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## Diagnosis of Airway Malacia by Virtual Bronchoscopy

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**Abstract:** The study was aimed to identify the role of virtual bronchoscopy in detection of airway malacia in children. In a pre-experimental study over 3 years (from Nov. 2003 to Oct. 2006), 35 consecutive patients were presented to Tabriz Children's Hospital with clinical manifestations of airway malacia, examined by the technique of virtual bronchoscopy. Thirty five patients including 23 males and 12 females with the mean age of  $3.7 \pm 1.6$  months were studied. The presence of airway malacia and its location and severity were determined by virtual bronchoscopy in all studied cases; that revealed: laryngomalacia, bronchomalacia, tracheomalacia, laryngotracheomalacia and laryngobronchomalacia in 42.8, 25.7, 20, 8.6 and 2.9% of patients, respectively. Virtual bronchoscopy is a non-invasive, accurate and rapid imaging technique with an excellent validity for diagnosis of airway malacia and stenosis, therefore it can replace conventional bronchoscopy.

**Key words:** Virtual bronchoscopy, laryngomalacia, tracheomalacia, bronchomalacia

### INTRODUCTION

The term malacia means morbid softening or softness and in medical terminology refers to weakness of bone or cartilage (Austin and Ali, 2003). Laryngomalacia is the most common cause of congenital stridor in infancy (Grzegowski and Pucher, 2000).

Its annual incidence is thought to be about 1/2100 infants (Boogard *et al.*, 2005). Laryngomalacia is the most common congenital anomaly of larynx and may result in recurrent attacks of aspiration pneumonia (Medulla *et al.*, 2004).

About 7-22% of patients with laryngomalacia may present with life threatening symptoms that need surgical intervention (Vollrath, 2004). Tracheomalacia refers to weakness of tracheal cartilage which is usually caused by decreased or atrophied longitudinal elastic fibers (pars membrana) or any structural defect in the cartilage that softens the airway and predisposes it to collapse. Bronchomalacia means weakness and collapsibility of one or both main bronchi (Carden *et al.*, 2005). Tracheomalacia is the most common congenital anomaly of trachea (Holiger, 1980) and may be seen as an isolated anomaly in all infants but more commonly in premature newborns (Jacobs *et al.*, 1994). Primary tracheomalacia is a self-

limiting disorder in many otherwise healthy term and even preterm infants which often disappears spontaneously after 2 years of age (Cogbil *et al.*, 1983). These disease processes may become persistent or even fatal in those patients who have an underlying connective tissue disorders or some congenital syndromes (Chen *et al.*, 1982).

The acquired or secondary form of airway malacia is often induced by prolonged endotracheal intubation but other factors such as increased airway pressure during mechanical ventilation, oxygen toxicity and recurrent infections may also play some role in its pathophysiology. It seems that premature neonates with respiratory distress syndrome are the most susceptible group for this condition because their supportive structures are not yet complete (Duncan and Eid, 1991). Tracheostomy is a predisposing factor for acquired tracheomalacia too, which acts by means of pressure necrosis, infection and mucosal erosion, all are imposed by friction and impaired tissue circulation (Azizkhan *et al.*, 1993).

The incidence of tracheomalacia is supposed to be about 1/1445 infants (Callaban, 1998).

Considering the natural history, wide spectrum of clinical manifestations and the possible complications of airway malacia, early diagnosis of these disorders is

crucial and will prevent unnecessary work-up and administration of drugs specially antibiotics, which otherwise are frequently prescribed for these patients (Yacilin *et al.*, 2005). There are two ways to recognize airway malacia: conventional (endoscopic) and virtual bronchoscopy. Although endoscopy is the perfect, preferable and definitive method for watching the airways during real breathing but collapsing airways can not be seen in an anesthetized or paralyzed child under positive-pressure ventilation (Austin and Ali, 2003).

Virtual bronchoscopy as was first explained in 1997 is created by frequent images of computerized-tumographic thin slices of airways which are transferred to work station where a specialized software reconstructs and edits them to form the animation of virtual bronchoscopy (Mark *et al.*, 2001). In the other words, virtual bronchoscopy is a digital facility to show several sequential cuts of airways in 3-dimensional model and conducting the animation through the bronchial tree within a time period similar to those of a real bronchoscopy (Aquino and Vining, 1999). In this method both volume and surface rendering techniques are used to show the shape and size of the patient's airways. Its principal advantages are being "non-invasive" and its ability "to pass virtually through intensely stenotic lumens" visualizing the distal airways (Hoppe *et al.*, 2002). The patients are not exposed to excessive irradiation by this imaging method (Finkelstein *et al.*, 2004). Virtual bronchoscopy can be used to recognize bronchial stenosis due to intra or extra-luminal pathologies and evaluate surgical sutures after lung transplantation (De Waver *et al.*, 2005).

Considering the above mentioned characters of virtual bronchoscopy, we planned this study to assess its abilities for evaluating airway malacia.

## **MATERIALS AND METHODS**

In a pre-experimental study over 3 years (from Nov. 2003 to Oct. 2006); 35 consecutive patients were presented to Tabriz Children's Hospital with clinical manifestations of airway malacia and examined by the technique of virtual bronchoscopy. The studied patients were infants under 6 months of age who had intermittent or persistent stridor as an isolated symptom or accompanied with expiratory wheezing and recurrent episodes of choking and/or cyanosis during feeding or crying, their stridor were decreased in intensity with changes of position, parents often complained of their babies' noisy breathing whole the days and nights.

We used volume rendering technique in this study to transform 2-dimensional images to 3-dimensional model for showing anatomy of airways. By considering maximal CT-number for soft tissue and radiopaque parts with

maximum intensity projection and also minimal CT-number for air spaces with minimum intensity projection, the most accurate images of organs and their precise volume are constructed, we created semi-transparent pictures from walls of tracheobronchial tree visualizing its shape and template by using minimum intensity projection.

## **RESULTS**

We studied 35 patients including 23 males (65.7%) and 12 females (34.3%) with the mean age of  $3.7 \pm 1.6$  months when diagnosed.

The clinical manifestations such as noisy breathing, cough and recurrent respiratory distress were seen in all patients (100%).

And Cyanosis during crying or feeding, wheezing, stidor and concomitant wheezing and stridor were seen in 74, 54, 43 and 57%, respectively.

Virtual bronchoscopy confirmed the diagnosis of airway malacia and localized the lesion as follows:

Laryngomalacia in 15 cases (42.8%), Bronchomalacia in 9 cases (25.7%), Tracheomalacia in 7 cases (20%), Laryngotracheomalacia in 3 cases (8.6%) and Laryngobronchomalacia in 1 case (2.9%).

## **DISCUSSION**

This study was designed to evaluate the role of virtual bronchoscopy in the diagnosis of airway malacia. one study showed a meaningful correlation between the results of virtual bronchoscopy and pulmonary function test in assessment and grading of tracheal and bronchial stenoses, but no similar correlation between the results of virtual and fiber-optic bronchoscopies. Therefore, they claimed that virtual bronchoscopy is a perfect procedure for follow up studies (Shirit *et al.*, 2005). In a study on 12 patients the researchers examined every participant by both virtual and fiber-optic bronchoscopies and found compatible results (Honnef *et al.*, 2005). The above mentioned documents indicate that fiber-optic bronchoscopy can be replaced by virtual bronchoscopy, although this has two major disadvantages: it is impossible to watch mucosal color or to do any therapeutic intervention during virtual bronchoscopy (Hoppe *et al.*, 2002). In a 10-years-lasting study the bronchoscopic examination of 885 patients revealed airway malacia in 299 cases (34%), 24% of these cases had laryngotracheomalacia and 47% tracheobronchomalacia (Master *et al.*, 2002). The findings of this study are incompatible with ours, as our study showed isolated forms of airway malacia (such as laryngomalacia in 42.8%, bronchomalacia in 25.7% and tracheomalacia in 20%) to be more common than compound forms (such as laryngotracheomalacia in 8.6% and laryngobronchomalacia in 2.9%). In a study on 50

children with tracheomalacia, consisted from 24 (48%) primary and 26 (52%) secondary type cases; 96% of secondary cases were premature neonates with the history of prolonged mechanical ventilation due to respiratory distress syndrome (Jacobs *et al.*, 1994), while all 7 cases of tracheomalacia in our study were primary type. Our study showed male preponderance (56.7%) in airway malacia, this had been similarly reported by Master *et al.* (2002).

Airway malacia may be basically missed or misdiagnosed as asthma or other pulmonary disorders, because it has a spectrum of clinical manifestations with varying severity from mild to life threatening forms (Mair and Parsons, 1992), therefore its early diagnosis is necessary. Virtual bronchoscopy is a non-invasive diagnostic method with high validity that can facilitate early diagnosis and reduce unnecessary costs.

## CONCLUSION

Virtual bronchoscopy is a non-invasive and rapid imaging technique with high validity for assessment of airway malacia and stenosis, therefore it can replace conventional fiberoptic bronchoscopy.

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