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Minimally invasive innominate artery transection for tracheomalacia using 3-dimensional multidetector-row computed tomographic angiography: report of a case

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Abstract We successfully performed transection of the innominate artery in a patient with a neuromuscular disorder through minimally invasive access after confirming the anatomical relationships of the vessel using 3-dimensional multidetector-row computed tomographic angiography. A 16-year-old girl with spinal muscular atrophy type 1 had been on long-term mechanical ventilation with a tracheostomy. She had scoliosis and tracheomalacia. Bronchoscopy showed a flattened and narrow lower trachea and an anterior pulsatile compression by the innominate artery. She underwent transection of the innominate artery to prevent tracheoinnominate artery fistula formation. Based on preoperative 3-dimensional multidetector-row computed tomographic angiography images, the innominate artery was transected through a small transverse curvilinear skin incision just below the suprasternal notch and an oblique partial manubriotomy from the suprasternal notch to the first left intercostal space.

Patients with neuromuscular disorders often require tracheostomy and long-term mechanical ventilation, and develop spinal deformities such as scoliosis [1]. This condition may lead to the trachea being pinched between the innominate artery and the spine in the superior mediastinum, resulting in tracheomalacia and subsequent formation of a tracheoinnominate artery fistula. Surgical transection of the innominate artery is one useful therapeutic strategy for preventing fatal airway hemorrhage or obstruction [2]. Herein, we present our experience using minimally invasive innominate artery transection for tracheomalacia with particular emphasis on a novel approach facilitated by 3-dimensional multidetector-row computed tomographic angiography (3D-MDCTA).

1. Case report

A 16-year-old girl with spinal muscular atrophy type 1 (Werdnig-Hoffmann disease) was referred to our service because of minor tracheal bleeding. She had received

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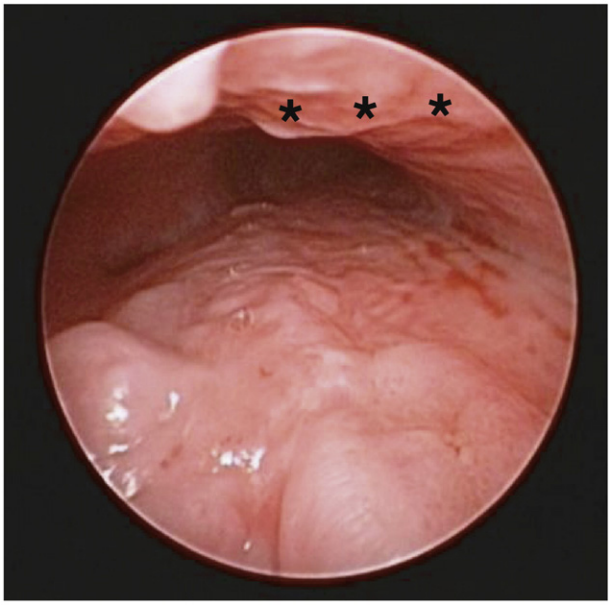

Fig. 1 Bronchoscopy shows the flattening and narrowing of the lower trachea, and a pulsatile compression on its anterior wall from outside (black asterisk).

mechanical ventilator support following a tracheostomy performed at 2 years of age, and subsequently developed severe scoliosis and tracheomalacia. Bronchoscopy revealed flattening and narrowing of the lower trachea, and a pulsatile external compression of the anterior tracheal wall (Fig. 1). There was no obvious bleeding at the time of endoscopy at the site of pulsatile compression of the trachea, but the development of tracheoinnominate artery fistula owing to progression of scoliosis was anticipated. Brain magnetic resonance angiography showed an intact circle of Willis without any occlusion or stenosis of extracranial cerebral arteries, and internal carotid or innominate artery. We planned a prophylactic transection of the innominate artery to avoid fatal airway hemorrhage or obstruction.

Three-dimensional MDCTA was performed before surgical intervention. The 3D-MDCTA images were reviewed and measured at an Aquarius Workstation (TeraRecon, San Mateo, CA) to determine the anatomical relationship between the trachea, the innominate artery, and the sternum. The innominate artery was found to cross over the trachea from left to right in an oblique fashion just below the left side of the manubrium, extrinsically compressing the trachea (Fig. 2).

In the operating theater, the patient was positioned supine under general endotracheal anesthesia administered through her tracheostomy stoma that was carefully isolated from the operating field. Operation was performed through a small curvilinear transverse skin incision (4 cm) just below the suprasternal notch (Fig. 2B). Mediastinal exposure was achieved by oblique osteotomy of the manubrium from the suprasternal notch to the first left intercostal space (Fig. 2C, D). Bleeding from the sternum was controlled with bone wax, and a small self-retaining retractor was positioned. The innominate artery was exposed over the compressed tracheal site. To evaluate the integrity of the cerebral circulation, the regional cerebral tissue oxygen saturation (rSO_2) in both cerebral hemispheres was monitored using near-infrared spectroscopy, with an INVOS 5100C cerebral oximeter (Somanetics, Troy, MI). After clamping of the innominate artery, rSO_2 was reduced to only 86% of baseline. Based on this data, the innominate artery over the compressed tracheal site was transected. The proximal and distal arterial stumps were closed with continuous 5-0 Prolene sutures and dissected away from the trachea, proximally and distally, as much as possible. The manubriotomy was closed using Vicryl sutures and a bioabsorbable bone fixation device (NEOFIX; Gunze, Kyoto, Japan). Rigid ventilating bronchoscopy, immediately after the procedure, showed a widened trachea and a complete relief of compression. The postoperative course was uneventful. Blood pressure in the right arm was 90% of that in the left arm, and there were no neurologic complications. The patient was discharged in satisfactory condition on the ninth postoperative day.

2. Discussion

Scoliosis, defined as a lateral curvature of the spine, is commonly associated with a variety of neuromuscular disorders including conditions affecting upper and lower motor neurons, as well as myopathies [3]. The progression of scoliosis causes a narrowing of the mediastinum owing to chest deformity, resulting in an anatomical distortion among the trachea, innominate artery, sternum, and vertebrae. Because there can be considerable variation in the anatomical relationships of the mediastinum, a full understanding of the anatomy, preoperatively, is necessary for surgical planning.

With recent advances in technology, MDCT, which can provide high–spatial resolution images with fast acquisition times, may have an important role in the noninvasive evaluation of the central airway in pediatric patients [4,5]. Three-dimensional MDCTA provides the clearest visualization of the detailed anatomy, especially the relationship of vessels. It also allows for simulation of the operative field and preoperative measurement of the distance and angles of anatomical positions. Based on the results of 3D-MDCTA in the present case, we were able to obtain precise knowledge about the position of crucial anatomical landmarks and develop a less invasive mediastinal approach for innominate artery transection in this patient with severe scoliosis and tracheomalacia. We suggest that 3D-MDCTA can add to the clinician's repertoire of surgical options to deal with situations of this type. Based on the 3D-MDCTA findings, thoracoscopically performed innominate artery transection through either the right or left chest may be considered; or