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Pneumomediastinum in blunt trauma: If aerodigestive injury is not seen on CT, invasive workup is not indicated

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ABSTRACT

Background: Pneumomediastinum following blunt trauma is often observed on CT imaging, and concern for associated aerodigestive injury often prompts endoscopy and/or fluoroscopy. In recent years, adoption of multi-detector CT technology has resulted in high resolution images that may clearly identify aerodigestive injuries. The purpose of this study was to evaluate the utility of multi-detector CT in the identification of blunt aerodigestive injuries.

Methods: Over five years, patients with pneumomediastinum following blunt trauma were identified from the registry of a level 1 trauma center. All CT imaging of trauma patients during this time period was accomplished with 64-slice scanners.

Results: 127 patients with blunt traumatic pneumomediastinum were identified. Five airway injuries were identified, and all injuries were evident on CT imaging. No patient was found to have airway injury by endoscopy that was not evident on CT. No patient had an esophageal injury.

Conclusion: Multi-detector CT imaging identifies aerodigestive injuries associated with pneumomediastinum following blunt trauma. The absence of a recognizable aerodigestive injury by CT effectively rules out the presence of such injury.

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Background

Pneumomediastinum following blunt trauma is often observed on computed tomography (CT) imaging, with an incidence as high as 10%.¹ Associated aerodigestive injuries, however, are rare, and are more likely to be associated with high-energy mechanism or direct blow to the neck.² Pneumomediastinum very often has a benign etiology, resulting from extension of a pneumothorax or air dissecting along the bronchovascular sheath.^{2,3} Nonetheless, concern for an associated aerodigestive injury often prompts a more invasive work up that may include bronchoscopy, endoscopy,

and/or contrast esophagram. Previously, such evaluation has been recommended for all patients with pneumomediastinum. However, overutilization of these invasive procedures can potentially lead to increased complications, cost of care, and longer hospital length-of-stay.

In recent years, adoption of multi-detector CT (MDCT) technology and routine use of coronal and sagittal reformatted images have produced high spatial resolution images and have resulted in reduced scan times and thus fewer motion artifacts. This has allowed for the ability to clearly identify aerodigestive injuries, obviating the need for expensive and invasive procedures. The purpose of this study was to evaluate the utility of modern day MDCT in the diagnosis of aerodigestive injury following blunt trauma.

Methods

This study was conducted at St. Joseph's Hospital and Medical Center, an American College of Surgeons verified level 1 trauma center, in Phoenix, Arizona. Patients with pneumomediastinum

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following blunt trauma were retrospectively identified from the hospital's trauma registry over a five-year period (January 2013 through December 2017). Data collection was approved by our Institutional Review Board. All registry records with blunt mechanism of injury and ICD-9 or -10 codes descriptive of pneumomediastinum were identified. These patients were cross-referenced with admission imaging reports to confirm the presence of pneumomediastinum on CT scan.

Review of medical records was performed to record mechanism of trauma, injuries identified, length of stay, mortality, and procedures performed with attention to bronchoscopy, esophagoscopy, and contrast esophagrams. Demographic data including gender and age were recorded. CT images of the neck or chest and imaging reports were reviewed to identify aerodigestive injuries. Patients without cross sectional imaging were excluded. CT imaging of all patients during this time period was performed with 64-detector CT scanners (LightSpeed VCT; GE Medical Systems, Milwaukee, WI). Axial images were reconstructed with 5.0 mm slice thickness and multi-planar reformations in coronal and sagittal planes were provided (3.0 mm slice thickness) for all patients. No oral contrast agents were administered for CT imaging. Descriptive statistical analysis was performed for the study population. Sensitivity and specificity analysis of CT imaging for diagnosis of aerodigestive injury was performed with 95% confidence intervals.

Results

10,381 patients with blunt mechanism of injury were identified in the hospital's trauma registry for the period of study. Among this cohort, a total of 127 patients (1.22%) had admission CT scan finding of pneumomediastinum. Patient characteristics and specific mechanism of injury are demonstrated in Table 1. Ninety-one (72%) were male and the age range of patients was 18–83 years old with an average age of 38.6 years (SD 20.0 years). The most common mechanism of injury was motor vehicle collision (47%). The most common associated injuries included hemo/pneumothorax (101 patients, 80%) and rib fractures (95 patients, 75%).

Six patients died within 24 h and are excluded from further analysis. They all had pneumomediastinum on imaging without suspicion for specific aerodigestive injury, and were excluded because none lived long enough to undergo either diagnostic confirmation of injury with endoscopy or observation that would unmask a latent injury. Among the remaining 121 patients, diagnostic workup for pneumomediastinum is demonstrated in Fig. 1. Forty (33%) patients underwent tracheobronchoscopy and 13 (11%) patients underwent esophagoscopy. Four (3%) patients had

fluoroscopic contrast esophagrams. 62 patients (51%) had observation alone. Among these 121 patients, mortality was 10.7%. Average length of stay was 10.8 days (SD 9.1 days).

Sensitivity, specificity, and positive and negative predictive values regarding CT imaging for diagnosis of aerodigestive injury are displayed in Table 2. Five patients had CT scan evidence of airway injuries, all confirmed with bronchoscopic visualization. No patient was found to have airway injury by bronchoscopy that was not evident on CT. No patient had evidence of esophageal injury by CT, esophagoscopy or esophagram. For those patients that had observation for pneumomediastinum, none developed evidence of latent aerodigestive injury. Two (2%) false positive CT scans were identified, with radiology reports concerning for tracheal injuries; however, no injuries were identified on subsequent bronchoscopy.

Among the patients with airway injuries, one patient had a laryngeal injury as a result of a direct blow to the neck. The mechanism of trauma for the remainder of patients with airway injuries consisted of two auto-pedestrian collisions, one auto-cyclist collision, and one motor vehicle collision. These patients had significant associated injuries including two patients with atlanto-occipital dislocations (tracheal injuries), one patient with upper thoracic spine fracture-dislocation (bronchial injury), and one patient with high-grade pulmonary contusions and multiple rib fractures (bronchial injury). Among these patients, all survived to hospital discharge except for one, who succumbed to injuries that included atlanto-occipital dislocation and severe traumatic brain injury. Representative axial CT image of one of the tracheal injuries is demonstrated in Fig. 2.

Discussion

Our 5-year cohort of blunt trauma patients had an overall pneumomediastinum rate of approximately 1%. The incidence of associated injuries to the aerodigestive tract is quite low, with only 4 patients (3%) in our cohort having aerodigestive injuries. Previous retrospective analyses have returned similar results, with reports of anywhere from 0% to 7%.^{2,4–7} Similar to recent studies, the majority of our patients had associated hemo/pneumothoraces (80%) and rib fractures (75%).^{2,5,6,8}

In the majority of cases, pneumomediastinum following blunt trauma is benign. It is often attributed to the Macklin effect, whereby air dissects medially along bronchovascular sheaths following alveolar rupture.³ Alveolar rupture may occur as the result of a Valsalva-like acute increase in airway pressure that may be sustained on blunt-force impact. Nonetheless, physicians may be hesitant to attribute pneumomediastinum out of concern for an underlying aerodigestive injury, which may not be immediately symptomatic or otherwise apparent.

Given the potential morbidity associated with tracheobronchial injuries, bronchoscopy has been recommended for the finding of pneumomediastinum to definitively rule out airway injury. A retrospective study published in 2000 evaluated patients with confirmed tracheal injuries and concluded that CT imaging was inadequate for excluding airway injuries.⁹ However, CT imaging in that study was accomplished with 7 mm slices, in contrast to today's 5 mm axial slices with 3 mm multi-planar reformations. Modern, high-resolution CT imaging and the routine use of high quality coronal and sagittal reformatted images has allowed for reliable detection of aerodigestive injuries. All 5 patients with tracheobronchial tree injuries in our cohort had injuries visible on CT imaging. This is congruent with more recent literature, with two large retrospective studies demonstrating 100% sensitivity of CT imaging for diagnosis of airway injuries.^{2,5} In addition, experience reported from Grady Memorial Hospital noted that among 74 patients with pneumomediastinum on CT scan, all patients with

Table 1

Characteristics of patients with pneumomediastinum following blunt trauma. Continuous variables presented as mean (standard deviation). Categorical variables presented as n (%). ED = Emergency Room. GCS = Glasgow Coma Scale.

	Total (127)	Documented Airway Injury (5)
Age (years)	38.6 (20.0)	49.5 (26.6)
Male gender	91 (71.7)	4 (80)
Mechanism of Injury		
Motor vehicle collision	60 (47.2)	1 (20)
Motorcycle collision	13 (10.2)	
Fall	13 (10.2)	
Auto vs. pedestrian	12 (9.4)	2 (40)
Auto vs. bicycle	13 (10.2)	1 (20)
Assault	6 (4.7)	
Other	10 (7.9)	1 (20)
Injury Severity Score	22 (14.2)	24 (11.5)
Admission GCS	11 (5.1)	4 (1.34)
Initial Systolic Blood Pressure	127 (45.9)	135 (31.0)
Chest Tube Placed in ED	40 (33.9)	3 (60)

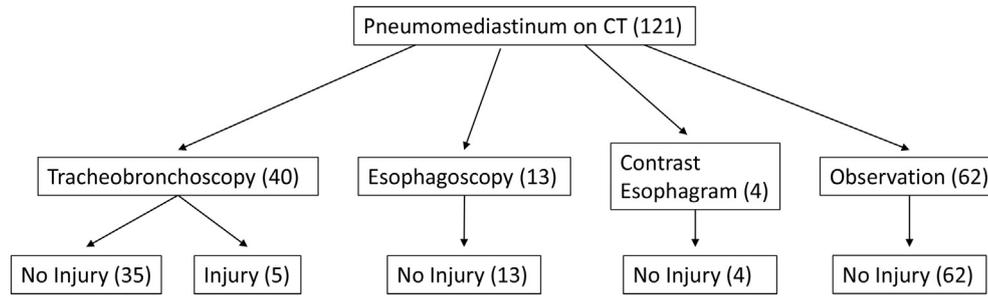


Fig. 1. Diagnostic follow-up to pneumomediastinum observed on admission CT scan.

veritable aerodigestive or tracheobronchial injuries had associated open wound or significant symptom (stridor, hoarseness, dysphonia, hemoptysis, subcutaneous air, dyspnea, dysphagia, or odynophagia).¹⁰ The authors of this study concluded that pneumomediastinum in isolation does not predict significant injury and warrants further investigation only in the presence of associated signs and symptoms.

Esophageal injuries as a result of blunt trauma occur with relative infrequency. In our series, none of 121 patients with pneumomediastinum were identified to have an esophageal injury. Chouliaras et al. identified one esophageal injury among 258 patients with pneumomediastinum following blunt trauma.⁵ This injury was not evident on CT scan, and was identified with contrast esophagram. The authors noted, in retrospect, that there should have been high suspicion for this injury based on the CT scan finding of retropharyngeal prevertebral air. Dissanaikie et al. observed two esophageal injuries among 136 patients with pneumomediastinum following blunt trauma, and both injuries were suspected from CT scan findings based on the pattern of air tracking alongside the esophagus.² We conclude that any suspicion for esophageal injury from CT scan and/or clinical findings warrants contrast esophagram and/or esophagoscopy to rule out the presence of esophageal perforation. However, the presence of pneumomediastinum alone on CT should not mandate routine esophagography or esophagoscopy.

Mechanism of injury may be associated with increased risk for aerodigestive injury. Dissanaikie et al. observed, not surprisingly, that direct blows to the neck were five times more likely to have laryngeal fractures than the rest of their cohort.² We also observed laryngeal injury as a result of a direct blow to the neck, and recognize that this injury mechanism warrants vigilance for aerodigestive injury. Our remaining injuries were associated with high-energy mechanisms resulting in atlanto-occipital dissociation in two patients and thoracic fracture dislocation in another. Pneumomediastinum associated with these types of relatively severe injuries also warrant a higher level of suspicion for an associated aerodigestive injury. Nonetheless, all of the airway injuries in the present study were apparent by CT imaging alone.

The injuries identified on imaging were visualized as focal disruptions in the continuity of the trachea or as irregularity of the

tracheal or bronchial wall. The pattern of pneumomediastinum associated with the injuries was a slightly asymmetric distribution of air within the mediastinum, with the majority of air on the side of the injury and a large amount of air at the level of the injury predominantly surrounding the trachea. One patient had a right mainstem bronchus injury that was described on the radiology report as a focal irregularity of the posterior wall; this patient had a large volume of pneumomediastinum that was disproportionately located on the right side of the mediastinum and had only a few locules of air in the left side. Thus, the pattern of pneumomediastinum on imaging could be used to at least raise suspicion of a tracheobronchial injury if one is not readily visualized on imaging.

This study has some limitations worthy of review. The retrospective design of the study, without a rigid protocol whereby all patients underwent confirmatory diagnostic evaluation for aerodigestive injury via endoscopic or contrast radiograph, leaves open the possibility that a number of injuries went unidentified. Nonetheless, patients were observed relatively long enough for most latent injuries to make themselves known. In contrast, however, Kiser et al. observed that some patients may not manifest acute symptoms from tracheobronchial injury until many months following injury, and it is possible that such patients would present to a different institution.¹¹ It is also possible that some subclinical injuries were present, as it is known that relatively minor injuries to either the airway or esophagus can heal without any

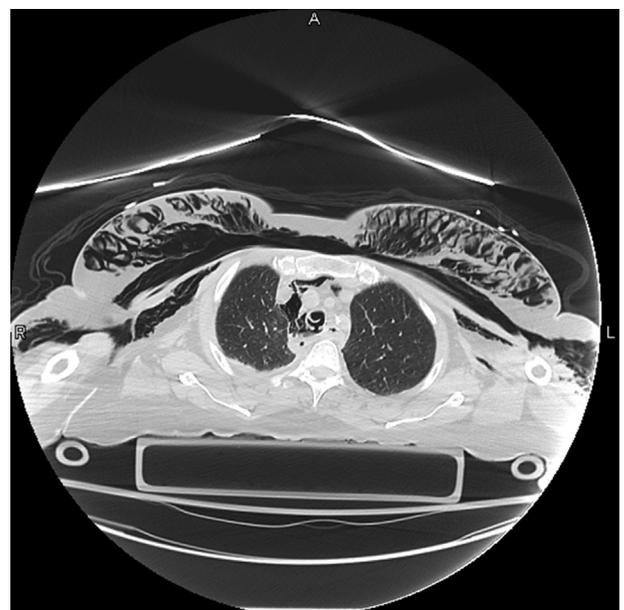


Fig. 2. Representative image of CT finding of posterior tracheal injury.

Table 2
Sensitivity, Specificity, Positive and Negative Predictive Values for CT diagnosis of aerodigestive injury.

	Estimated Value	95% Confidence Interval
Prevalence	0.041	0.015–0.099
Sensitivity	1	0.463–1.000
Specificity	0.983	0.933–0.997
Positive Predictive Value	0.714	0.303–0.949
Negative Predictive Value	1	0.959–1.000

intervention.^{12,13} Similarly, the overall low incidence of pneumomediastinum in trauma patients, along with the exceedingly rare nature of blunt esophageal injury (none in this study), limits the ability to conclude that a CT without discernible esophageal injury effectively rules out the presence of such injury. In addition, this study was performed at a single trauma center with a radiology residency program. It is unknown as to whether the results may be achieved in other centers, and particularly those without the benefit of a radiology residency (resulting in more than one person reviewing each scan) or those that outsource diagnostic imaging interpretation to offsite practices (such as Nighthawk).

Conclusion

Contemporary MDCT imaging with coronal and sagittal reformatted images has the spatial resolution to identify aerodigestive injuries following blunt trauma. Although pneumomediastinum is observed with relative frequency in patients with blunt trauma, the absence of a recognizable aerodigestive injury by CT effectively rules out the presence of such clinically relevant injury. Endoscopy and contrast fluoroscopy to further rule out an underlying injury are not warranted. A major caveat, however, is that our limited single-institutional experience with esophageal injury, similar to others, leaves open the possibility that CT alone is not sensitive enough to rule out esophageal injury. A multi-institutional prospective observational study of pneumomediastinum following blunt trauma is thereby warranted. In the meantime, in the absence of identifiable aerodigestive injury, clinical suspicion based on signs and symptom tso guide further investigation, as recommended by MacLeod et al.¹⁰ is recommended.

Conflicts of interest

The authors declare no conflicts of interest.

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