

## Tracheal Injury Diagnosed with Three-Dimensional Imaging Using Multidetector Row Computed Tomography

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Tracheobronchial injury is a rare and serious complication of blunt chest trauma. Diagnosis of this injury requires a high index of clinical suspicion. Delay in diagnosis is the single most important factor influencing the outcome. Diagnosis of this injury may be delayed because of subtle and nonspecific clinical and radiological findings and the much more overt clinical signs of other more-frequently associated injuries. Although the radiographic findings and axial computed tomographic (CT) findings of this type of injury have been reported in the literature, to the best of our knowledge, the use of 3-dimensional (3D) CT has never been reported. We report a case of such an injury demonstrated by multiplanar and 3D imaging using a multidetector row computed tomographic scanner. A large carinal laceration was clearly depicted on multiplanar and 3D CT images. (*Chang Gung Med J* 2004;27:217-21)

**Key words:** tracheobronchial injury, computed tomography.

Traumatic tracheobronchial injuries (TBI) are rare but associated with high mortality and morbidity if not promptly diagnosed.<sup>(1)</sup> Early imaging diagnosis and early treatment are known to produce the best outcome. Several reports have used chest radiography and axial computed tomography (CT) in diagnosing this type of injury.<sup>(2-7)</sup> Recently, Nakamori et al. reported a case of ruptured trachea that was diagnosed with virtual CT bronchoscopy.<sup>(6)</sup> We present a case of tracheal injury using multidetector row CT-derived 2-dimensional (2D) multiplanar and 3-dimensional (3D) imaging.

### CASE REPORT

A 16-year-old boy was injured in a motor vehicle collision. He suffered from shortness of breath and chest pain with initial loss of consciousness. At the emergency department, an initial chest radiograph showed right hemopneumothorax, left pneu-

mothorax, extensive subcutaneous emphysema, and pneumomediastinum. Bilateral chest tubes were immediately inserted. The examination showed clear consciousness with a blood pressure of 110/85 mm Hg, heart rate of 98 beats/min, respiratory rate of 30 breaths/min, and body temperature of 37.5°C. On hospital day 3, he had new respiratory distress, and a chest radiograph revealed a widened upper mediastinum, and resolution of the pneumothorax and subcutaneous emphysema. Blood gas obtained while the patient breathed room air showed a pH of 7.3, hypoxemia (PaO<sub>2</sub> of 41.8 mmHg), CO<sub>2</sub> retention (PcO<sub>2</sub> of 45.6 mm Hg), and O<sub>2</sub> saturation of 73.5%. Blood-tinged sputum and a blood pressure of 124/80 mm Hg were noted. In view of the above findings, the patient was intubated and given mechanical ventilatory support. An airway injury and/or great vessel injury were suspected, so helical CT was suggested for evaluation. Contrast-enhanced helical chest CT was performed with a 4-channel multidetector

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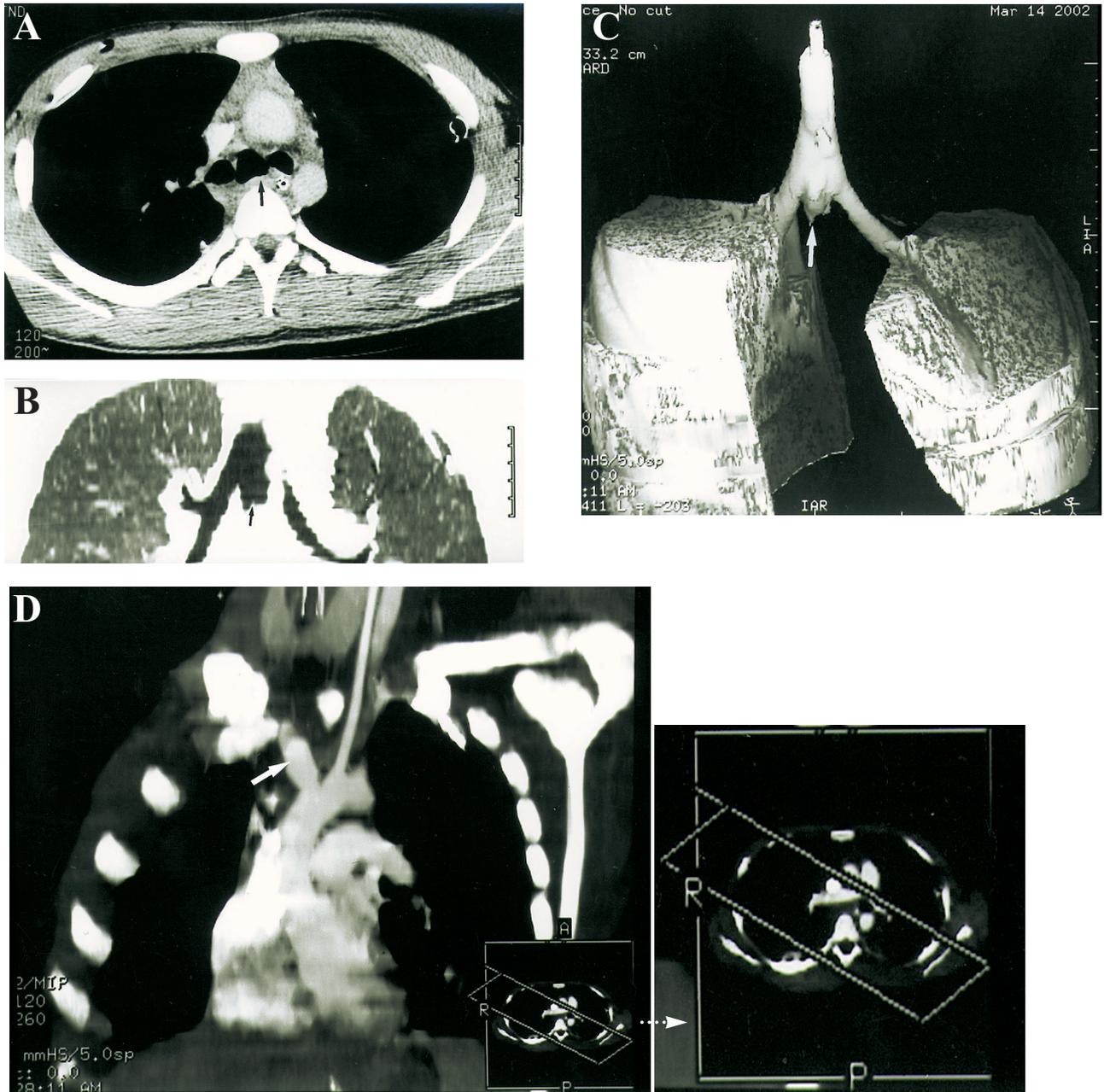
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Received: Apr. 17, 2003; Accepted: Jul. 16, 2003

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row CT scanner (Lightspeed QX/I; General Electric Medical Systems, Milwaukee, WI) using 120 ml of contrast material injected (300 mg I/ml) with a power injector through an 18G intravenous catheter in the antecubital vein at a flow rate of 3 ml/s. The

patient was scanned from the lower neck to the diaphragm using the following parameters: 2.5-mm collimation in fast mode, a table speed of 7.5 mm per gantry rotation, a 1.25-mm reconstruction interval, and a pitch of 6. Axial CT revealed a deformity and



**Fig. 1** (A) Axial CT image showing a deformity and abnormal air collection at the tracheal carina (arrow). (B) Coronal multiplanar re-formation showing a large laceration of the tracheal carina (arrow). (C) 3D CT image showing a large laceration of the tracheal carina (arrow). (D) Coronal maximal intensity projection CT angiogram revealing a pseudoaneurysm of the innominate artery (arrow).

abnormal air collection at the carina, while a coronal 2D-multiplanar reformatted CT image showed a large laceration in that area (Fig. 1A, B). The reconstructed axial images were sent to a separate workstation (Advantage Windows 3.1P; GE Medical Systems), and a 3D externally rendered CT image confirmed a large carinal laceration (Fig. 1C). Subsequent bronchoscopy showed a totally destroyed carina with erythematous mucosa in the anterior portion and a small laceration forming a hole in the posterior portion. Axial CT images and maximal-intensity projection images also showed superior mediastinal hematoma due to a traumatic pseudoaneurysm of the innominate artery, which was further confirmed by CT angiography (Fig. 1D). The carinal laceration was managed conservatively. A chest radiograph taken on hospital day 12 revealed a clear lung without recurrent pneumomediastinum, pneumothorax, or subcutaneous emphysema. Bilateral chest tubes and endotracheal tubes were removed on hospital day 13 with no respiratory symptoms. From hospital day 14 onward the patient was in a good general condition. On hospital day 30, a surgical operation with resection of the traumatic dissecting aneurysm of the innominate artery and interposition of a "Y" vascular graft was successfully performed. The patient's recovery was uneventful, and he was discharged from the hospital on day 38 with no complications. A follow-up chest radiograph on day 40 showed clear lung fields and no extraluminal air.

## DISCUSSION

Tracheobronchial injury (TBI) is rare and is reported to account for only 0.5% to 2.8% of blunt thoracic injuries.<sup>(1,6,7)</sup> Early diagnosis and treatment of TBI is crucial because of its high mortality and morbidity rates. Delay in diagnosis is the single most important factor influencing the outcome. Early diagnosis of TBI depends on the clinical manifestations, radiographic findings, and bronchoscopy.

Diagnosing TBI can be difficult or often delayed because these injuries are usually not obvious at the time of physical examination. The clinical findings include dyspnea, sternal tenderness, subcutaneous emphysema, hemoptysis, cyanosis, flailing chest, shock, coma, hoarseness, aphonia, and stridor.<sup>(6,8)</sup> These findings may appear minimal or remain undetected during the acute phase after the injury. The

clinical manifestations may be also obscured by the much more overt clinical signs of other more-commonly associated injuries.

The radiographic findings of TBI are nonspecific and vary according to the site and extent of injury. The major radiographic findings include subcutaneous emphysema, pneumomediastinum, and pneumothorax.<sup>(6,9)</sup> Our patient also presented with all these major radiographic findings. Other less common radiographic findings of TBI are disrupted or blurred major airway, abnormal endotracheal tube or cuff position, the "fallen-lung" sign, and pneumopericardium. Some patients have no radiographic evidence of TBI.<sup>(6)</sup>

Traditionally, the gold standard for diagnosis of TBI is bronchoscopy because it enables visualization of both the site and extent of the injury. But in patients with severe respiratory insufficiency or in hemodynamically unstable patients, it may be impossible to perform bronchoscopy. Bronchoscopy is not only time-consuming but also not always immediately available. Unlike bronchoscopy, CT is noninvasive, faster, and more readily available.

Because helical CT is increasingly being used for evaluating patients with thoracic and visceral abdominal injuries, familiarity with the specific CT findings of TBI would be helpful. Several case reports have indicated that axial CT, performed with appropriate window settings, can demonstrate the exact site of a TBI by showing focal defects or the circumferential absence of the tracheal wall, a contour deformity, or abnormal communication with other mediastinal structures.<sup>(3-5,7)</sup> Recently, a larger study evaluated the utility of conventional and helical single-detector CT for evaluating tracheal rupture, and found an overall sensitivity of 85%.<sup>(2)</sup> Many specific CT findings described include overdistension of the tracheal tube balloon or herniation of the deformed endotracheal tube balloon beyond the trachea, an extraluminal position of the endotracheal tube, a focal defect or discontinuity, and a contour deformity or fracture of the trachea.<sup>(2)</sup> Our patient also has a focal defect and deformity at the carina as depicted on axial CT images, but the complex airway injury was better demonstrated on multiplanar and 3D images. The CT findings of TBI in the present case helped change the management of this patient, resulting in treatment of the TBI, allowing the lacerated carina to heal by itself prior to sur-

gical treatment of the pseudoaneurysm of the innominate artery. Although routine axial CT images suffice for radiologic evaluation of central airway abnormalities, limitations do exist with the exclusive reliance on axial images. With only axial CT images, the craniocaudal extent of airway disease may be underestimated, the complex 3D relationships of the airways are not easily displayed, and there is inadequate representation of the airways that are oriented obliquely to the transverse plane. Helical CT produces excellent nonaxial (2D) multiplanar and 3D images and provides a meaningful display of complex airway structures. In our patient although axial CT images showed a deformity and abnormal air collection at the tracheal carina, excellent diagnostic information was obtained from 2D multiplanar and 3D imaging. The use of a multidetector CT scanner provides a faster speed, greater coverage, thin collimation, and improved spatial resolution, and allows higher-quality 2D multiplanar and 3D reconstruction images for the evaluation of patients with severe thoracic trauma. Although the creation of 2D multiplanar and 3D images offers complementary ways of viewing the information present in the axial CT images, axial images are still needed for a comprehensive review of the entire thorax, as an important point of reference for optimal interpretation.

In summary, in addition to standard diagnostic axial CT images, 2D multiplanar and 3D reconstruction images provide useful diagnostic information for

evaluating patients with TBI, leading to early confirmatory bronchoscopy. Such images are also a more-effective means of communicating significant findings to referring physicians.

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# 利用多偵測探頭電腦斷層掃描機器重組三維立體影像 來診斷氣管傷害

林坤榮 劉原彰 許元昱

在胸部鈍撞外傷中，氣管支氣管的傷害是很少見但是嚴重的併發症。診斷氣管支氣管的外傷需要臨床上高度的懷疑，因為這類的撕裂傷害很少而且在臨床及放射線影像上都沒有特異性的發現，並有其他明顯且發生頻率高的其他胸部鈍撞外傷的相關傷害，因而可能被延遲診斷。雖然一般X光素片表現及橫切面電腦斷層攝影表現已有文獻報告，不過應用三維立體影像來呈現這類外傷還未有文獻報告。我們使用多偵測探頭電腦斷層掃描機器重組出多面向及三維立體影像來呈現一個氣管支氣管受傷的案例。(長庚醫誌 2004;27:217-21)

**關鍵字：**氣管支氣管傷害，電腦斷層。

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受文日期：民國92年4月17日；接受刊載：民國92年7月16日。

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