Original Article

Direct and indirect CT imaging features of esophago-airway fistula in adults

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Background: Esophago-airway fistula (EAF) is an abnormal connection between the esophagus and the trachea or a major bronchus. While contrast esophagography remains the primary radiographic tool for the diagnosis of EAF, computed tomography (CT) is often employed in its evaluation. A systematic analysis of CT findings of EAF in adults has not been previously published. The goal of our study is to determine the direct and indirect CT findings of EAF in adults.

Methods: We identified patients with EAF detected on CT at our institution between January 1, 2001 and December 31, 2019, with endoscopic or surgical confirmation. We collected patient clinicopathologic characteristics and assessed CTs for direct and indirect imaging features of EAF in these patients.

Results: Twenty-six patients (median age: 56 years; range, 25–79 years; F=13, 50% and M=13, 50%) with confirmed EAF were identified. Half of the patients had an underlying malignancy. On CT, a direct connection between the esophagus and the airway was identified in most cases (22/26; 85%). Common indirect CT findings of EAF included esophageal wall thickening (21/26, 81%), mediastinal fatty stranding (21/26, 81%), airway wall thickening (20/26, 77%), fluid or debris within the airways (17/26, 65%), and focal or diffuse esophageal dilation with air (17/26, 65%). Mediastinal fluid collections were infrequently seen (4/26, 15%), but findings of aspiration or other pneumonia were common (19/26, 73%).

Conclusions: CT plays an essential role in both the primary and secondary evaluation of adult EAF resulting from both malignant and benign etiologies. CT may be the first diagnostic exam to suggest and detect the presence of EAF and may precede clinical suspicion, and it can detect a subset of fistulas not demonstrated on esophagography. There are several direct and indirect imaging findings on CT that can help in the detection of EAF.

Keywords: Imaging; radiology; esophago-airway fistula (EAF); tracheoesophageal fistula (TEF); bronchoesophageal fistula

Submitted Jan 07, 2020. Accepted for publication Mar 21, 2020.
doi: 10.21037/jtd-20-244
View this article at: http://dx.doi.org/10.21037/jtd-20-244

Introduction

Esophago-airway fistulas (EAF) include both tracheoesophageal (TEF) and bronchoesophageal fistulas (BEF) and are pathological connections between the esophagus and the trachea or a major bronchus. While EAF are rare, they cause significant morbidity and mortality due to recurrent respiratory infections and malnutrition (1,2).

When diagnosed in adulthood, the EAF is typically acquired. Malignancies, most commonly esophageal cancer followed by lung cancer, account for more than half of the cases in the adult (3,4). Benign conditions such as prolonged intubation, trauma (both iatrogenic and non-iatrogenic), and infections are other less common causes of acquired EAF (1,5-9). Even less frequent are small congenital TEFs that are diagnosed or recur late in adulthood (10-12).

The contrast esophagogram, typically using barium, remains the primary radiographic tool for the diagnosis of TEF and BEF. Computed tomography (CT) is also often employed in cases of suspected or proven fistulas in adults to further characterize the fistula and the esophageal and airway anatomy, to evaluate for complications including mediastinal and lung infections, and as an alternative in patients who are unable to swallow or unable to cooperate or tolerate fluoroscopy, such as those with altered mentation or on ventilator support. Sometimes, previously undiagnosed and unsuspected EAF can be detected on CT performed in patients presenting with respiratory symptoms underscoring the importance for radiologists to be familiar with CT findings of this entity (13,14).

While the findings of TEF and BEF on contrast esophagography are well-described, to our knowledge, a systematic analysis of CT findings of EAF in adults has not been previously published. The goal of our study was to determine the direct and indirect CT findings of EAF in adults.

Methods

Patient identification and inclusion

The institutional review board approved this study, with informed consent waived due to its retrospective nature (IRB# 2018P003136). We queried our institutional radiology information system for chest CT examinations performed between January 2001 and December 2019 at a major academic center with reports containing "tracheoesophageal fistula" or "bronchoesophageal fistula" in the indication, body, or impression of the report. The patients with confirmed EAF on endoscopy, or surgery were selected for review. The CT closest to the date of confirmatory study and before the intervention was selected for review, if multiple scans were performed.

Review of CT imaging studies

CT examinations were performed on multidetector row CT scanners from different vendors, with a slice thickness of 1.25 to 2.5 mm. Unless contraindicated, intravenous contrast was routinely administered and, in 6/26 cases, oral contrast was also administered. Three radiologists with subspecialty training in thoracic imaging (SRD, BPL, and DPM) reviewed the studies independently using the institutional picture archiving and communications system (AGFA Impax 6, Mortsel, Belgium). Disagreements, if any, were resolved by consensus.

The EAF findings on CT were categorized as direct or indirect. Identification of a tract between the esophagus and trachea or bronchus constituted a direct sign. The size (width and length) and location of the fistulous connection and tract contents (air, fluid, or both) were recorded.

The indirect findings were assessed in the airway, esophagus, mediastinum, and lungs. The airway findings included tracheal and bronchial wall thickening >4 mm (15), dilation of the trachea, and debris or fluid within the central airways. The esophageal findings included wall thickening >4 mm (16), esophageal dilatation with air, extravasation of oral contrast into either airways and/or mediastinum (when oral contrast was given), presence of a sinus tract arising from the esophagus but not appreciably connecting to the trachea, and gastric distention. The mediastinal findings were fat stranding, extraluminal air or fluid, and lymphadenopathy (lymph nodes >1 cm in the short axis). The indirect lung findings were consolidations, ground glass opacities, and bronchocentric nodules, suggestive of aspiration or other pneumonia.

Statistical analysis

Patient characteristics and imaging features of the fistulas were analyzed using descriptive statistics. The features of benign and malignant causes of EAF were compared using the Wilcoxon rank-sum test and Fisher's exact test for continuous and categorical variables, respectively. All tests were two-sided. A P value of 0.05 or less was considered

significant.

Results

Patient characteristics

We identified 26 patients with CT studies with TEF or BEF and with endoscopic or surgical confirmation (*Table 1*). Seven patients also had a contrast esophagogram performed prior to the CT as part of the workup; of these, EAF was identified in 4/7 (57.1%), while in 3/7 (42.9%), the fistula could not be demonstrated.

The clinicopathologic characteristics are summarized on *Table 2*. Half (13/26; 50%) of the patients had an underlying malignancy. The most common malignancies were esophageal cancer (6/13; 46.2%) and lung cancer (3/13; 23.1%). There were also one each case of head and neck cancer, tracheal adenoid cystic carcinoma, lymphoma, and breast cancer with lung metastases. Most of these patients (11/13; 84.6%) underwent combined chemotherapy and radiation therapy. Most EAF in these patients (9/13; 69.2%) developed after cancer-related treatments, while the remainder (4/13; 30.8%) were found before treatment due to direct tumor extension.

The second most common etiology for EAF formation was prolonged or traumatic intubation (5/26; 19.2%). Other etiologies included non-iatrogenic trauma (3/26; 11.5%), congenital-developmental anomaly (3/26; 11.5%), and infection (2/26; 7.7%). Non-iatrogenic traumatic etiologies included a transmediastinal gunshot wound, a foreign body retained in the esophagus, and a reported remote "crush" injury. Infectious causes included mediastinal tuberculosis and herpes esophagitis in the setting of HIV infection.

Most patients (17/26) were diagnosed in an inpatient setting. In those that were diagnosed as in the outpatient setting (9/26), three were congenital, three were due to non-iatrogenic trauma, two were due to prolonged intubation, and one was due to infection. Although there was a significant overlap in the symptoms and presentation of patients, the most common presenting symptoms in half of the patients were dysphagia and aspiration (13/26; 50%). While most (22/26, 84.6%) of the TEF were known or suspected at the time of CT, 4 (15.4%) were detected and diagnosed by CT prior to any clinical suspicion.

CT imaging features of fistulas

Direct and indirect imaging features identified on CT are presented in *Table 3*. The fistula was most commonly between the trachea and esophagus (23/26; 88.5%) and most commonly arose from the upper trachea (10/26; 38.5%), followed by the mid- (7/26; 26.9%) and lower trachea (6/26; 23.1%). The BEFs were less frequent (3/26; 11.5%). A direct tract between the esophagus and adjacent airway was identified in most cases (22/26; 84.6%). In the three patients in whom the barium esophagography was negative, a direct connection between the airway and esophagus was could be identified (*Figure 1*). When identified, the tract mostly contained air (12/22; 54.5%) or both air and fluid (8/22; 36.4%), rather than fluid alone (7/22; 31.8%). When oral contrast was administered (6/26; 23.1%), extra-esophageal contrast was noted only in one (16.7%) patient.

Inflammatory changes to the esophagus, airway, and mediastinum were common, with esophageal wall thickening and mediastinal fat stranding in 80.8% (21/26) of patients and airway wall thickening in 76.9% (20/26) of patients. Fluid or debris within the airways (17/26; 65.4%) and focal or diffuse esophageal dilation with air (17/26; 65.4%) were also commonly found. Most patients (19/26; 73%) had lung parenchymal abnormalities related to aspiration or other pneumonia. When present, there were typically bilateral (16/19; 84.2%). Pneumomediastinum (11/26; 42.3%) and discrete mediastinal fluid collections (4/26; 15.4%) were, however, less frequently present.

Malignancy-related versus benign fistulas

A comparison of patients with malignancy-related and non-malignancy related EAF is presented in *Table 4*. Those with malignancy-related fistulas tended to be older than those with non-malignant causes (median age, range, 61 years, 38–79 years versus 50 years, 25–69 years; P=0.019). In general, however, there were no statistically significant differences between the two subgroups regarding the imaging features related to the EAF.

Discussion

TEF and BEF, although rare in adults, can result in significant morbidity and mortality if left undiagnosed and untreated. CT plays an important role in their diagnosis and characterization. In this study, we determined the direct and indirect findings of TEF and BEF on CT. We found that, in most cases, a direct connection between the esophagus and the airway is seen on CT and that several other ancillary findings may assist in the detection of EAF. Our findings

Table 1 Included patients (n=26) with confirmed esophago-airway fistulas from both malignant and non-malignant causes

Patient number	Sex	Age (years)	Etiology	Other details	Location
Malignant					
1	Male	54	Esophageal cancer	Palliative therapy	Mid
2	Female	62	Metastatic breast cancer	CTX-RT	Bronchial
3	Male	38	NSCLC	CTX-RT, dilatations	Mid
4	Male	49	NSCLC	CTX-RT	Lower
5	Female	61	Esophageal cancer	CTX-RT	Lower
6	Male	61	Esophageal cancer	CTX-RT	Lower
7	Male	72	Esophageal cancer	Surgery, CTX	Mid
8	Female	79	Adenoid cystic carcinoma	CTX-RT	Lower
9	Male	60	Esophageal cancer	CTX-RT	Upper
10	Female	63	NSCLC	CTX-RT	Upper
11	Female	55	Hodgkin lymphoma	CTX-RT, dilatations	Bronchial
12	Male	65	Head and neck cancer	CTX-RT	Upper
13	Female	72	Esophageal cancer	CTX-RT	Upper
Non-malignant					
14	Male	39	Prolonged/traumatic intubation		Upper
15	Female	57	Prolonged/traumatic intubation		Upper
16	Male	51	Prolonged/traumatic intubation		Upper
17	Female	69	Prolonged/traumatic intubation		Upper
18	Female	66	Prolonged/traumatic intubation		Upper
19	Female	59	Non-iatrogenic trauma	Retained foreign body	Lower
20	Male	49	Non-iatrogenic trauma	Gunshot wound	Mid
21	Male	25	Non-iatrogenic trauma	Crush injury	Mid
22	Female	38	Congenital		Upper
23	Female	51	Congenital		Mid
24	Female	42	Congenital		Mid
25	Male	38	Infection	Herpes esophagitis	Bronchial
26	Male	50	Infection	Mediastinal tuberculosis	Lower

CTX, chemotherapy; XRT, radiation therapy.

also suggest that CT may be helpful in cases of EAF that are not detected by contrast esophagography and may be the first imaging study to suggest their presence.

Our series consisted of 26 adult patients with EAF found by CT in both benign and malignant settings. Consistent with prior reports, half of our patients had an underlying malignancy (3,4). Notably, EAF developed after or as a sequela of treatment of the malignancy. In those with non-malignant causes, prolonged intubation was the most common cause, as is consistent with prior reports (1,5,6). In 4 cases, CT was the first diagnostic study to suggest or detect the TEF and preceded clinical suspicion and diagnosis.

The CT findings of adult EAF have been previously

Table 2 Clinicopathologic characteristics of adult patients with esophago-airway fistula detected on CT (n=26)

Characteristics	n	%
Age (in years), median [range]	56 [25–79]	
Sex		
Male	13	50.0
Female	13	50.0
Etiology		
Malignancy	13	50.0
Treatment-related (i.e., radiation; dilations)	9	34.6
Direct tumor extension	4	15.4
Prolonged or traumatic intubation	5	19.2
Traumatic, non-iatrogenic	3	11.5
Congenital	3	11.5
Infectious	2	7.7
Chief complaint/presentation		
Dysphagia/aspiration	13	50.0
Pneumonia	9	34.6
Chronic cough	2	7.7
Excessive belching	2	7.7

CT, computed tomography.

Table 3 Direct and indirect CT imaging findings of esophago-airway fistulas (n=26)

Imaging feature	n	%
Direct connection identified	22	84.6
Fistula location		
Trachea: upper third	10	38.4
Trachea: middle third	7	26.9
Trachea: lower third	6	23.1
Bronchus	3	11.5
Extraluminal contrast (n=6)	1	16.7
Sinus tract	11	42.3
Esophageal wall thickening	21	80.8
Esophageal dilation with air	17	65.4
Diffuse	12	46.2
Focal	5	19.2
Gastric distension with air	4	15.4
Airway wall thickening	20	76.9
Tracheal debris/fluid	17	65.4
Tracheal dilation	2	7.7
Pneumomediastinum	11	42.3
Mediastinal fluid collection	4	15.4
Mediastinal fatty stranding	21	80.8
Mediastinal lymphadenopathy	12	46.2
Aspiration/pneumonia findings	19	73.1
Bilateral	16	61.5
Unilateral	3	11.5

CT, computed tomography.

described only in case reports (11-14,17-21). A small series of 10 congenital fistulas in neonates with esophageal atresia showed a good correlation between CT and surgical findings (22). Several authors have also analyzed the potential role of CT in the management of EAF in children (23-25). However, to our knowledge, a systematic analysis of CT findings of adult EAF has not previously been published.

In our cohort, CT demonstrated a direct connection between the airway and esophagus in the majority (85%) of the patients. When CT and esophagography do not identify a fistulous tract, several indirect imaging features on CT may raise suspicion of an EAF. All 4 patients in whom a fistulous tract was not seen on CT had other indirect signs including esophageal or airway wall thickening or mediastinal fatty stranding (*Figures 2* and *3*). Other indirect signs seen in most of the patients included esophageal distention with air (*Figure 1*), fluid or debris within the airways, and lung parenchymal abnormalities suggestive of aspiration or infectious pneumonia (*Figure 1*). Endoscopy to directly examine the esophagus or tracheobronchial tree is ultimately used to confirm fistulous communication when imaging findings are equivocal in patients with suspected EAF.

Somewhat surprisingly, oral contrast opacification of the fistulous tract or extra-esophageal extravasation of oral contrast was present in only one of the six cases in which oral contrast was administered (*Figure 2*). When demonstrated, the extra-esophageal extension of the oral contrast into the airway is diagnostic of EAF; its absence, however, does not exclude a fistula. Failure to demonstrate oral contrast within a fistulous tract at CT might be due to characteristics of the fistula, such as small size or obstructing debris within the tract, transient opening and closing of the

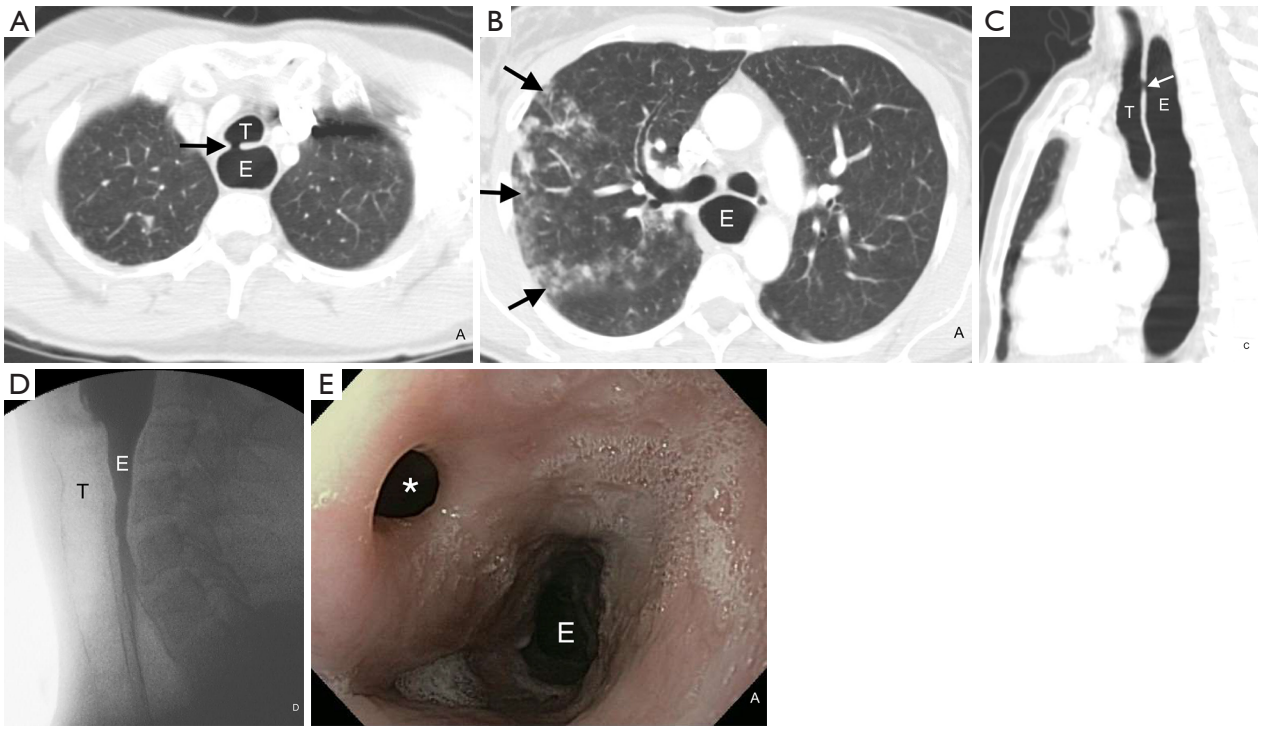

Figure 1 Small congenital H-type tracheoesophageal fistula (TEF) in a 51-year-old woman presenting with chronic, excessive belching. Chest CT (A,B,C) clearly demonstrates a direct connection (A and C, arrow) between the upper trachea (T) and upper esophagus (E). There is also marked air-filled dilation of the esophagus. Centrilobular ground glass opacities and patchy consolidation in the right upper lobe (B, arrows) are consistent with aspiration. Contrast esophagogram (D) performed prior to the chest CT was falsely negative. Endoscopy (E) confirmed the presence of the TEF (E, asterisk).

fistula, or an acute angle of origin of the fistula preventing the exit of contrast. The method of administration of oral contrast may also play a role in opacification of the tract; administration in the upright position, as was the practice in our series, is likely not as effective as oral contrast administration to a patient in prone or lateral decubitus position due to the more favorable dependent position of the fistula in the latter positions. In addition, given that most fistulas identified on CT contained air or both air and fluid, air may prove to be a helpful contrast agent in detecting these fistulas. As clinically allowable and technically feasible, gentle insufflation of the esophagus or hyperventilation in intubated patients may increase air within the aerodigestive tract and allow for better detection of these fistulas.

Contrast extension from the esophagus to the adjacent airway on contrast esophagogram is diagnostic of EAF (26). Contrast esophagography, however, is not 100% sensitive. The sensitivity and specificity of esophagography in the detection of EAF have yet to be reported, but esophagography has been found to be helpful in detecting leaks following surgery to the neck, esophagus, or stomach, and it is the study of choice in patients presenting with dysphagia following these surgeries (27). Esophagography has been reported to be 36–79% sensitive and 73–97% specific in diagnosing a postoperative leak (28,29). It has also been reported that CT in addition to esophagography can raise sensitivity in detecting postoperative leaks to up to 100% (29). In our cohort, the fistula was not demonstrated in 3 of the 7 patients who underwent contrast esophagography. This observation, however, does not prove that CT is more sensitive than contrast esophagography, as our cohort was selected from a group of patients who had CT for EAF, but it does support the hypothesis that CT can diagnose EAF that are undetectable by esophagography.

Additionally, CT better demonstrates surrounding structures than esophagography, facilitating identification of complications. Mediastinal fluid collections were infrequent and were seen in only 4 of the 26 patients. When present, they may be complicated by an infection. Most patients also had lung parenchymal abnormalities consistent with

Table 4 Comparison of the patient characteristics and fistula features among those with malignancy-related and non-malignancy-related EAF

Characteristics	Malignant (n=13)		Non-malignant (n=13)		P value
	n	%	n	%	
Demographics					
Age, median [range]	61 [38–79]		50 [25–69]		0.019
Sex					1
Male	7	53.8	6	42.9	
Female	6	46.2	7	50.0	
Fistula features					
Location					0.49
Upper third	4	30.8	6	46.2	
Middle third	3	23.1	4	30.8	
Lower third	4	30.8	2	15.3	
Bronchial	2	15.4	1	7.7	
Direct connection identified	11	84.6	11	84.6	1
Esophageal wall thickening	12	92.3	9	69.2	0.32
Esophageal dilation with air	7	53.8	10	76.9	0.41
Sinus tract	6	46.2	5	38.5	1
Gastric distension with air	1	7.7	3	23.1	0.59
Airway wall thickening	11	84.6	9	69.2	0.64
Tracheal debris/fluid	8	61.5	9	69.2	1
Tracheal dilation	2	15.4	0	0.0	0.48
Pneumomediastinum	6	46.2	5	38.5	1
Mediastinal fluid collection	3	23.1	1	7.7	0.59
Mediastinal fat stranding	10	76.9	11	84.6	1
Mediastinal lymphadenopathy	4	30.8	8	61.5	0.24
Aspiration/pneumonia findings	9	69.2	10	76.9	1
Bilateral	7	53.8	9	69.2	
Unilateral	2	15.4	1	7.7	

EAF, esophago-airway fistula.

aspiration and infectious pneumonia that tended to be multifocal when present.

We also sought to compare the imaging features of EAF related to malignancy to those of EAF from non-malignant causes. While it did not reach statistical significance, it is notable that EAF related to malignancy were nearly equally distributed throughout the upper, mid, and lower trachea, while TEFs due to benign causes were slightly more frequently seen in the upper trachea. This variance in distribution was likely driven by TEF secondary to prolonged intubation, all five of which occurred in the upper trachea. TEF from prolonged intubation is thought to result from sustained pressure of the hyper-inflated endotracheal tube cuff against the posterior wall of the trachea, which is pushed against the rigid nasogastric tube in the esophagus, resulting in ischemia, necrosis, and tissue breakdown (30). Several risk

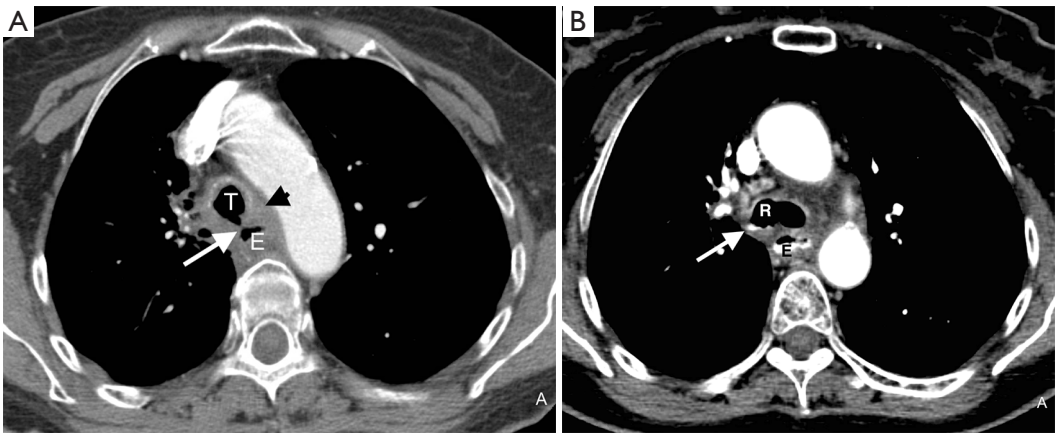

Figure 2 Acquired tracheoesophageal fistula in a 79-year-old man status post chemotherapy and radiation therapy for tracheal adenoid cystic carcinoma. CT shows a direct communication (A, white arrow) between the trachea (T) and esophagus (E) at the level of the aortic arch. There is also wall thickening of the affected tracheal and esophageal segments, with surrounding mediastinal fatty stranding (A, black arrow). Administered oral contrast is also seen within the right mainstem bronchus (B, arrow) and esophagus, confirming the fistulous connection.

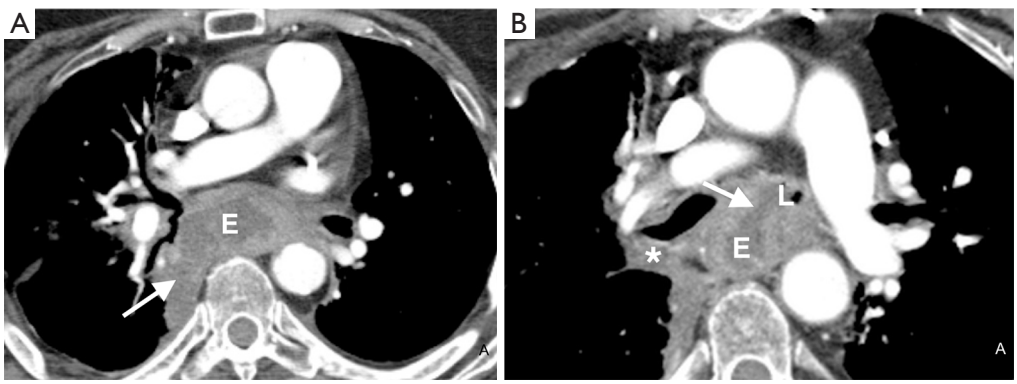

Figure 3 Acquired bronchoesophageal fistula in a 55-year-old woman with esophageal squamous cell carcinoma and chronic esophageal candidiasis. (A) CT image shows irregular thickening (arrow) of the esophageal wall (E) and a tract extending to the mediastinum and toward the right pleura. (B) The esophagus (E) shows a fluid-filled fistula (arrow) to the left main bronchus (L). Mediastinal fluid and stranding (asterisk), endobronchial fluid and thickening of the wall of the left mainstem bronchus are also present.

factors, including steroid treatment, chronic hypoxia, poor nutrition, sepsis, and prolonged episodes of hypotension, have been associated with TEF formation in chronically intubated patients (30,31).

There were no other significant differences in the imaging features of EAF related to malignant and non-malignant causes. Both groups had high frequencies of identifiable fistulas and esophageal, airway, and mediastinal inflammatory changes. Lymphadenopathy was seen in both groups, with slightly increased (although not statistically significant) frequency in benign EAF, suggesting that these lymph nodes are most likely reactive. Both groups also had a similar incidence of associated lung parenchymal findings of aspiration and other pneumonias.

Definitive surgical repair of acquired EAF should be considered, especially when of benign etiology and with an otherwise reasonable prognosis. CT imaging findings may guide the approach and surgical technique used for repair (32). The level of the fistula, which is well characterized by CT, may dictate whether a cervical or trans-thoracic operation is necessary. Additionally, patients must be optimized before surgical intervention; CT evaluation of the lung parenchyma is helpful to ensure that the pneumonia has been adequately treated.

Our study has limitations. Our retrospective study included patients from a review of CT reports for the presence of an EAF, which could yield selection bias. All of the patients are from a single institution and may limit the generalization of our findings, as there could be variations in scan technique and protocol. Finally, our cohort is small, on account of the rarity of EAF in adults and the variable use of CT for their detection and characterization. Further investigation will be required to evaluate the sensitivity and specificity of findings observed in our study for clinical practice. Nevertheless, our findings show that CT can play an essential role in the evaluation of EAF.

Conclusions

CT is a useful tool in both primary and secondary evaluation of adult EAFs resulting from both malignant and benign etiologies. Although endoscopy is the gold standard for the detection and characterization of TEF and BEF, CT provides accurate characterization of adult EAFs in a wide variety of clinical scenarios, with several characteristic direct and indirect findings. CT may be the first diagnostic exam to suggest and detect the presence of EAFs, preceding clinical suspicion. CT can also detect a subset of fistulas not demonstrated on esophagography and is complimentary to the esophagogram in other cases, providing valuable information about the extent of the fistula and related complications within the mediastinum and lungs. Finally, CT may also be helpful for surgical planning, when appropriate.

Acknowledgments

Funding: None.

Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jtd-20-244). BPL reports other from Elsevier, outside the submitted work. JB Ackman reports other from Elsevier, outside the submitted work. JAS reports other from Elsevier, outside the submitted work. SRD reports other from Merck, other from Pfizer, other from Bristol Mayer Squibb, other from Novartis, other from Roche, other from Polaris, other from Cascadian, other from Abbvie, other from Gradalis, other from Clinical Bay, other from Zai laboratories, other from Siemens Medical Solutions, outside the submitted work. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The institutional review board approved this study, with informed consent waived due to its retrospective nature (IRB# 2018P003136).

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Cite this article as: Little BP, Mendoza DP, Fox A, Wu CC, Ackman JB, Shepard JA, Muniappan A, Digumarthy SR. Direct and indirect CT imaging features of esophago-airway fistula in adults. J Thorac Dis 2020;12(6):3157-3166. doi: 10.21037/jtd-20-244