

Computed tomography angiography diagnosis of tracheo-innominate fistula: a case report and review of literature

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Introduction

A tracheo-innominate fistula (TIF) is a rare complication of tracheostomy placement, developing after less than 1% of surgical tracheostomies. It usually occurs within 3 days to 6 weeks after surgery (1,2). The development of a TIF is devastating and nearly uniformly fatal without treatment (3). Even with treatment, the survival rate is low, as operative mortality is greater than 50%, and fewer than 50% of patients withstanding surgery survive more than 2 months (1,4).

Case report

A 64-year old female nursing home resident presented with uncontrollable bleeding from her tracheostomy. The patient experienced a pontine infarct seven weeks previously, which resulted in severe neurological deficits. The tracheostomy had been inserted at that time.

The tracheostomy cuff was initially inflated, which tamponaded the bleeding, but subsequent deflation of the cuff resulted in a loss of 500 mL of bright red blood. Translaryngeal intubation was performed and a cuffed oro-endotracheal tube was placed distal to the tracheostomy cannula to prevent blood from accumulating in the lungs.

A TIF was suspected and computed tomographic angiography (CTA) of the neck was performed to isolate the source of the hemorrhage. The CTA was performed by using a 16-detector row CT scanner (General Electric LightSpeed 16; General Electric, Fairfield, CT) scanning from the mid brain to the aortic arch. Scan parameters were 120 kV, 350 mA, 0.6 second rotation time, 1.25 mm slice thickness, 1.0 mm reconstruction interval, and pitch

of 0.938:1. Intravenous injection of 105 mL of nonionic iodinated contrast media (iohexol, Omnipaque 300, GE Healthcare Inc., Princeton, NJ) was administered with an automatic dual syringe injector at a rate of 4 mL/s, followed by 30 mL of saline solution at a rate of 2.5 mL/s (Stellant D Dual Syringe CT Injection System, Indianola, PA). The injection was timed with a bolus tracking technique.

Initial multiplanar reconstructions (MPRs) and maximum-intensity projections (MIPs) were produced on the CT scanner console. The axial images were transferred to a workstation (Vitrea 4.1; Vital Images, Minnetonka, MN), where additional MPRs, MIPs, and 3-dimensional volume-rendered (3D VR) images were created.

The CTA of the neck revealed extravasation of contrast into the airway and pooling around the tracheostomy cuff, in the hypopharynx and in the oropharynx (*Figure 1*). The fistulous connection between the proximal innominate artery and the trachea was visualized better on the initial coronal MPRs (*Figure 2a*), than on the initial coronal MIPs or axial source images (*Figures 2b,3*). Further MIP and 3D VR image processing and removal of the overlying structures clearly demonstrated the fistulous tract (*Figure 4a,b*).

An open surgical repair was not feasible due to associated comorbidities. Emergent endovascular treatment was therefore undertaken. Arteriography revealed extravasation at the level of the innominate artery. Using a retrograde right common carotid artery approach, a modified, covered stent was placed into the innominate artery. After ballooning the graft, a completion angiogram revealed no further extravasation from the innominate artery. Excellent flow in the aorta and right common carotid artery were observed.



Figure 1 Extraluminal IV contrast accumulating in the oropharynx (arrow) on sagittal MPR. Tracheostomy cannula is present (arrowhead)

Discussion

A TIF is an uncommon occurrence encountered following placement of a tracheostomy. A TIF has been described both as early (1) and late term tracheostomy complications (5). Although the exact pathogenesis is not entirely understood, known risk factors include low placement of the stoma, infection and pressure necrosis from high cuff pressure (6). Hamano *et al.* described 10 patients with TIFs in whom an endotracheal granuloma resulted in inflammation extending to the surrounding tissue (7).

The majority of tracheoarterial fistulas communicate with the innominate artery (1,7). Tracheo-carotid arterial fistulas are less common.

The small size of the fistula presents a major diagnostic challenge (1). While bronchoscopy had been indicated as the diagnostic procedure of choice (1,6,8), CTA can be helpful in surgical planning by identifying the fistula and the responsible vessel. Non-invasive CTA has already been proven to be an accurate modality and is widely used in pre-procedural assessment of aorto-esophageal (9), intracranial (10,11), coronary (12,13), peripheral arterial (14,15),

aorticaval (16) and iatrogenic (17,18) fistulas.

TIF visualization with catheter angiography is well documented (4,8,19,20). Use of multidetector CT with 3D reconstructions has been described prior to (21) and following (19) the repair of a TIF and for prophylactic innominate artery transection (22). If an endovascular repair is selected, a CT angiogram demonstrating the location of the pathology allows for precise placement of the stent. Prior imaging can also help direct open surgical repair. CTA has several advantages relative to conventional angiography including a reduction in the radiation dose of at least two to three times (23) and more rapid acquisition times.

Although CT has been reported to identify tracheal compression by an artery (22), intimate contact of an artery with the trachea (8), arterial erosion (21) and mediastinal infiltration (8), actual visualization of a fistula with CTA has not yet been reported. To our knowledge, this is the first reported case clearly illustrating the TIF course with CTA and demonstrating its impact on subsequent management.

Preoperative diagnosis of a TIF allows for operative management using either an endovascular or open surgical approach. Since publication of the first endovascular repair with stent grafting 10 years ago (24), this therapeutic option has become widely accepted (2,25,26). It has been found useful particularly in patients with multiple comorbidities as either a temporizing (8,19) or a definitive measure (24). Review of five TIF cases with 14 to 24 month follow up treated with endografts by Sorial *et al.* (27) demonstrated that three patients survived. The option of endovascular embolization of the innominate artery has also been discussed in the literature (26).

The traditional open approach with ligation of the innominate artery (6) and debridement of the affected trachea (1,28) is the mainstay of surgical treatment with survival ranging from 25% (29,30) to less than 50% (4).

We compared the quality of TIF visualization on axial images vs. various post-processing techniques including MPRs, MIPs and 3D VR. We found better visualization of the fistula on the sagittal and coronal MPRs.

Part of the benefit of MPRs can be explained by the predominant craniocaudal orientation of the fistulous tract, which is in the plane of these reformations. The narrow shape of a TIF (1) and its short dimension in the anterior-posterior plane render visualization on axial images rather challenging. The ability to visualize a narrow contrast column with MPRs has been illustrated during analysis of a

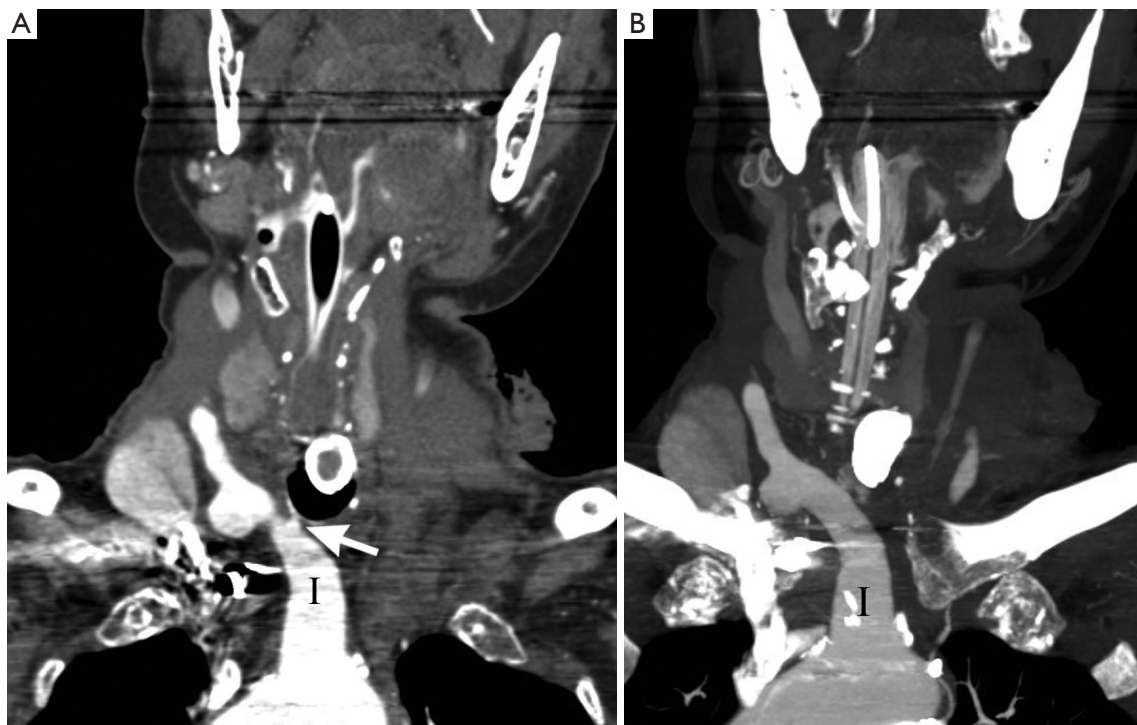


Figure 2 Coronal MPRs (A) and MIPs (B). The fistulous tract is evident on MPRs (arrow), but is obscured by pooling of blood and the tracheostomy cannula on the MIPs. I, innominate artery

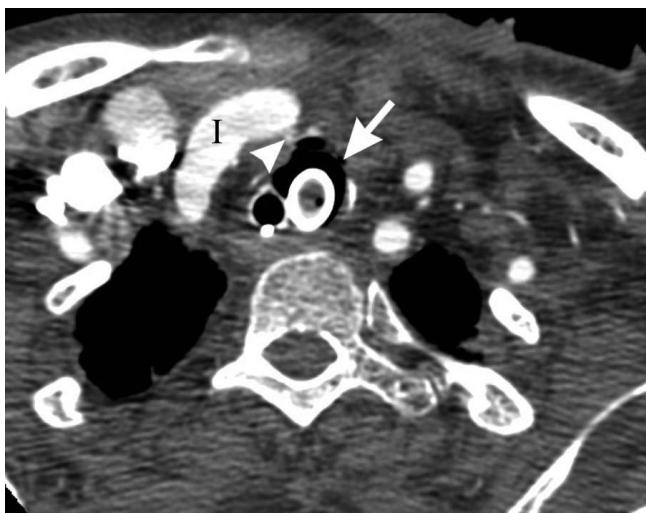


Figure 3 Subtle appearance of a tracheo-innominate fistula on an axial contrast-enhanced CT image. The fistulous tract (arrowhead) extends from the dorsal margin of the innominate artery (I) to the trachea. The inflated cuff of the tracheostomy cannula (arrow) is also visible

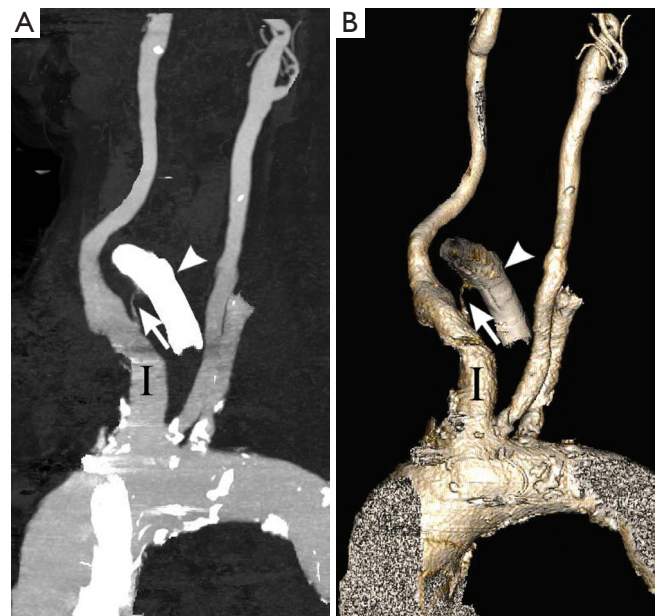


Figure 4 MIP (A) and 3D VR (B). A narrow tracheo-innominate fistula tract (arrow) is readily apparent after removal of the overlying tissues. Tracheostomy cannula (arrowhead); innominate artery (I)

thin stenotic lumen in carotid arteries (31).

On the initial MIPs performed with the entire data set, the faint TIF was obscured because it was less dense than the overlapping high attenuation pool of extravasated contrast material and the prominent eroded vessel. This limitation is inherent in MIPs' display of only the highest attenuation values, with loss of depth perception within the displayed plane (32-35). The resulting superimposition artificially alters and hides small structures.

Unlike MIPs, MPRs use all attenuation values in the data set (32). This improves visualization of a thin contrast filled fistulous tract surrounded by adjacent high density vessels, pooling endotracheal contrast, and the tracheostomy cannula.

Three dimensional imaging, and especially volume rendering, has been shown to be valuable for accurately depicting small vascular structures (36) and narrow contract columns (37). After prior localization with MPRs and removal of overlying structures, the 3D images and matching MIPs provided clear delineation of the spatial relationship of the slender fistulous tract to the anatomic structures of interest. This information has been shown to be of value specifically in innominate artery surgical planning (22).

On 3D imaging, it is helpful to decrease the artifact from the dense tracheostomy cannula with a bone subtraction algorithm (38).

In conclusion, this is the first report of a clearly visualized TIF with CTA together with a review and analysis of the relative utility of various image post-processing techniques. We believe that CT angiography has an important role in management of this devastating condition, as it enables expedited diagnosis in a critical setting requiring emergent intervention.

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