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CLINICAL REPORT

Tracheal intubation in a patient with undetectable tracheal narrowing on chest radiography

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Abstract We report here a 59-year-old man with a saber-sheath tracheal narrowing who was scheduled to undergo pharyngeal tumor resection under general anesthesia. The tracheal narrowing was not clearly detected by chest radiography during the preoperative examination, but it was visible on axial computed tomography (CT) images taken earlier for diagnostic purposes. Following fiber optic examination of the narrowed segment with the patient under anesthesia, the tube was inserted into the trachea using an Airway Scope. The tube was deliberately advanced into the trachea and was able to pass through the stenosis without any resistance. On postoperative radiological analysis, three-dimensional reconstruction of the trachea and virtual bronchoscopic images revealed a saber-sheath type tracheomalacia located from below the cricoid cartilage to the carina. The membranous wall had a normal width. This case indicates that chest radiographs may occasionally be inadequate for evaluating asymptomatic patients with tracheomalacia. If CT images have been taken for diagnostic purposes, they should be examined together with the chest radiograph. Digital chest radiography with edge enhancement may become a useful tool in the preoperative detection and evaluation of undetectable tracheal narrowing on conventional chest films.

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Introduction

Tracheal rupture is one of the most feared immediate complications of intubation, with a reported mortality rate of approximately 22% [1]. Tracheal narrowing is one of the causes of tracheal rupture. As such, preoperative airway assessment is essential, especially in patients who are scheduled to undergo tracheal intubation. Although radiographic examinations, such as lateral thoracic inlet radiography, axial computed tomography (CT), CT tracheobronchography, virtual bronchoscopy, magnetic resonance imaging (MRI), and bronchoscopy have been used as diagnostic tools in patients with suspected central airway anomaly [2, 3], a postero-anterior (P-A) chest radiograph has been the primary investigative tool for preoperative airway assessment. Here, we report a patient with a tracheal narrowing that was not detected by preoperative P-A chest radiography but was confirmed by preoperative diagnostic axial CT images.

Case

A 59-year-old man (height 168 cm, weight 73 kg) was scheduled to undergo pharyngeal tumor resection under general anesthesia. He had undergone an appendectomy under spinal anesthesia at the age of 20 years and a pharyngeal tumor resection under general anesthesia using an endotracheal tube at the age of 58 years without any complications. Four months following his last surgery,

tumor recurrence was detected and a second operation scheduled. Laboratory findings and electrocardiography were normal during the preoperative examination, and auscultation of the chest demonstrated normal breath sounds. Although the patient had smoked 15 cigarettes per day for more than 25 years, he had no respiratory problems. A preoperative P-A chest X-ray was unremarkable, although the left margin of the trachea was obscured by the vertebrae (Fig. 1a). However, an axial CT (slice thickness 5 mm) taken 5 months previously at the first medical examination showed a saber-sheath type tracheal narrowing at the thoracic inlet; there was no tracheal compression by other structures, such as a thyroid goiter, vascular anomaly, or neoplasia (Fig. 1b).

We planned a fiberoptic examination of the tracheal narrowing prior to the insertion of an endotracheal tube. We first prepared a video laryngoscope (Airway Scope AWS-100, AWS; Pentax, Tokyo, Japan) with a specialized blade (Intlock ITL-S; Pentax) and a 8-mm-internal diameter wire-reinforced tracheal tube (Rüsch Flex; Rüschelit, Rüsch, Germany) and then threaded a flexible bronchoscope in the tube guide groove of the Intlock blade. The patient received midazolam (3 mg, intramuscularly) as premedication 1 h prior to surgery. The induction of anesthesia was initiated with intravenous (i.v.) propofol (70 mg) and inhalation of 2% sevoflurane in oxygen. Following the confirmation of mask ventilation, we started an i.v. infusion of remifentanil (0.25 μg/kg/min) and administered rocuronium (40 mg, i.v.). The tip of the Intlock blade was then inserted into the pharyngeal space. Following verification of the vocal cords in the liquid crystal display (LCD) monitor of the video laryngoscope, we then advanced the bronchoscope into the trachea through the tube. Tracheal narrowing with smooth normal colored tracheal mucosa was ascertained at approximately 55 mm below the vocal cords (Fig. 2a). The tube was deliberately advanced into the trachea and was able to pass through the stenosis under bronchoscopic guidance without any resistance. Anesthesia was maintained with 1–2% sevoflurane in 50% oxygen balanced with nitrogen and continuous remifentanil infusion, and surgery proceeded uneventfully. Following the operation, the patient showed adequate spontaneous respiration and arousal response and was extubated; he breathed spontaneously without difficulty. His subsequent recovery was uneventful.

Three-dimensional image reconstruction and digital edge enhancement of the trachea

On the second postoperative day, multi-slice three-dimensional (3D) CT was performed in the inspiratory phase. We then evaluated the tracheal narrowing from the 3D

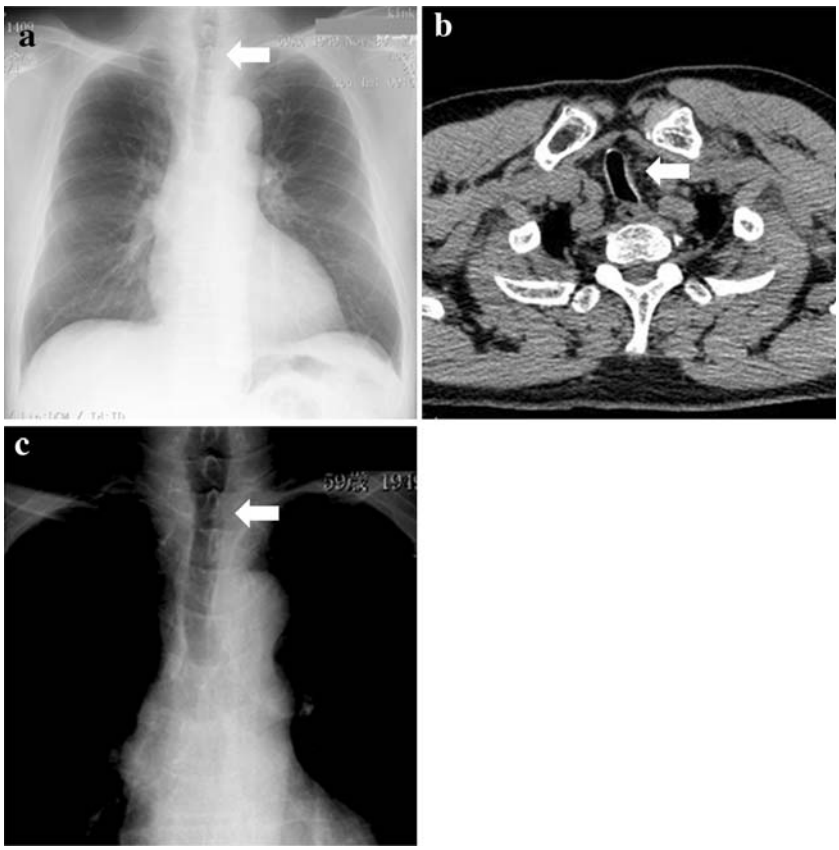

Fig. 1 Preoperative original chest radiograph (**a**), axial computed tomography (CT) image (**b**), and edge-enhanced tracheal image (**c**). *Arrows* indicate saber-sheath tracheal narrowing at the thoracic inlet. The left margin of the trachea on the original chest radiograph was obscured by the vertebrae. The edge-enhanced tracheal image provides better visibility of the tracheal narrowing than the original chest image

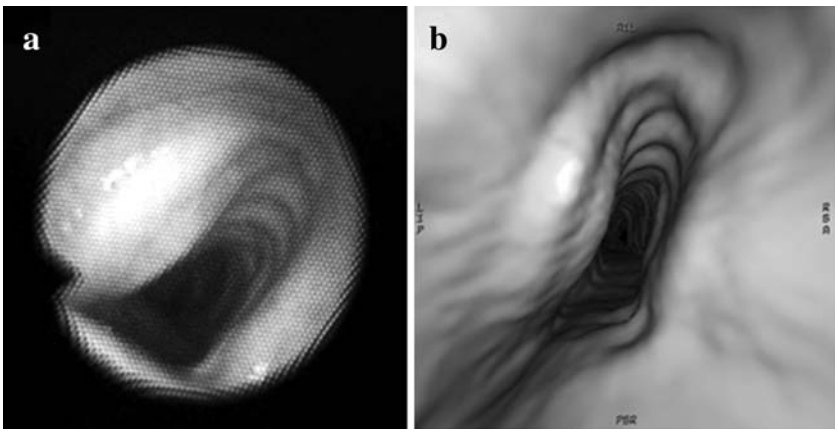

Fig. 2 Fiberoptic bronchoscopic image (**a**) and virtual bronchoscopic image from multi-slice three-dimensional (3D) computed tomography (**b**) of the tracheal narrowing at the thoracic inlet

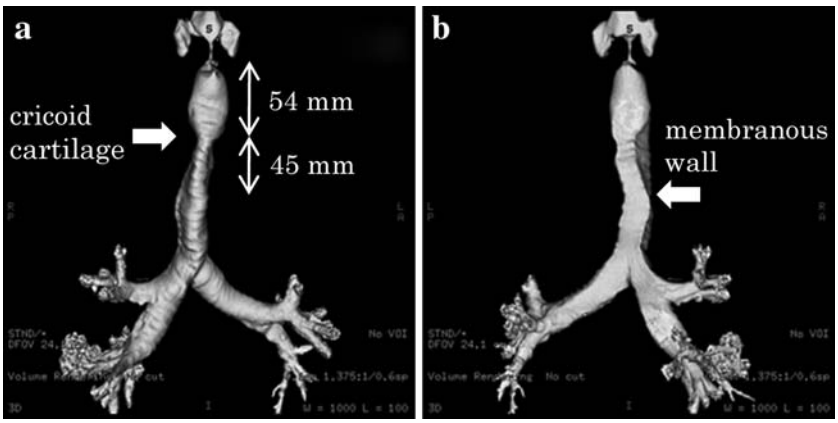

Fig. 3 Anterior (**a**) and posterior view (**b**) of 3D reconstructed trachea in the inspiratory phase. A markedly stenotic segment is located just below the cricoid cartilage (length 45 mm, 54 mm below the vocal cords). The width of the membranous wall of the trachea was constant

reconstructed trachea and virtual bronchoscopic images (Figs. 2b, 3a, b). On the anterior view, 3D images of the trachea showed coronal compression of the trachea from below the cricoid cartilage to the carina. A markedly stenotic segment with an internal diameter of 5 × 16 mm (coronal × sagittal diameter) was located just below the cricoid cartilage (length 45 mm, 54 mm below the vocal cords). On the posterior view, however, the membranous wall of the trachea had a constant width and ran downward in a gentle curve to the carina. Virtual bronchoscopic images revealed that the tracheal wall had a smooth surface and confirmed coronal compression of the trachea at the narrowest region. These bronchoscopic images were comparable to the fiberoptic bronchoscopic views.

For improved visibility of the trachea, we applied edge enhancement to the preoperative chest X-ray. This improved the visibility of the narrowed tracheal segment overlying the vertebrae when compared with the original chest X-ray (Fig 1a, c).

Discussion

Tracheal narrowing influences clinical decision-making with regard to the mode of anesthetic induction and intubation. The existence and extent of tracheal narrowing can often be detected by P-A chest radiography or lateral thoracic inlet radiography [3, 4]. Although axial CT images in the patient presented here showed a saber-sheath type tracheal narrowing, preoperative P-A chest radiograph did not clearly reveal this condition.

Stenoses of the central airway resulting from congenital tracheobronchial malformations include tracheobronchial stenosis and malacia (primary malacia). Linna et al. [5] reported that 14 of approximately 2000 school-age children (0.7%) were diagnosed with narrowing in the tracheal or laryngeal region. Moreover, secondary malacia that results from degeneration of previously normal cartilage is associated with extrinsic vascular compression, bronchial neoplasms, chronic obstructive airway disease, trauma, long-term intubation, and tracheostomy [6, 7]. Patients are asymptomatic or present with nonspecific symptoms that include stridor, wheeze, cough, dyspnea, recurrent respiratory tract infections, sputum production, and cyanotic spells, hence many patients with tracheal narrowing are misdiagnosed as having asthma [5, 7]. Tracheomalacia refers to a weakness of the walls of the trachea and central bronchi and leads to increased flaccidity and collapse of the major airways during forced expiration [7]. The abnormal configuration of the trachea in tracheomalacia is classified

as crescent type (markedly reduced sagittal diameter) or saber-sheath type (markedly reduced coronal diameter) [7, 8]. Kwong et al. [7] noted that acquired saber-sheath trachea is commonly associated with chronic obstructive pulmonary disease and almost exclusively occurs in male patients.

Our patient had no features suggesting tracheal narrowing; he had no relevant medical history except for long-term smoking, he had uneventfully undergone surgery with tracheal intubation, and his preoperative chest radiograph was normal. Accordingly, we would not have suspected the existence of saber-sheath trachea without evidence indicating this condition on the CT images taken for diagnostic purposes. As such, this case indicates that the membranous wall of the trachea can have a normal width on P-A chest radiograph, despite the finding of saber-sheath type tracheomalacia on CT images. This discrepancy suggests that there can be occasional diagnostic difficulties in asymptomatic patients with tracheomalacia.

Tracheal rupture is one of the most feared immediate complications of intubation, although it is rate, with a reported incidence ranging from 0.05 to 0.37% of all orotracheal intubation. However, the mortality rate in patients with this complication is high: 22.4 and 14.2% in emergency and elective intubation, and 22.7 and 22.5% in single lumen and double lumen tube intubation, respectively [1]. Mechanical factors associated with tracheal rupture have been described, including introducers that protrude beyond the tip of the endotracheal tube, overinflation of the cuff, incorrect position of the tip of the tube, repositioning of the tube without deflation of the cuff, inappropriate size of the tube, and significant cough [9–11]. Harris et al. [11] reported a case of tracheal laceration after tracheal intubation in a patient with severe tracheomalacia and presumed that the most likely cause was massive overinflation of the endotracheal tube cuff combined with the preexisting tracheal wall weakness. Therefore, assessment of the tracheal wall prior to insertion, gentle insertion of tube, and prevention of cuff overinflation are essential to prevent tracheal rupture.

Although virtual bronchoscopy provides a similar view to that seen at conventional bronchoscopy, as we have demonstrated, it cannot show the true color or vascularity of the mucosa, and this limits the detection of subtle mucosal lesions [3]. We assessed mucosal appearance and the degree of narrowing by fiberoptic examination prior to the insertion of the tracheal tube. The AWS device and Intlock blade are equipped with an LCD monitor and guide groove and, consequently, they provide easy access to vocal cords for bronchoscopy and tracheal intubation. These optical devices enable prompt fiberoptic examination and a gentle insertion procedure within the limited time available for tracheal intubation.

Tracheal narrowing is a possible cause of severe tracheal injury, despite its rare incidence. To prevent such injury, preoperative airway assessment, including a detailed medical history, careful examination of chest radiographs, and bronchoscopy prior to tube insertion, is essential in patients with suspected tracheal narrowing. Digital chest radiography, which in recent years has been increasingly replacing the conventional systems, has a wider dynamic range and provides better visibility of pathologic lesions than conventional chest radiography [12]. Digital chest radiography with edge enhancement may be a useful tool for the detection and evaluation of undetectable tracheal narrowing in conventional chest films. In addition, axial CT images taken for diagnostic purposes should be examined together with the chest radiograph, since tracheal narrowing not visible on the chest radiograph may exist in such patients, as has been described herein.

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