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Tips and tricks in tracheobronchial perforations

Trakeobronşiyal perforasyonlarda ipuçları ve püf noktaları

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ABSTRACT

Background: This study aims to present our experience regarding tracheobronchial perforations and their management.

Methods: Records of 16 patients (9 males, 7 females; mean age 46.6 years; range 1 to 83 years) with tracheobronchial perforation between January 1999 and March 2015 were retrospectively evaluated according to age, sex, symptoms, radiological findings, diagnostic methods, therapeutic options, localization of perforation, length of perforated area, intubation difficulty, etiological causes, clinical course, and complications of treatment.

Results: The most frequent radiological finding was subcutaneous emphysema (n=6). Mean length of perforations was 2.6 cm (range 0.5 to 8 cm). The localizations of perforations were trachea in 12 patients (75%), left main bronchus in three patients (18.8%), and trachea plus right main bronchus in one patient (6.2%). Diagnosis was confirmed by bronchoscopy in 11 patients (68.7%) and inspection findings were sufficient in the remaining five patients (31.3%). Causes of tracheobronchial perforations were iatrogenic in 12 patients (75%), self-expandable esophageal metallic stent in two patients (12.5%), gunshot wound, and stab wound in one patient each (6.25%). Surgery was performed in 12 patients and observation was sufficient in two patients. We offered tracheal stent to patients with esophageal stent; however, one of them refused our offer and he died at home, while the other patient died in the hospital while waiting for the purchase of the tracheal stent. In postoperative period, esophageal fistula developed in one patient while total atelectasis developed in left lung of another patient. Four patients died but none of them was related to our surgical procedures.

Conclusion: The basic management in airway perforations is early diagnosis and surgical treatment. Surgery may be performed with low complication rate.

Keywords: Esophageal injury; penetrating trauma; tracheobronchial perforation.

ÖZ

Amaç: Bu makalede trakeobronşiyal perforasyonlar ve bunların tedavisi ile ilgili deneyimlerimiz sunuldu.

Çalışma planı: Ocak 1999 ve Mart 2015 tarihleri arasında trakeobronşiyal perforasyonu olan 16 hastanın kayıtları (9 erkek, 7 kadın; ort. yaş 46.6 yıl; dağılım 1-83 yıl) yaş, cinsiyet, semptomlar, radyolojik bulgular, tanı yöntemleri, tedavi seçenekleri, perforasyonun yeri, perfore alanın uzunluğu, entübasyon zorluğu, etyolojik nedenler, klinik seyir ve tedavinin komplikasyonlarına göre retrospektif olarak değerlendirildi.

Bulgular: En sık radyolojik bulgu subkutan amfizem idi (n=6). Perforasyonların ortalama uzunluğu 2.6 cm (dağılım 0.5-8 cm) idi. Perforasyonların yerleri 12 hastada (%75) trakea, üç hastada (%18.8) sol ana bronş ve bir hastada (%6.2) trakea artı sağ ana bronş idi. On bir hastada (%68.7) tanı bronkoskopi ile desteklendi ve kalan beş hastada (%31.3) inspeksiyon bulguları yeterli idi. Trakeobronşiyal perforasyonların nedenleri 12 hastada (%75) iyatrojenik, iki hastada (%12.5) kendi kendine genişleyebilen metalik özofageal stent, birer hastada (%6.25) ateşli silah yaralanması ve kesici-delici alet yaralanması idi. On iki hastada cerrahi uygulandı ve iki hastada gözlem yeterli oldu. Özofageal stentli hastalara trakeal stent önerildi fakat bunlardan biri önerimizi kabul etmedi ve evinde öldü, diğer hasta ise trakeal stent alınmasını bekler iken hastanede öldü. Ameliyat sonrası dönemde bir hastada özofageal fistül, bir hastada ise sol akciğerde total atelektazi gelişti. Dört hasta kaybedildi fakat bunların hiçbiri bizim cerrahi işlemlerimiz ile ilgili değildi.

Sonuç: Hava yolu perforasyonlarının temel yönetimi erken tanı ve cerrahi tedavidir. Cerrahi düşük komplikasyon oranıyla uygulanabilir.

Anahtar sözcükler: Özofageal yaralanma; penetran travma; trakeobronşiyal perforasyon.

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Tracheobronchial perforations (TBP) usually occur due to iatrogenic causes such as bronchoscopy, endotracheal intubation, tracheal stent placement, esophageal surgery, tracheotomy, and thyroidectomy.[1-6] Other most common causes of TBPs are blunt and penetrating traumas. The incidence of aerodigestive perforation in penetrating neck injuries was reported as 0.09% in the literature.[7] Nevertheless, the incidences of tracheobronchial system injuries in blunt and penetrating thorax traumas are between 1% to 2% and 2% to 9%, respectively.[8] Clinical situation varies according to the perforation site and size.[9] The management of TBPs includes invasive and non-invasive methods.[10] In this article, we aimed to present our experience regarding tracheobronchial perforations and their management.

PATIENTS AND METHODS

We retrospectively evaluated records of 16 patients (9 males, 7 females; mean age 46.6 years; range 1 to 83 years) with tracheobronchial perforation at Medical Faculty of Atatürk University between January 1999 and March 2015 according to age, sex, symptoms, radiological findings, therapeutic option, localization of perforation, length of perforated area, intubation difficulty, etiological causes, clinical course, and complications of treatments. Diagnosis was established by means of direct visual inspection findings, endoscopic evidences, and radiologic data. Bronchoscopy was the principal method in diagnosis. We performed esophagoscopy in suspected esophageal perforations. Primary repair was the main surgical technique in tracheobronchial and esophageal perforations. Nevertheless, we performed debridement and supporting of perforated area by muscle flaps in esophageal perforations. We preferred to observe management in appropriate patients. The study protocol was approved by the Medical Faculty of Atatürk University Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

We diagnosed eight patients in perioperative period (50%). Most common radiological evidences were subcutaneous emphysema (n=6), pneumomediastinum (n=4), and pneumothorax (n=3). Symptoms and physical findings were subcutaneous emphysema (n=6), coughing (n=3), hemoptysis (n=1), dyspnea (n=1), and fever (n=1). Mean length of perforations was 2.6 cm (range 0.5 to 8 cm). The localizations of perforations were trachea, left main bronchus, and trachea plus right main bronchus in 12 (75%) and three (18.8%) patients, and one (6.2%) patient, respectively. We confirmed diagnosis by bronchoscopy in 11 patients (68.7%) and direct visual inspection findings were sufficient in the remaining five patients (31.3%). We detected associated esophageal perforation in five (31.3%) patients and established diagnosis of esophageal perforations by esophagoscopy in two patients (40%), bronchoscopy in two (40%) patients, and direct visual inspection in one patient (20%). Causes of tracheobronchial perforations were iatrogenic in 12 patients (75%), self-expandable esophageal metallic stent in two patients (12.5%), gunshot in one patient (6.25%), and stab wounds in one patient (6.25%). We performed primary repair by absorbable sutures on 12 patients and used debridement and sternocleidomastoid/omohyoid muscle flaps for supporting the esophageal perforation area in five of these 12 patients. Postoperative morbidity occurred in two patients. Esophageal fistula occurred in one patient with synchronous esophageal perforation which could be sealed with conservative treatment. A total atelectasis occurred on the left side and we performed rigid bronchoscopy in another patient with left main bronchial perforation. Although, we observed postoperative mortality in four patients, none of them was related to surgery. Causes of mortality were underlying cerebrovascular event, septicaemia, lung, and esophageal cancer. We offered tracheal stent to patients with lung and esophageal cancers but one of them refused our offer and died at home, while the other patient died in the hospital while waiting for the purchase of the tracheal stent. Only two patients had perforation smaller than 1 cm and they developed no complication. Patients' characteristics are listed in Table 1.

DISCUSSION

Tracheobronchial perforations are usually seen as a complication of thoracic surgery and anesthesiology interventions. Experience of surgeons and anesthesiologists, underlying disease, surgical techniques, and equipment used are the most effective factors in iatrogenic TBPs.[11] Furthermore, female sex, chronic obstructive pulmonary disease, small stature, and steroid treatment increase susceptibility to perforation.[4] The treatment of tracheobronchial perforations varies depending on clinical status and size of perforations. Although conservative treatment may be preferred in patients with small perforation (<2 cm) and mild symptoms, surgical repair should be preferred in patients with perforation greater than 2 cm.[12] Tips and tricks regarding our experiences on tracheobronchial perforations are summarized in Table 2.

Table 1. Patients' characteristics

No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Age (years)	34	52	43	51	1	83	49	58	29	36	45	58	49	62	67	28
Gender	M	F	M	M	M	M	M	F	M	M	F	F	M	F	F	F
Location	T	T	T	T	LMB	T	T	T	T	T	LMB	LMB	T	T	T	T+ RMB
Etiology	Stab	Gun	SES	SES	RB	FB	TE	PDT	ACPI	ACPI	MIE	OE	ETI	ETI	ETI	ETI
Symptom/finding	SA, H	SA	D, C	C	-	C	-	-	SA	F	-	-	SA	-	SA	SA
Radiology	SA, PM	PT	-	-	-	PT, PM	-	-	SA	CA	-	-	SA	PM	SA	SA, PT, PM
Diagnostic method (FT)	BC	BC	BC	BC	BC	BC	I	I	BC	I	I	I	BC	BC	BC	BC
Esophageal perforation	-	+	+	+	-	-	-	+	-	+	-	-	-	-	-	-
Diagnostic method (FE)	-	EC	BC	BC	-	-	-	I	-	EC	-	-	-	-	-	-
Difficult intubation	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-
Perioperative diagnosis	-	-	-	-	+	-	+	+	-	+	+	+	-	+	-	+
Length (cm)	3*	1	3	1	2	5	1	5	2.5	3	2	2	1	0.5	3	8

F: Female; M: Male; T: Trachea; LMB: Left main bronchus; RMB: Right main bronchus; Stab: Stabbing; Gun: Gunshot; FB: Foreign body; TE: Thyroidectomy; SES: Self expandable stent; RB: Rigid bronchoscopy; PDT: Percutaneous dilatation tracheostomy; ACPI: Anterior cervical plate instrumentation; MIE: Minimal invasive esophagectomy; OE: Open esophagectomy; ETI: Endotracheal intubation; SA: Subcutaneous emphysema; H: Hemoptysis; D: Dyspnea; C: Cough; F: Fever; PM: Pneumomediastinum; CA: Cervical abscess; PT: Pneumothorax; FT: For Trachea; FE: For Esophagus; * There were two separate perforations in this patient; first was of 1 cm and second was of 2 cm.

Endotracheal intubations are the most common causes of TBPs. The incidence in double lumen intubations is between 0.12% to 0.26% in the literature.[3,13] Difficult, repeated and emergent intubation, large diameter of intubation tube, or intubation without guidance of fiberoptic bronchoscopy increase TBP risk.[3,4] In this paper, we presented four patients who had TBPs related to endotracheal intubation. First patient was intubated with single lumen tube for the caesarean section. We performed rigid bronchoscopy and identified a tear starting 4 cm below the vocal cords and extending to the carina. We performed right posterolateral thoracotomy and identified a tear of 8 cm in length, which was extending until right main bronchus. Since anesthesiologist pushed forward the intubation tube blindly and without deflation of tube cuff, the length of the tear increased. Primary suturing was performed. Second patient was intubated by single lumen for an ophthalmic procedure. She had a difficult intubation history. Subcutaneous emphysema occurred in this patient after extubation. We performed flexible bronchoscopy and detected a tear of 3 cm in length in the upper half of the trachea. We conducted right cervical incision and repaired the tear primarily. We did not identify esophageal injury perioperatively in these two patients. The third patient had a pulmonary nodule, and the fourth was a patient with pulmonary hydatid cyst. They were intubated by double lumen intubation tube and both patients had difficult intubation history. In the third patient, we aimed to evaluate the trachea since excessive manipulations were done for intubation and rigid bronchoscopy was performed. We were able to identify the perforated area before starting the surgery. Its length was 0.5 cm and it was localized at the upper half of the membranous part of the trachea. Anesthesiologists intubated the patient with thin and single lumen tube and pushed the intubation tube to the distal site of perforation. After this securing maneuver, the thoracoscopic wedge resection could be performed. The fourth patient underwent cystotomy and capitonnage. Subcutaneous emphysema in neck occurred immediately after the extubation. We performed rigid bronchoscopy rapidly and found a perforation of 1 cm in length in the upper portion of the membranous part of the trachea. In the last two patients, conservative management for tracheal perforations was sufficient.

The incidence of TBPs in thoracic surgery is between 0.37% and 7.1% in the literature.[14] Particularly, this risk increases during esophagectomy; its incidence related to esophagectomy was reported to be between 4% and 10% in the literature.[15] Esophagectomy without

Table 2. Tips and tricks in tracheobronchial perforations

Etiology	Tips	Tricks
ETI	• Excessive manipulations for intubation • Sudden subcutaneous emphysema in cervical region after extubation or during surgery • Pushing forward the intubation tube without deflating the cuff	• Rapid bronchoscopy after extubation • Intubation with small-size tube in small perforations diagnosed before surgery
OE/MIE	• Excessive inflation of intubation tube cuff	• Attention during esophageal dissection in subcarinal region • Supporting of the perforation area with omental tissue
ACPI	• Subcutaneous emphysema in neck at postoperative period	• Esophagus should be evaluated • Tracheal perforation may be overlooked in pentaplegic patients since they remain intubated even after surgery • Muscle flaps for supporting the perforation areas
PDT	• Repeated efforts for PDT • Inexperienced staff	• Simultaneous perforation of anterior and posterior tracheal wall • Simultaneous esophageal perforation • Repairing the membranous portion throughout the anterior tracheal tear • Muscle flaps for supporting the perforation areas
TE	• Direct visualization of intubation tube	• Even small-sized perforations should be repaired because of hemorrhage after thyroidectomy and blood aspiration
RB		• Re-bronchoscopy should be performed after removal of foreign body
FBA	• Aspiration of sharp and pointed foreign body	• Primarily repair under sedoanalgesia in patient with tracheostomy
SEMS	• Irritative cough	• Tracheal stent placement without delay
PCT		• Simultaneous bronchoscopy and esophagoscopy should be performed • Debridement of necrotic tissues and muscle flaps for supporting the perforation areas

ETI: Endotracheal intubation; OE: Open esophagectomy; MIE: Minimal invasive esophagectomy; ACPI: Anterior cervical plate instrumentation; PDT: Percutaneous dilatation tracheostomy; TE: Thyroidectomy; RB: Rigid bronchoscopy; FBA: Foreign body aspiration; SEMS: Self expandable metallic stent; PCT: Penetrating cervical trauma.

thoracotomy, neoadjuvant chemoradiotherapy, and tumor with advanced T stage facilitate the occurrence of perforation.[16,17] The jeopardy of TBPs is higher during transhiatal esophagectomy since esophageal dissection is conducted blindly.[17] Between 2000 and 2015, esophagectomy was performed in 302 patients with esophageal cancer in our department. In our series, left main bronchial perforation occurred in two patients during esophagectomy (0.7%). In the first patient, we performed open Ivor-Lewis esophagectomy. Rupture of membranous part of left main bronchial occurred during dissection of the esophagus in the thorax. We repaired the bronchus primarily. After primary suturing, we supported the perforating area

with omentum. We harvest large omental tissue during skeletonization of stomach in esophagectomy and use this omentum for supporting the anastomosis. In the second patient, we performed minimal invasive Ivor-Lewis esophagectomy. During thoracoscopic releasing of the esophagus, membranous part of the left main bronchus was perforated. We noted the cuff in the left main bronchus (Figure 1). We extended the already existing utility thoracotomy and performed primary suturing. We used omental tissue for support in this patient, too. Atelectasis occurred on the left side in this patient during postoperative period and we conducted bronchoscopy. Postoperative recovery was uneventful in these two patients. Our incidence of TBP related to esophagectomy is low when compared with the literature since esophageal cancer is endemic in our geographic area and we have been performing esophagectomy for many years in our department; therefore, we are greatly experienced in this topic.

Although esophageal perforations related to anterior cervical instrument placement were reported in the literature, data about tracheal perforations related to this procedure is insufficient.[18] The incidence of esophageal perforation was reported as approximately 0.1% in these operations.[19] Usually, esophagus is injured by direct effect of cervical instrument or during retraction. Among our patients, two underwent anterior cervical plate fixation. First patient who was pentaplegic was injured in a motor accident. A neurosurgeon placed the anterior cervical plate. We performed flexible esophagoscopy and observed perforation in cervical part; however, we were unable to determine the tracheal perforation before surgery since we did not consider tracheal perforation. We opened the previous right cervical incision and noted a tracheal perforation on the cartilaginous portion of the trachea. Firstly, we repaired the esophageal perforation after debridement of necrotic tissues and used omohyoid muscle flap for esophagus. Secondly, we sutured the trachea primarily. This patient died because of bacterial septicaemia. The second patient was also injured in a traffic accident and had cervical vertebra fractures. We performed flexible bronchoscopy and observed a cartilaginous tear of 2.5 cm in length. We opened the previous right cervical incision again and conducted primary suturing. We checked the esophagus and did not find esophageal perforation during the operation. No complication occurred after the operation.

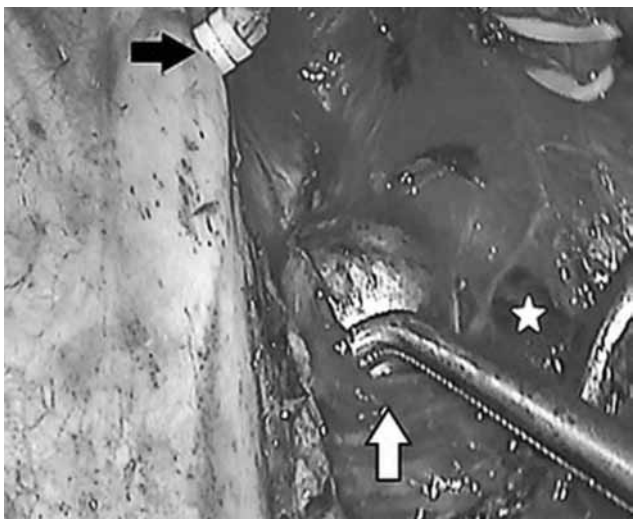

Figure 1. Left main bronchial perforation due to minimal invasive esophagectomy.
Black arrow: Clipped azygos vein; White arrow: Left main bronchus; Star: Right main bronchial lymph node.

Percutaneous dilation tracheostomy (PDT) is widely performed in intensive care units. When compared to open tracheostomy, complication rate of this technique is equivalent while its complication severity is greater than conventional tracheostomy.[20] For this technique, the incidence of tracheal injury was reported as a rate of between 0.2% to 4.8% in the literature.[20,21] One of the most severe complications of PDT is esophageal perforation and its incidence was reported as 0.2% in a large series.[21] Membranous tear of trachea is usually accompanied by esophageal injury. In our series, we had one patient who underwent PDT (Seldinger procedure). An anesthesiologist performed PDT due to prolonged intubation. We detected a tear of 5 cm in length on the cartilaginous portion. Furthermore, we identified perforations in rear trachea and esophagus. We did not perform bronchoscopy and esophagoscopy on this patient and inspection findings were sufficient for diagnosis. Firstly, we repaired the membranous portion rapidly throughout the anterior tracheal tear. Secondly, we closed the cartilaginous trachea primarily. Finally, we repaired the esophagus and supported it by omohyoid muscle flap. We noted no complication related to surgery; however, patient died on the fourth day due to cerebral event.

Tracheal perforation due to thyroidectomy is an extremely rare condition. In a large series consisting of 11,917 patients, tracheal perforation occurred in seven patients during thyroidectomy (0.06%).[6] In our series, tracheal perforation related to thyroidectomy developed in one patient with multinodular goitre. The location of injury was the anterior surface while its length was 1 cm. Although perforation length was short, primary suturing was performed at the same operation because the diagnosis was established perioperatively and suturing took a few minutes. We believe that due to

Figure 2. A long tear in rear trachea and primary suturing.

a blood aspiration risk because of hemorrhage after thyroidectomy, even small-sized tracheal perforations should be repaired.

Rigid bronchoscopy is the gold standard in the management of tracheobronchial foreign body aspirations. This procedure is performed with low complication rate. Nevertheless; tracheobronchial perforations, pneumomediastinum, and pneumothorax may be seen after rigid bronchoscopy.[22] After the extraction of the foreign body, tracheobronchial system must be carefully examined for any perforation. We had a one-year old patient with bronchial perforation related to rigid bronchoscopy in this series. We identified a membranous tear of 2 cm in length in the left main bronchus after removing a sunflower seed from the left main bronchus. We conducted left posterolateral thoracotomy and repaired the tear primarily. No complication occurred.

Airway perforation after foreign body aspiration is extremely rare. Perforation occurs when foreign body is sharp and pointed. In our series, there was one patient who had aspirated a sharp and pointed plastic object. Also, he had undergone laryngectomy because of laryngeal carcinoma. An otolaryngologist extracted the foreign body by Mcgill clamp throughout stoma. We performed bronchoscopy firstly and detected a tear of 5 cm in length in membranous portion. Esophagoscopy was normal. We repaired this long tear primarily through stoma under sedoanalgesia (Figure 2). No complication occurred after the operation.

Self-expandable metallic stents (SEMSs) are the most preferred method for palliation of malignant dysphagia in inoperable esophageal cancers.[23] Tracheal perforation due to SEMSs usually occurs while the stent is removed.[24] Nevertheless, esophageal and tracheal wall may be eroded by SEMSs.[23] There were two patients with tracheal perforation related to esophageal stent in this series. The first patient had a right pneumonectomy due to squamous cell carcinoma. Self-expandable metallic stent was placed for palliation of dysphagia since chemoradiotherapy (CRT) could not improve dysphagia. Fiberoptic bronchoscopy was

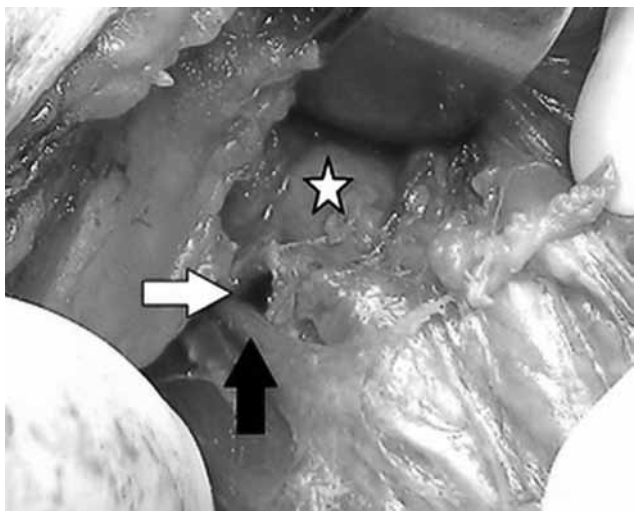

Figure 3. Tracheal perforation in female patient who was injured by gunshot.

White arrow: Tracheal perforation; Black arrow: Left recurrent laryngeal nerve; Star: Anterior tracheal wall.

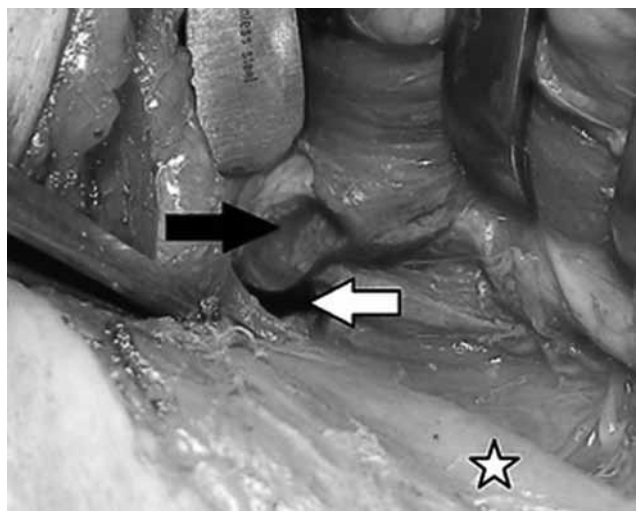

Figure 4. Simultaneous esophageal perforations in same patient who was injured by gunshot.

Black arrow: Esophageal perforation; White arrow: Apertura thoracic superior; Star: Left subclavian artery.

Figure 5. Harvested sternocleidomastoid muscle.

performed and the membranous tracheal perforation of 3 cm in length was identified four months after this procedure. We offered the tracheal stent, but the patient refused our offer and died at home sixth months after SEMS placement. Other patient had primary esophageal cancer. He took CRT for palliation of dysphagia. SEMS was placed seven months ago since CRT was ineffective. We performed flexible bronchoscopy and identified a membranous tear of 1 cm in length in trachea. The patient was hospitalized for tracheal stent placement. Unfortunately, he died at hospital during the purchasing process of tracheal stent. We are greatly experienced in using esophageal stents for esophageal cancer. Our surgical team placed 441 esophageal stents for palliation of malignant dysphagia between 1999 and 2015 and the incidence of tracheal perforation related to SEMS is about 0.5% in our patients. SEMS may produce severe complications such as tracheal perforation in late period in cervical and upper thoracic esophageal cancers. Therefore, we firstly recommend CRT to our patients who are not eligible for esophagectomy. When CRT fails or patient refuses this treatment, we place the SEMSs.

The incidence of tracheoesophageal perforation in penetrating cervical traumas is 0.09%, with penetrating thorax traumas being between 2% to 9% in the literature.[7,8] Endoscopic evaluation must be performed for tracheobronchial system and esophagus in penetrating neck trauma. In our study, there were two patients with tracheal perforation related to penetrating trauma. First was a patient suffering from gunshot wound at left lower neck region. We performed flexible esophagoscopy and bronchoscopy and identified tracheal and esophageal perforations on the left lateral side, of which both lengths were about 1 cm (Figure 3 and 4). We repaired the trachea and esophagus primarily after the debridement was performed for esophagus. Perforated areas were supported by omohyoid and sternocleidomastoid muscle flaps (Figure 5). Esophageal fistula occurred during postoperative period, which could be managed by conservative treatment. The second patient was injured with stab wounds on the neck. We performed bronchoscopy and esophagoscopy. Esophagus was intact but there were two perforations of 1 and 2 cm in lengths on the cartilaginous trachea. We performed primary suturing and the postoperative period was uneventful.

The limitations of this study are retrospective design and single-centre site.

The most important factors that increase mortality are underlying diseases in tracheobronchial perforations. While primary suturing of perforated tracheobronchial area is usually an effective method in most cases, debridement of perforated esophageal tissue should also be performed on patients with simultaneous esophageal perforations. These surgical techniques may be applied with low complication rates.

Declaration of conflicting interests

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