches from the anterior commissure, usually a small piece of cartilage also detaches. Rupture or detachment results in bunching of the vocal cord and narrowing of the airway. The injury is always accompanied by severe edema of the Reinke's space. Dislocation of the arytenoid cartilage may also accompany the injury [15].

Suicidal or accidental hanging causes trauma to the supraglottic larynx. The rope around the neck tightens at the level of the thyrohyoid membrane [18]. The external pressure causes the preepiglottic space to move posteriorly, pushing the epiglottis against the arytenoid cartilages. This causes complete obstruction of the airway. If the person survives the impact, the subsequent injury is severe supraglottic edema. The thyrohyoid membrane may rupture, and the preepiglottic fat tissue may herniate into the airway. Hyoid bone fractures occur rarely if the rope tightens at the level of the hyoid bone [19]. Hyoid bone fractures do not have any clinical implications unless a fragment tears through the airway mucosa. Thyroid and cricoid cartilage can also be fractured. Laryngotracheal separation has been reported to occur due to hanging injuries [20].

8.4 Emergency Management of Laryngotracheal Blunt Trauma

Blunt trauma to the laryngotracheal area can cause an airway emergency. All cases should be managed according to the emergency airway management protocol of the managing (??? manageing yerine başka bir gelime gelebilir mi?) institution regardless of the degree and the place of trauma. Loss of critical time can be lethal in case of laryngotracheal injuries. Elaborate examination and imaging should be left for later. Management of the airway is the primary objective. If the patient is not breathing at the time of initial management, cardiopulmonary resuscitation (CPR) should be carried out immediately. Many of these patients have accompanying cervical spine injuries. Care should be taken not to move the cervical spine. Unless proven otherwise, all patients should be assumed to have cervical spine injury.

Endolaryngeal edema develops immediately after laryngotracheal trauma. If the emergency team arrives soon after the trauma, orotracheal intubation may be successful. After a certain period of time edema would be present, and intubation could be extremely difficult, necessitating a tracheotomy [21, 22]. The team in charge of the patient must keep in mind that the airway will become worse in time as the edema increases. In case of extensive laryngotracheal trauma, intubation should be considered even if the patient is able to breathe sufficiently. As mentioned, intubation could be difficult if not impossible as time passes. Orotracheal intubation can be achieved even in case of laryngotracheal separation. Laryngotracheal separation usually occurs in the anterior wall of the trachea between the cricoid and the first tracheal rings, with the posterior wall of the trachea staying intact. If the endotracheal tube is advanced following the tract of the posterior tracheal wall, intubation of the separated tracheal segment can be achieved. Even if complete separation occurs, the surrounding soft tissues would not collapse immediately and can

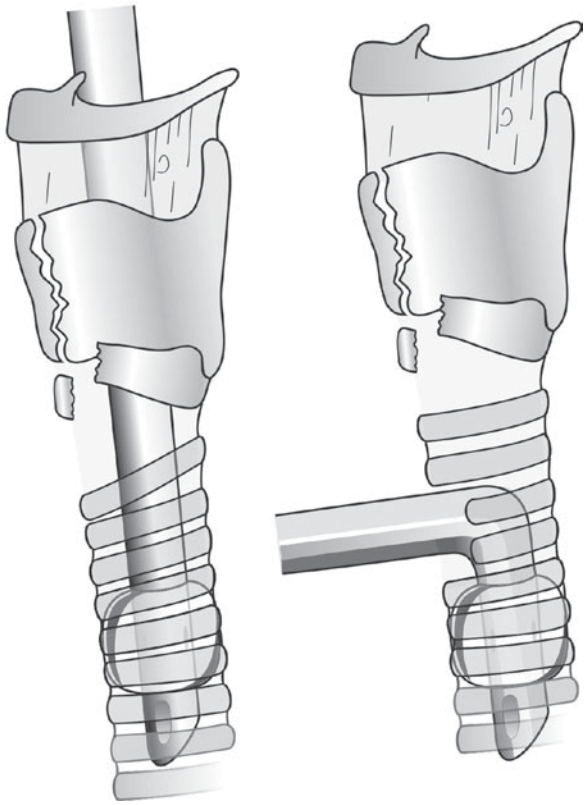

Fig. 8.9. The first option for airway management is endotracheal intubation. The posterior tracheal wall can guide the endotracheal tube in the airway even if the distant airway cannot be visualized. The second option is to perform a tracheotomy. The best place to perform a tracheotomy is two tracheal rings below the site of injury

serve as a guide for intubation [21, 22] (Fig. 8.9). If orotracheal intubation can be achieved, the endotracheal tube serves as a stent, preventing possible synechia of the endolaryngeal mucosa thus making further airway management easier. If intubation cannot be achieved after a few trials, no time should be wasted before attempting the tracheotomy.

The level of tracheotomy should be chosen according to the level of the place of the trauma. For a high positioned laryngeal injury, such as a hanging case, the fastest and easiest method would be a cricothyrotomy. However, if the thyroid cartilage and/or the cricoid cartilage is fractured, a lower tracheotomy would be necessary. The level of the place of the injury can be determined by palpating the neck under emergency conditions. Fragments of cartilage and/or depressions in the laryngotracheal framework indicate the site of injury. Sometimes edema and hematomas developing in the soft tissues of the neck make this examination difficult. In such a case, the mechanism of injury gives clues about the injury site. As already noted, the most common laryngotracheal injuries are caused by steering wheel and dashboard impacts in motor vehicle accidents, inducing injuries at the level of the thyroid and cricoid cartilages. Bicycle and sports accidents also cause injuries at the same level. In this case, the best level for tracheotomy is two tracheal rings below the injury site [21, 22] (Fig. 8.9). Tracheotomy should be performed below the third tracheal ring.

Laryngotracheal separation is likely to occur in case of a jet-ski or snowmobile accident, where the neck comes in contact with a fixed object such as a rope. Laryngotracheal separation is the most difficult injury to manage in terms of the airway. The airway can be secured by neck exploration and identification of the separated tracheal segment low in the neck or thorax. The endotracheal tube can be passed through the separated trachea. The tracheal segment should be secured to the skin incision and to the head of the clavicle with nonabsorbable sutures. This step facilitates reintubation in case of accidental extubation. Once the airway is secured, other life-threatening injuries should be addressed before any attempt is made to repair the laryngotracheal damage.

8.5 Evaluation of Laryngotracheal Injury

Once the patient is stabilized, evaluation of the laryngotracheal damage should be done. Endoscopic assessment is the next step. Today, fiberoptic laryngoscopy has become the initial evaluation tool. It is less traumatic and more comfortable for the patient than the methods mentioned previously. Checking airway patency and any potential causes that might impair the airway is the priority. Tracheotomy should be performed in case of increasing edema or hematoma. If the airway patency is adequate, the site and degree of damage are then evaluated. Mucosal lacerations, location of arytenoids, and vocal cord mobility must be assessed.

Supraglottic edema may prevent examination of glottic and subglottic areas [23]. In case the endolarynx cannot be assessed with flexible laryngoscopy due to laryngeal edema, direct laryngoscopy can be carried out under general anesthesia. During direct laryngoscopy all of the upper aerodigestive tract mucosa is

examined. Mobility of the arytenoid cartilages is tested with a blunt instrument, such as a velvet tipped suction or cup forceps with the tip in closed position. Additional trauma to the laryngeal mucosa should be avoided.

Bronchoscopy is performed to assess the trachea. Esophagoscopy should be carried out as well because esophageal trauma as a result of an impact to the neck can be infrequent.

The downside of direct laryngoscopy is the inability to assess function properly. Videostroboscopy is a valuable tool for assessing vocal cord injuries. It can even reveal subtle injuries to the vocal cords. If the patient is already intubated, direct laryngoscopy is indicated.

Imaging of the laryngotracheal framework can precede direct laryngoscopy. Computed tomography (CT) scans of the neck should be performed if flexible laryngoscopy reveals extensive soft tissue injury, vocal cord paralysis, bare cartilage or if there are palpable cartilage fractures and crepitations in the neck. The CT scan should include fine cuts through the larynx. Special attention should be given to thyroid, cricoid, and tracheal cartilages as well as the localization of arytenoid cartilages. Magnetic resonance imaging (MRI) is better for assessing soft tissue injuries, but CT remains to be the first method of choice for imaging while assessing the laryngotracheal framework.

Laryngeal EMG is important for assessing nerve injuries. The superior laryngeal nerve is usually not injured by external trauma to the larynx. However, the recurrent laryngeal nerve is frequently affected by injury involving the cricoid cartilage and laryngotracheal separation. EMG can detect contraction potentials and resting potentials even in unconscious patients.

If observation is chosen, repeated fiberoscopy or direct laryngoscopy can be performed at 24, 48, and 72 hours after surgery to monitor the endolaryngeal edema.

8.6 Laryngotracheal Trauma Repair

Once the lethal injuries are addressed and the patient is stabilized and assessed, surgical repair of the larynx and cervical trauma should be done as soon as possible. Early repair has more favorable results than late repair [24].

The decision to repair the laryngotracheal injury should be based on the presence and the severity of cartilage fragmentation, the degree of airway obstruction, and a recurrent laryngeal nerve injury (Table 8.1). A patient with minimal soft tissue edema, mobile vocal cords, and no difficulty breathing can be observed closely without any surgical intervention. The managing team should remember that soft tissue edema may get worse with time. Close observation is necessary. Extensive soft tissue injuries necessitate either endoscopic or open repair. Table 8.2 is a list of endoscopic findings that indicate laryngeal repair. If an arytenoid dislocation is observed, the best results are obtained with early endoscopic reduction.

Table 8.1. Indications for open surgery

Displaced single fracture of the laryngotracheal framework
Multiple fractures of the laryngotracheal framework (including nondisplaced fractures)
Laryngotracheal separation
Thyroarytenoid muscle and ligament tear or detachment
Esophageal tears
Arytenoid dislocation that cannot be reduced endoscopically
Hematoma that is obstructing the airway
Denuded cartilage

Table 8.2. Endoscopic findings that require surgery

Exposed cartilage
Depressions in the airway that suggest cartilage fracture
Laryngotracheal separation
Mucosal fragments that obstruct the airway
Injury to the free edge of vocal cords
Cricoarytenoid dislocation
Displacement of the epiglottis
Herniation of preepiglottic contents
Thyroarytenoid muscle or ligament injury

Cartilage fractures usually require open exploration, repair, and fixation. Although there is no displacement some cartilage fractures can be detected by CT. Single median or paramedian vertical thyroid cartilage fractures are the most common. Close observation is an option if the fracture is single and not displaced and if there is no extensive soft tissue injury or detachment of the thyroarytenoid muscle. However, fixation of the framework by an external approach is a safe alternative because the fragments of cartilage can be displaced afterwards, obstructing the airway.

Penetrating tears of the esophagus should be addressed with an open neck exploration.

If there is no indication for the open approach (see Table 8.1), repair can be carried out with rigid laryngoscopy. Mucosal flaps that obstruct the airway or interfere with phonation should be removed. Obtaining straight,

free edges of vocal cords is essential. Mucosal flaps on the free edges of the vocal cords should be positioned back in place or removed. Cold steel instruments, powered instruments, or laser can be used for removal. If the preepiglottic space contents are herniated into the airway without accompanying fractures, these tissues should be removed. In case of the epiglottis obstructing the airway, the entire epiglottis or a part of it can be resected. This can be achieved with laser or powered instruments.

In case of cricoarytenoid luxation, repositioning the arytenoid cartilage should be attempted. Early reduction has better results because ankylosis becomes apparent within about a week. Posterior dislocation can be reduced by applying a medial and anterior force with an instrument placed posterior to the dislocated arytenoid. The laryngoscope can be used to force the arytenoids anteriorly. Anterior dislocations can be reduced by placing the rigid laryngoscope just anterior to the displaced arytenoids and applying posterior pressure. With anterior dislocations there is a tendency of the arytenoid to be displaced inferiorly. In that case, a blunt right-angle instrument such as a blunt hook can be placed anteriorly and inferiorly to the arytenoid, and the arytenoid can be lifted and pushed posteriorly. The maneuvers must be gentle. These vocal process can be fractured with forceful movements, resulting in poor quality of the voice after the reduction.

On some occasions, endoscopic repair can be combined with an open neck approach. Open surgery is done through a horizontal incision in a skin crease or close to the thyroid cartilage. Subplatysmal flaps are elevated, and strap muscles are divided in two through the midline and retracted laterally. Adequate exposure of the thyroid and cricoid cartilages is essential. Care should be taken not to injure the external branches of the superior laryngeal nerves or the recurrent nerves. If there is a vertical thyroid cartilage fracture, entry to the larynx can be through the fracture line. The mucosal incision is preferentially made through the midline across the anterior commissure to prevent further mucosal injury. If there is a horizontal fracture, the opening can be achieved with a laryngofissure vertical to the midline.

Mucosal injury should be assessed when exposure is achieved. Reconstruction of the deep structures is the first step. Arytenoid cartilages are restored to their original positions, and thyroarytenoid muscle or ligament tears are repaired with sutures. If there is a thyroarytenoid muscle detachment, a strong suture can be passed through the vocal ligament and fixed to the cartilage segment corresponding to the original position of the anterior commissure (???) (Fig. 8.10). Incorrect positioning of the vocal ligament results in poor vocal quality. Once the deeper architecture is restored, the mucosal tears can be considered. The goal is to cover the entire endolaryngeal surface with mucosa to facilitate wound healing and to prevent granuloma formation. Irreparable mucosal fragments are removed. Remaining mucosa is then aligned and sutured with fine absorbable sutures. If there is not enough mucosa to cover the entire larynx, priority is given to the glottic area and especially the anterior commissure, which is the most common site of scar and synechia formation. Keels can be used to prevent web formation as well. The second important area is the arytenoid cartilage. Adequate covering of the arytenoids prevents ankylosis of the joint by scar formation. Local mucosal flaps can be raised to facilitate mucosal redraping. Laterally based piriform sinus flaps and posteriorly based postcricoid flaps can be used to cover the arytenoid region. Epiglottic flaps can be used to cover the anterior commissure. If there is extensive mucosal and cartilage fragmentation in the anterior commissure, the epiglottic cartilage can be mobilized from its anterior attachments and pulled inferiorly to cover both the mucosa and the cartilage defects.

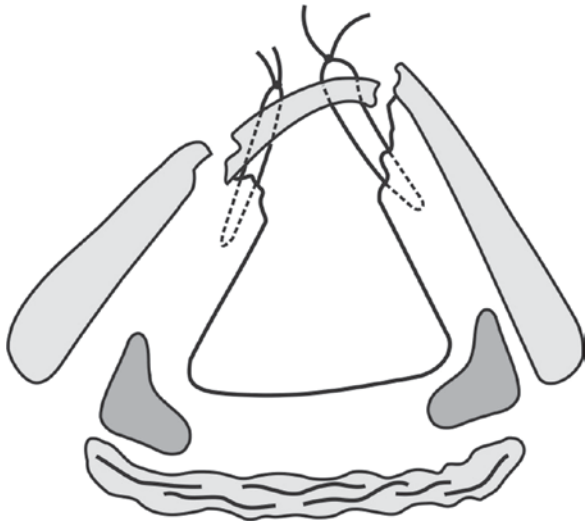

Fig. 8.10. In the case of detachment of the anterior commissure, the vocal ligaments should be suspended to the cartilage fragment that corresponds to the cartilage portion of the anterior commissure with nonabsorbable sutures

In case of epiglottis displacement and herniation of the preepiglottic contents, the is epiglottic contents are removed and the epiglottis is pulled anteriorly and fixed

to the hyoid bone with strong absorbable sutures. Removal of part of the epiglottis should be considered if traction cannot be achieved.

When the endolaryngeal repairing is achieved, it must be decided whether to place a stent or not. Stents are useful for preventing synechiae. If the mucosal injury is extensive and synechia formation is likely to happen, a stent should be placed. There are several commercially available stents. A custom-made stent can be constructed from a finger of a surgical glove or a Penrose drain filled with sponge and tied at both ends with silk sutures. Stents should be fixed to the neck skin to prevent dislocation. Strong silk sutures are passed through the stent and brought to the neck skin; they are then tied on a button to prevent pulling on the sutures and irritating the neck skin. Stents can be taken out endoscopically after 3–5 weeks. In case of anterior commissure injury, a keel should be placed and secured to the skin (see Chapter 12b).

The next step is the reconstruction of the laryngotracheal framework. Each cartilage fragment has to be identified and positioned in correct alignment. Perfusion of the cartilage is through the perichondrium. Free cartilage fragments can still be used as free grafts as long as they are covered with well perfused tissue. Comminuted pieces that cannot be fixed are removed. Complete reconstruction of the cartilage frame is not necessary as long as the three-dimensional shape of the larynx can be achieved. Miniplates and recently introduced absorbable plates are the best materials to use for joining the cartilage fragments (Fig. 8.11). Single fractures that resemble their natural shape once brought together can be repaired with wire or sutures, but miniplates should be used if they are available. Miniplates of 1.0–1.4 mm thickness are preferred because they are easy to shape and their thinner profile is not visible through the skin. If the remaining cartilage is not sufficient to reconstruct the framework, free cartilage grafts (e.g., nasal septal cartilage or costal cartilage) can be used. The epiglottis is another source of cartilage and has the advantage of providing a pedicled flap. Correct placement of the vocal ligaments is essential to obtain a good vocal-quality after reconstruction. The cartilage fragment attached to the vocal ligaments must be exactly positioned at the level of the normal anterior commissure. If one of the vocal ligaments is detached, it must be reattached at exactly the same level of the contralateral ligament with a sturdy suture. If the vocal ligament cannot be attached to a cartilage fragment, the suture can be tied on a plate. In this case, nonabsorbable suture and plate are preferred to avoid detachment.

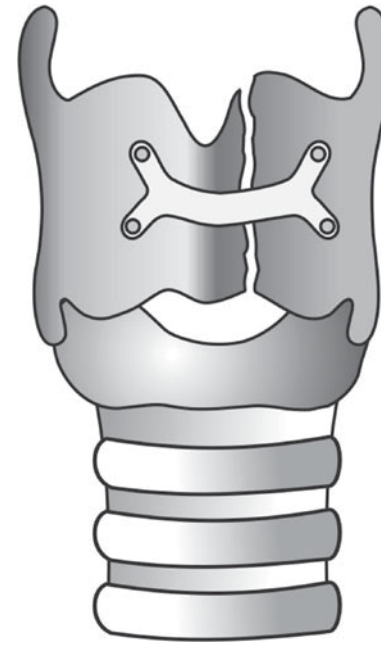

Fig. 8.11. External fixation of the tracheal cartilage with miniplates gives excellent reconstructive results

Laryngotracheal separation is repaired by end-to-end anastomosis. If the tracheotomy tube is placed in the tracheal segment, it must be removed and placed through a tracheotomy incision two or three rings below the avulsed site as the first step of reconstruction. If the tracheal ring is severed, it should be removed.

The tracheal ring is suspended to the cricoid ring with sturdy absorbable sutures that are outside (???) as much as possible. Ideally, the stitches are also placed extramucosally. These precautions are taken to prevent granulomas and stenosis. If the end-to-end anastomosis cannot be performed perfectly and the laryngeal reconstruction is not stable, a T-tube is put in place to serve as a stent, allowing voice production and breathing. According to the trauma and reconstruction, this tube can stay in place 3 weeks to 3–4 months.

All additional neck injuries are addressed as the neck is being explored. Esophageal tears should be repaired as soon as possible. Leaks from the esophagus may have life-threatening consequences, such as mediastinitis. Tears should be closed in a watertight fashion. Today absorbable sutures placed in a running mattress style are preferred. A second layer of muscle should be closed over the suture line. A nasogastric feeding tube can be placed in during surgery to allow postoperative feeding.

If a recurrent nerve injury is observed, the separated segments should be sought. It is sometimes difficult to find both ends of the recurrent laryngeal nerve in the trauma field. The nerve may part intralaryngeally or, more frequently, right where it enters the larynx. If both ends of the nerve are found, end-to-end anastomosis should be done. Primary repair of the recurrent laryngeal nerve does not have favorable results. Abduction and adduction functions of the vocal cords may not return. However, if tonus to the vocal cord can be achieved, voice rehabilitation is easier.

Additional repair may be necessary after the initial surgical repair. Laryngotracheal separation causes a high rate of stenosis after primary anastomosis. Anterior commissure injuries are associated with anterior web formation. Synechiae and granulomas may develop after extensive soft tissue injuries. Secondary repairs are beyond the scope of this chapter and are addressed in the other chapters of this book. Unilateral vocal cord paralysis can be treated by applying vocal cord injection or medialization thyroplasty.

8.7 Postoperative Management

Last but not least, (??? daha profesyonel bir ifade kullanılabilir mi?) postoperative care is crucial. Voice rest and adequate humidification helps the healing process. Antibiotics are administered to prevent chondritis. Antireflux medications should also be given Steroids may be used to limit endolaryngeal edema for patients without tracheotomy. Patients with tracheotomy, however, should not receive steroids, as steroids may impair tissue healing. Stents and keels are usually removed 3–5 weeks after placement.

Closing the tracheotomy should be delayed until the tissue edema is resolved and the patient is able to clear secretions adequately. Permanent tracheotomy may be necessary for some patients—in case of severe stenosis or bilateral vocal cord paralysis. Speech therapy is an important part of postoperative care. Speech therapy should be initiated as soon as the tissue edema is resolved.

8.8 Tips and Pearls

- The level of injury can be determined by palpating the neck under emergency conditions. Fragments of cartilage and/or depressions in the laryngotracheal framework indicate the site of injury. Edema and hematomas developing in the soft tissue of the neck can make this examination difficult. In this case, the mechanism of injury gives clues about the injury site.
- Suicidal or accidental hanging causes trauma to the supraglottic larynx. The most common laryngotracheal injuries are caused by steering wheel and dashboard impacts in motor vehicle accidents, inducing injury at the level of the thyroid and cricoid cartilages. Bicycle and sports accidents also cause injury at that level. Laryngotracheal separation is likely in case of jet-ski or snowmobile accidents where the neck comes in contact with a fixed object such as a rope.
- Large lacerations of the mucosa may cause emphysema by air leakage into the soft tissues of the neck. Extensive ecchymosis and crepitation of the skin makes the diagnosis of emphysema easily recognizable (???).
- Intubation or tracheotomy is easier to apply in cases of incomplete separation airway, the posterior wall serving as a guide for airway management.
- On some occasions, endoscopic repair can be combined with open neck approach.
- If there is a vertical thyroid cartilage fracture, entry to the larynx can be through the fracture line. If there is a horizontal fracture, the opening can be achieved with a midline vertical laryngofissure. Mucosal incision is preferentially made through the midline across the anterior commissure to prevent further mucosal injury.
- If there is not enough mucosa to cover the entire larynx, priority is given to the glottic area and especially the anterior commissure.
- Complete reconstruction of the cartilage frame is not necessary as long as the three-dimensional shape of the larynx can be achieved.
- Miniplates and recently introduced absorbable plates are the best materials to use for joining cartilage fragments.
- If the reconstruction is not stable, a T-tube is put in place to serve as a stent, allowing voice production and breathing.

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