Multidetector CT diagnosis of tracheobronchial stenosis associated with congenital heart diseases in pediatric patients

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Learning Objectives

Congenital heart disease associated with tracheobronchial stenosis is rare but hard to management. Dose-reduced multidetector-row CT (MDCT) with its postprocessing techniques is found to be a reliable, noninvasive method that allows depicting the degree and length of tracheobronchial stenosis and the relationship with vessels, and therefore provide essential evidence for the preoperative scheme.
Background

With the development of surgical management of complex congenital heart disease for infants and neonates, an increasing number of patients were clinically found with tracheobronchial stenosis[1-3]. Management of congenital heart disease and failure to repair the tracheobronchial stenosis results in depending on breathing machine and complicating respiratory infection, which finally leads to respiratory failure and death. The preoperative investigation of airway contributes to simultaneously repairing congenital tracheobronchial stenosis and cardiovascular anomalies under general narcosis [4]. It has been reported that the diagnostic efficiency of multi-postprocessing techniques of MDCT was closely correlated with that of fiberoptic bronchoscopy [5, 6]. The purpose of this study was to retrospectively assess the accuracy of postprocessing techniques of MDCT in determining the degree and length of tracheobronchial stenosis in pediatric patients with congenital heart disease by using surgical findings as the reference standard.
Multidetector CT was performed with a 64-slice helical CT scanner. Scan parameters followed a low-dose protocol. Mean effective dose was calculated for all examinations. A low-dose protocol with the following scan parameters was used: 80 kV, tube current 80-120 mA (weight #25 kg) or 100 kV tube current 110-200 mA (weight #25 kg). Patients were examined at single-phase scan. Nonionic iodinated contrast medium was administrated at a flow rate of 2-4 ml/sec by power injector via a 21-23 gauge line in an antecubital vein or scalp vein. Volume dose was used according to weight (weight #25 kg, 2 ml/kg; weight 25-40 kg, 1.5 ml/kg; weight #40 kg, 60-70 ml). An automated tracking system was used. Images reformation with MPR, CPR, MinIP and VR were performed at a workstation by two cardiovascular radiologists. Interpretation and measurements of reformatted images were performed by the two radiologists with consensus who were blind to the clinical records. The site, length, degree and marginal feature of stenotic segments were recorded. Images of MPR or CPR were employed to measure the length of narrowing part; the degree of narrow part was measured with images of MPR/CPR, MinIP and VR, which was calculated as (the proximal normal caliber - the narrowest caliber) / the proximal normal caliber × 100%, i.e. (b-a)/b×100% (Fig. 1). To match with the measurements of operation, the grade of tracheobronchial stenosis measured with MPR/CPR, MinIP and VR was categorized semiquantitatively as mild (stenosis # 50%), moderate (stenosis 51-75%) and severe (stenosis 76-100%). The paired samples t-test was used to compare the significant differences in the length of stenotic segments between MPR or CPR and the operation. Mann-Whitney test was used to compare the significant differences in stenotic degree between the measurement of MPR/CPR, MinIP, VR and the operation.

A total of 52 segments of 37 cases were compared with the findings of operation. The sites of stenosis detected by all postprocessing techniques were in conformity with operation except for one small stenotic segment missed diagnosis by MinIP and VR. Solitary stenotic segments were 26 cases, in which stenosis of trachea (Fig. 1-5), left main bronchus (Fig. 6-7), right main bronchus, left upper lobe and right upper lobe bronchus were 12, 9, 2, 2 and 1, respectively. Concomitant stenosis were 11 cases, in which trachea complicating left and right main bronchus stenosis were 4 and 4 cases (Fig. 11-12), respectively; left main bronchus complicating left upper lobe and left lower segment lobe was 1 and 1 case, respectively. Right main bronchus complicating and intermedius bronchus was 1 case.

There was no significant difference in measuring the length of stenotic segments between MPR or CPR (20.50±10.13 mm) and the operation (19.29±10.23 mm), (d=1.208, t=5.115, P<0.001). MPR or CPR was significantly correlated with the operation in measuring the length of stenotic segments (r=0.987, P<0.001). There was no significant difference in measuring the degree of tracheobronchial stenosis between MPR/CPR, VR and the operation, (Z=-0.068, #=-0.94 and Z=-0.591, #=-0.555), while MinIP frequently
overrated the degree of stenosis compared with the measurement of operation ($Z=-2.177$, $\#=0.030$). The marginal features of tracheobronchial stenosis consisted of flat stenosis (Fig. 1-2) 10, secund stenosis (Fig. 2-7) 17, annular stricture (Fig. 13-14) 5 and irregular stenosis 20 (Fig. 11-12) segments. Mean effective dose of all examinations was 1.12 mSv (range, 0.52-1.67 mSv).
Images for this section:

**Fig. 1**: Fig. 1-2. CT images of right aortic arch with aberrant left subclavian artery and left arterial duct in a 6-month-old male infant with inspiratory stridor and dyspnea since birth. Fig. 1. VR image shows moderate stenosis of inferior segment of trachea (a stands for the narrowest caliber, b for proximal normal caliber and c for the length of stenosis).
**Fig. 2:** Transverse sections confirms aberrant left subclavian artery (black arrow) and left arterial duct (white arrow) constituting a vascular ring, as the cause of the tracheal compression.

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Fig. 4: MPR confirms right aortic arch #black arrow# as the cause of the airway compression.

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Fig. 5: MinIP shows tracheobronchial tree and moderate stenosis of inferior segment of trachea.

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Fig. 13: Fig. 13-14. Ventricular septal defect and patent ductus arteriosus with left main bronchus and left lower segment bronchus stenosis in a 6-month female infant. Fig. 13. MinIP shows local interrupt of left main bronchus, left lung atelectasis (bright area in left bronchial tree stands for inflammation).

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Fig. 12: VR image of airway shows the dysplasia and mild stenosis of trachea complicating tracheal diverticulum (arrow), left main bronchus presenting irregular severe stenosis.

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**Fig. 11:** Coalescing VR image of blood vessel and airway (from foot to head oblique view) shows the three dimensional relationship of pulmonary sling compressing trachea and right main bronchus.

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**Fig. 9:** Transverse image shows atrial septal defect (arrow).

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Fig. 10: Fig. 10-12. Pulmonary sling with trachea and right main bronchial stenosis in a 22-month male infant. Fig. 10. Transverse image shows the left pulmonary artery arises from the right pulmonary artery, circumambulating the back of trachea and causing tracheal compression (arrow).

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Fig. 8: Coronal MPR image shows Aorto-pulmonary septal defect (arrow).

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**Fig. 6:** Fig. 6-9. Aorto-pulmonary septal defect and atrial septal defect with left main bronchial stenosis in a 6-week male infant. Fig. 6. CPR shows a circumscribed severe stenosis in left main bronchus (arrow), which is caused by endogenous tracheal web but not vascular compresion.

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Fig. 14: CPR shows the stenosis of left main bronchus caused by dilated left pulmonary artery (short arrow) and descending aorta (long arrow) also shows the stenosis of left lower segmental bronchus which could not be seen in (Fig. 13).

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**Fig. 7:** MinIP shows a circumscribed interrupt of left main bronchus and atelectasis of left lung. It seems that the stenotic degree is severer than CPR.
Conclusion

The integrated image interpretation of dose-reduced MDCT scan can accurately evaluate the degree and length of tracheobronchial stenosis associated with congenital heart disease and provide essential evidence for the preoperative scheme.
Dr Rong-Pin Wang, M.D, Chief physician, major in cardiovascular disease. Dr Wang had made some presentations at RSNA, ECR and KCR about cardiovascular imaging in recent years.
References


