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Short Communication

Virtual bronchoscopy in the era of multi-detector computed tomography: Is there any reality?

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ABSTRACT

Virtual bronchoscopy, in conjunction with axial and MPR MDCT images, can enhance diagnostic accuracy of tracheo-bronchial endoluminal pathologies. We describe a few cases highlighting the utility of virtual bronchoscopy in the diagnosis of varied tracheo-bronchial pathologies encountered in the setting of a tertiary care Armed Forces Hospital of India.

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Introduction

Multi-Detector Computed Tomography (MDCT) has been a revolution in the CT technology, with its inherent speed and ability to acquire thinner sections volumetrically. Modern MDCT scanners (16 slice onwards) enable post-processing multi-planar reconstructions (MPR) in orthogonal and non-orthogonal planes including curved planes, with near isotropic resolution. Improved software and advanced work stations enable Radiologists to post-process datasets in 3D/volume rendered mode which supplements information available on the axial and MPR images, increasing the

diagnostic accuracy manifolds. Virtual bronchoscopy (VB) essentially is such a post-processing technique which creates 3D rendition of inner surface of the tracheo-bronchial tree simulating endoluminal view as would be visible on actual bronchoscopy. The full potential of this simple yet important add-on technique is being increasingly recognized.^{1–7} It is also important to understand the pearls and pitfalls of VB so that this technique can be optimally utilized. The following illustrative cases highlight the utility of VB in the diagnosis of varied tracheo-bronchial pathologies encountered in the setting of a tertiary care Armed Forces Hospital of India.

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Fig. 1 – NCCT Chest (Somatom Sensation 16, Siemens): Coronal reconstruction: Lung window (a) depicts evidence of hyperinflation of left lung with an intraluminal filling defect within the left main bronchus (LMB, black arrow). Also note motion artifacts of right dome of diaphragm which is not noted on the left side. This finding is consistent with restricted mobility of the left hemidiaphragm associated with hyperinflation of left lung. Soft tissue window (b) confirms occlusion of LMB lumen with a soft tissue density lesion (white arrow). (c): Virtual bronchoscopy (VB, view from top, above the level of carina) depicts carina, right main bronchus (RMB) which is clear. The LMB shows presence of polypoidal intraluminal filling defect consistent with a foreign body (FB) which is better appreciated on a magnified VB view of the LMB (d).

Fig. 2 – CECT Chest (Somatom Sensation 16, Siemens): (a) Coronal section (lung window): A small nodular lesion is seen abutting medial wall of right lower lobe RLL bronchus (black arrow). No other abnormality was detected. (b): (VB, view from top, at the level of proximal RLL bronchus) delineates the nodularity very well.

Case 1

An 18-month-old male patient presented with sudden onset cough, breathlessness and irritability for two days duration. No other definite history was available. On chest auscultation, diminished breath sounds were found on the left side. A chest radiograph revealed hyperinflation of left hemithorax. With a provisional diagnosis of foreign body aspiration (FBA), an urgent non-contrast computed tomography (NCCT) chest was carried out. CT scan chest confirmed presence of hyperinflation of left lung with an intraluminal obstructive pathology within the left main bronchus. A virtual bronchoscopic study clearly showed a polypoidal intraluminal filling defect causing near total occlusion of the lumen of left main bronchus (LMB). Based on the clinical profile and CT scan findings, a diagnosis of FBA was made (Fig. 1). The child was immediately taken up

for bronchoscopy. A foreign body (peanut) obstructing the lumen of LMB was removed successfully. The child made a quick recovery. Retrospectively, the mother gave history that the child was playing with peanuts before the onset of symptoms.

Case 2

23-year-old male patient presented with fever and dry cough for 2 months duration with associated weight loss of 5 (five) kg. He was initially treated with antibiotics with no definite improvement. ESR was raised (30 mm at the end of first hour, Westergren). All other tests including sputum test for acid-fast bacilli were within normal limits. Chest radiograph was normal. A CECT chest was carried out. There was no focal parenchymal lesion on either side. Mediastinal and hilar

Fig. 3 – (a) Chest radiograph (PA view) demonstrates opacities in right lower zone with clear diaphragmatic and right cardiac border suggesting possibility of involvement of lateral segment of RML. CECT (Somatom Sensation 16, Siemens) **(b)** Axial section (lung window) and **(c)** oblique coronal section (lung window) depicting collapse-consolidation of lateral segment of RML. In addition, the oblique coronal section demonstrates a nodular filling defect at the proximal aspect of lateral segmental bronchus (white arrow). **(d)** VB: Origin of medial segmental bronchus (MSB) of RML is clearly visualized and is patent. Origin of lateral segmental bronchus (LSB) of RML is occluded.

region was also normal. A small nodular lesion was noted abutting the right lower lobe bronchus (Fig. 2). Fiber optic bronchoscopic biopsy was taken from the nodular area which was suggestive of tuberculosis. A diagnosis of primary endobronchial tuberculosis was made and treated accordingly, and the individual recovered completely. Repeat CT scan after completion of treatment was normal.

Case 3

33-year-old male patient presented with cough, fever for 15 days duration. Chest radiograph (PA & lateral views) showed consolidation in lateral segment of right middle lobe (RML). Despite, adequate treatment, there was no significant clinical improvement or radiological clearance of lesions. He was referred for a CT scan study with a diagnosis of non-resolving pneumonia. CT scan study confirmed collapse-consolidation involving lateral segment of RML. In addition, there was a filling defect at the origin of lateral segmental bronchus of RML (Fig. 3). Fiber optic bronchoscopy revealed a mucous plug causing occlusion of lateral segmental bronchus of RML.

Case 4

26-year-old female patient, a case of endosulfan poisoning, was on prolonged endotracheal intubation. She developed a tracheal stricture detected on endoscopy. CT scan was done for documenting any associated intra-extra luminal pathology. The tracheal stricture was clearly demonstrated with VB correlating with the endoscopic findings (Fig. 4).

Case 5

68-year-old male patient presented with hoarseness of voice. On endoscopy, a nodule was seen at the posterior aspect of right vocal cord. CECT was done for further evaluation. CT scan study with VB confirmed nodular thickening of posterior aspect of right vocal cord (Fig. 5). The nodule was resected and recovery was uneventful. It was found to be benign in nature.

Discussion

Virtual bronchoscopy (VB) though first described in the mid-nineties,⁸ found increasing application in day-to-day practice in the last decade.^{1–7} VB is now a well accepted non-invasive modality for visualization of lumen and endoluminal surface of the tracheo-bronchial tree. With the improvement in CT technology and availability of modern MDCT scanners, it is now possible to obtain high resolution images at a great speed in any desired plane of interest including high quality 3D images. This has resulted in increased overall diagnostic accuracy.

As is mentioned in the literature and has been our experience too, VB is particularly useful during work up of FBA in children.^{1–3,9,10} Although, in an MDCT scanner, thin section axial images supplemented with MPR images would be able to offer a diagnosis of FBA in most cases, addition of VB in the diagnostic algorithm reaffirms the diagnosis. It has also been our observation that treating clinicians like ENT specialist or pulmonologist feels more comfortable about the diagnosis and further management when shown the VB images in addition to the axial and MPR images, possibly because they are able to interpret the VB images easier, as these images closely resemble conventional bronchoscopic images. Most of the children with suspected FBA are between 1 and 3 years of age and manifest respiratory distress of varying degrees at the

Fig. 4 – NCCT Neck (Somatom Sensation 40, Siemens): (a) Sagittal reconstruction (soft tissue window): Endotracheal tube is noted within the trachea (arrow). Stricture could not be demonstrated convincingly. (b) VB: View from top, at the level of proximal cervical trachea. The tight tracheal stricture is well documented (arrow).

Fig. 5 – CECT Neck (Somatom Sensation 40, Siemens): (a) Coronal reconstruction (soft tissue window): Nodular thickening is seen from the right vocal cord (arrow). (b) VB: The nodule is clearly defined and is seen to be related to the posterior aspect of right vocal cord (arrow).

time of hospitalization, in whom definite history of FBA is often not forthcoming. Clinical signs often being non-specific, there is a sense of urgency amongst the clinicians in such a setting for an early and confident diagnosis of FBA. Modern MDCT scanners (16 slice onwards) are particularly suited for such a situation. Despite tachypnea and motion blur, it is possible to obtain a technically & diagnostically adequate study in most patients, as has been shown in the illustrated cases. This is possible primarily because of increased temporal and spatial resolution inherent in the modern MDCT

scanners. By carefully manipulating the acquisition parameters one can reduce the overall radiation dose and yet obtain a diagnostic study.^{11,12}

Besides FBA, VB also has important role in the detection of many other intra luminal pathologies, some of which have been shown in this review. With VB, it is possible to go down to the level of segmental bronchi easily, which has been shown in Fig. 3. It is well known that conventional bronchoscopy is an invasive procedure and needs expertise which is not always easily available. Complications of conventional bronchoscopy

Fig. 6 – NCCT chest (Somatom Sensation 40, Siemens): (a) Sagittal reconstruction: shows a nodular lesion along the posterior wall of the trachea (arrow). (b) VB also confirms the same. It was reported as polyp. However, on fiber optic bronchoscopy no such lesion was found. It was possibly a mucous plug adherent to the dependent wall of the trachea which got cleared.

are known even in expert hands. When compared with conventional bronchoscopy, VB provides equivalent information regarding endobronchial mass, stenosis, obstruction and external indentations.² VB in association with axial and MPR images can delineate beyond an obstructive/stenotic pathology, which a conventional bronchoscope may not be able to negotiate. Looking around the lesion is of course a domain of cross sectional imaging and not conventional bronchoscopy.

It may be good idea to subject all pertinent cases to MDCT first, make a reasonably accurate diagnosis and filter out those cases that actually need conventional bronchoscopy. The MDCT images along with VB help facilitate pre-bronchoscopy planning and navigation during bronchoscopy.^{5–7} It may be pertinent to note here that, with the availability of modern MDCT scanners with improved software, MPR as well as VB images can be generated within a very short time frame. Secondly, MPR and VB images are obtained by a post-processing technique, which does not require additional scanning/radiation exposure to the patient. By the time, a patient leaves the CT scan department, a provisional diagnosis can be arrived at in most of the cases. Efforts are on to use VB as a guide to bronchoscopic needle placement.^{6,7}

VB has certain limitations, and is not a stand-alone technique. VB images are always interpreted in the light of baseline axial as well as MPR images. Though VB can detect contour abnormalities and intraluminal filling defects, it cannot always characterize a lesion accurately. Subtle mucosal and submucosal lesions are unlikely to be visualized in VB. Similarly, VB can not assess color, vascularity and mobility of a lesion. Many innocuous lesions like an adherent mucous plug on the tracheal lumen (Fig. 6) may at times produce false-positive 'lesions' on VB as we experienced in some of our cases. Finally, since VB is a computer generated simulation technique, direct therapeutic intervention is possible only with conventional bronchoscopy.

Conclusions

VB when used in conjunction with axial and MPR MDCT images can enhance diagnostic accuracy of tracheo-bronchial pathologies within a reasonable time frame and without any additional radiation burden to the patient. VB cannot replace conventional bronchoscopy for therapeutic/biopsy purposes, but it can certainly be an effective screening technique to identify those patients who would actually benefit from conventional bronchoscopy. VB can thus limit the number of patients who need to undergo conventional bronchoscopy which is an invasive procedure with its associated potential complications. Also, in patients ultimately needing a bronchoscopy, VB can serve as a useful navigational planner prior to the intervention.

Conflicts of interest

All authors have none to declare.

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