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Original Research Article

Computerized Tomography Virtual Bronchoscopy – Will it replace Fibre optic Bronchoscopy in Tracheobronchial Evaluation?

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ABSTRACT
Introduction: *Computerized Tomography (CT) Virtual Bronchoscopy is an emerging diagnostic tool in tracheobronchial evaluation with distinct advantages over Fibreoptic Bronchoscopy in that it is noninvasive and able to evaluate beyond significant obstruction. However, it has limited utility in mucosal lesions and there is no option for biopsy.*
Aim of the study: *To evaluate and compare the efficacy of CT Virtual bronchoscopy and Fibre optic bronchoscopy in the assessment of tracheobronchial lesions.*
Materials and Methods: *60 patients with respiratory symptoms underwent CT Virtual Bronchoscopy and Fibre optic Bronchoscopy. The findings in CT Virtual Bronchoscopy were evaluated and compared with Fibreoptic Bronchoscopy which was taken as the gold standard and various statistical calculations assessed.*
Results: *The sensitivity, specificity and accuracy of CT Virtual Bronchoscopy were assessed for endoluminal, extrinsic compressive, mucosal lesions and secretions in tracheobronchial tree in comparison with Fibreoptic Bronchoscopy.*
Conclusions: *CT Virtual Bronchoscopy has very high sensitivity, specificity and accuracy in detection of endoluminal and extrinsic compressive tracheobronchial lesions. The major limitation at present seems to be in detection of mucosal lesions and secretions. There is scope for improvisation of Computerized Tomography Virtual Bronchoscopy by decreasing the radiation exposure, improving the resolution to increase accuracy of detecting mucosal lesions and secretions and mathematical models to reduce inter-observer bias.*
Keywords: *Computerized Tomography, Virtual Bronchoscopy, Fibreoptic Bronchoscopy.*

INTRODUCTION

Fibreoptic bronchoscopy is a crucial tool in the diagnosis of a variety of chest diseases. Fibreoptic bronchoscopy (FOB) remains the gold standard for evaluation and surveillance of endoluminal lesions. It permits direct visualisation of the endoluminal and mucosal lesions of the respiratory tract; can also guide biopsies for histologic studies. FOB can have

important limitations: it is invasive and time consuming, and requires sedation. [1] It may not be tolerated in the young, in the critically ill, or in patients with coagulopathies. In patients with significant airway disease/stenoses, bronchoscopic evaluation of the airway distal to areas of stenoses/narrowing is technically difficult and may compromise patient oxygenation significantly. Equally important, the evaluation of extraluminal pathology is significantly limited in fibreoptic bronchoscopy. [2]

Virtual bronchoscopy (VB) is the specific application of virtual endoscopy for the tracheobronchial tree using CT technology. It is non-invasive, can be done in patients unfit for FOB and can produce views similar to those produced by conventional bronchoscopy. It can evaluate the airways beyond a high-grade stenosis and it can be performed in patients who cannot tolerate bronchoscopy. [3]

This study was conducted to evaluate the efficacy of CT Virtual Bronchoscopy in comparison with Fibreoptic Bronchoscopy which is considered to be the gold standard in evaluation of tracheobronchial pathology.

AIM OF THE STUDY

To evaluate and compare the findings of CT Virtual bronchoscopy and Fibre optic bronchoscopy in the assessment of tracheobronchial compressive lesions, endoluminal obstructive lesions, mucosal lesions and secretions.

MATERIALS AND METHODS

A hospital based cross sectional study was conducted in the Department of Radiodiagnosis, Govt. Medical College, Thrissur with the approval of the Institutional Ethics Committee, from February 2014 to July 2015. 60 patients with respiratory symptoms in whom fibreoptic bronchoscopy and CT thorax were indicated and being done, in Departments of Pulmonary Medicine and Radiodiagnosis respectively in Govt. Medical College Thrissur, were enrolled for the study. (Sample size calculated using the formula $4pq/d^2$ where p is the proportion of the patients in similar previous study, q is 100-p and d is maximum allowable error which is 20% of p. Taking the study conducted by Fulya Adali et al [(4)], as the reference study p =89; q= 11 and d=8.9. Hence sample size found to be > 49.4 and we rounded the figure to 60). The inclusion criterion was patient with respiratory symptoms undergoing both CT thorax and fibre optic bronchoscopy in Govt. Medical College Thrissur. The exclusion criteria were patients undergoing only one of these procedures in our hospital and the other from outside, patients undergoing incomplete study, patients not fit for fibre optic bronchoscopy, those with abnormal renal parameters or contrast allergy, patients not willing to provide written informed consent.

After obtaining an informed consent, examination, MDCT and Fibre optic bronchoscopy were performed. CT scan of the thorax was obtained using Siemens Somatom Emotion – 16 CT scanner. Patients were imaged supine with arms elevated over head to minimize beam hardening artefact. Axial 1.2 mm pre contrast images were obtained from thoracic inlet through adrenal gland. Intravenous non-ionic radiographic contrast injection was given and post contrast images were obtained in all patients if not contraindicated by altered renal function or previous history of hypersensitivity to radiographic contrast medium. Coronal and Sagittal reformations were done. Around 70 images of 5mm thickness and 500 to 700 reconstructed images of 0.6 mm thickness using the manufacturer's "standard" reconstruction algorithm was used. The patient dose was around 7.88 milligray.

CT images were converted to 3-D endoscopic views using commercial software on a workstation. The VB was derived from the CT axial images of the thorax with no further radiation exposure necessary. First the viewpoint was placed in the proximal trachea, retrograde inspection of the subglottic area of the trachea was performed. Subsequent analysis consisted of sequential ante grade inspection of the trachea, main stem bronchi, and lobar bronchi. Little additional time was needed to perform and interpret

the images. Transferring of axial CT images of thorax to 3D images was done by selecting the images or series to be processed and clicking on 3D MPR icon. 3D image is then loaded and fly through icon in settings subtask card clicked. Movements in fly segment available are rotated around viewing point, rotate view, push/pull functions via smart selection. Auto navigation was done where the virtual camera moves along a line calculated by the system for the cavity. Interactive navigation/ assessment was performed, paths through 3D image were viewed, edited and created. The structure was viewed, image data interpreted and images saved while flying.

Virtual bronchoscopic images obtained via the volume rendering computer program were evaluated simultaneously, dividing the computer screen into four equal quadrants in multi-view mode. The lumen of the tracheobronchial tree was evaluated by moving from the proximal trachea. The tracheobronchial tree was investigated after dividing it into 10 sections for an objective comparison between VB and FOB. Segmental bronchi were not separately documented and whenever segmental bronchi were involved it was charted in the corresponding lobar bronchi for ease of comparison.

A lesion wherever obtained was classified into one of the following groups

- Endoluminal obstructive– lesion within the lumen of tracheobronchial tree amounting to any degree of obstruction.
- Extraluminal compression- narrowing of tracheobronchial lumen due to any extrinsic lesion.
- Mucosal lesion- mucosal ulcers, erythema or irregularities/thickening.
- Secretions–any form of secretion(serous, purulent, mucoid, mucopurulent, serosanguinous).

Fibre optic bronchoscopy was done by the pulmonologist prior to or after virtual bronchoscopy. Bronchoscopies were performed via the oral or nasal route with a bronchoscope OLYMPUS CV-150 under anaesthesia (Lidocaine HCl 10 mg/dose spray - midazolam 5mg IV). Lesions of the tracheobronchial tree obtained on FOB were grouped as for VB. During FOB, samples were obtained using biopsy forceps, needle aspiration, brushing, bronchoalveolar lavage or a combination of them.

The data obtained was entered into Microsoft Excel Spreadsheet and descriptive statistics on the population of interest were generated. Statistical analysis was done using SPSS 16 for Windows by IBM Inc, and Epi-info statistical software version 7 by Centers for Disease Control and Prevention, 1600 Clifton Road Atlanta, GA 30329-4027, USA.

RESULTS

In the present study, by CT Virtual Bronchoscopy, 75% (45 cases) showed involvement of trachea, main stem bronchi or lobar bronchi. Fifteen cases (25%) had no abnormalities in their tracheobr-onchial tree studied with VB. Left upper lobe bronchus (16cases, 26.67%) was the most common part pathologically involved in VB followed by right main bronchus(7cases, 11.67%). The least common site involved was noted to be carina(1case, 1.67%). Six cases (10%) had involvement of multiple sites on VB, with one patient having three sites and remaining 5 having two sites involved. Among cases with multiple sites involved, it was noted that 4 had right main bronchus pathology.

In this study, by Fibreoptic Bronchoscopy, 91.67% (55 cases) showed involvement of trachea, main stem bronchi or lobar bronchi. Five patients (8.3%) had no abnormalities in FOB in the current study. The most common site involved in FOB was left upper lobe bronchus (20 cases, 33.33%) followed by right upper lobe and middle lobe (11 cases, 18.33%). The least common site involved was carina (2 cases,3.33%). Multiple sites were involved in ten cases with right main bronchi being the most involved in 6 cases (10%) and in those with right main bronchial involvement, four had right upper lobe bronchus also affected and only 2 had lower lobe involvement. In all the three cases where left main bronchus was affected there was associated pathology in right main bronchus as well.

Ten sections in the tracheobronchial tree were assessed in 60 patients making a total of 600 sections for assessment. They were individually compared with corresponding FOB findings.

For detection of extraluminal compression, VB had a sensitivity of 95.83 %, with a specificity of 99.65%. Two sections with extraluminal compression alone in VB, had both extraluminal and intraluminal lesions in FOB. One section with extraluminal compression was not identified with VB. In the remaining 574 sections of the 60 patients assessed VB and FOB showed no extra luminal compression.

Table 6.1 Extraluminal compression VB vs FOB

		FOB		Total
		Positive	Negative	
VB	Positive	23	2	25
	Negative	1	574	575
Total		24	576	600

Table 6.2 Extraluminal compression VB vs FOB

Diagnostic statistics	%
Sensitivity	95.83
Specificity	99.65
PPV	92
NPV	99.8

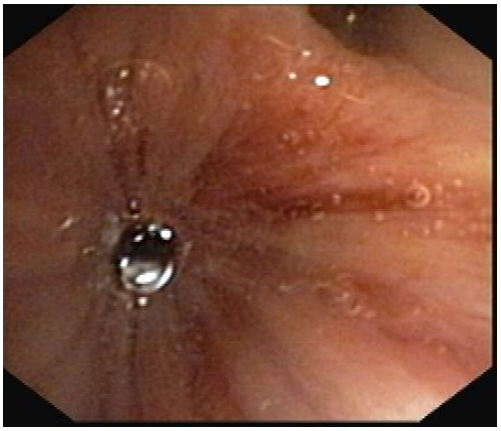

Fig.1 Extraluminal compression in right lower lobe bronchus in FOB

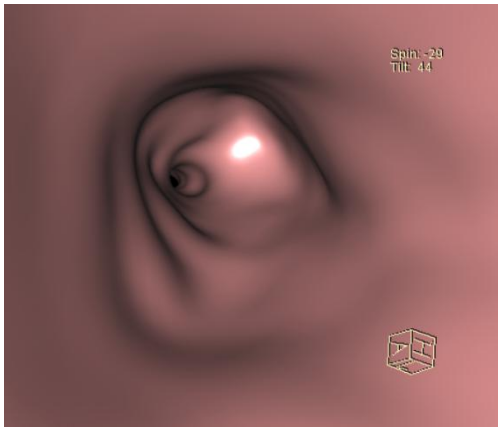

Fig.2 Extraluminal compression in right lower lobe bronchus in CT Virtual Bronchoscopy

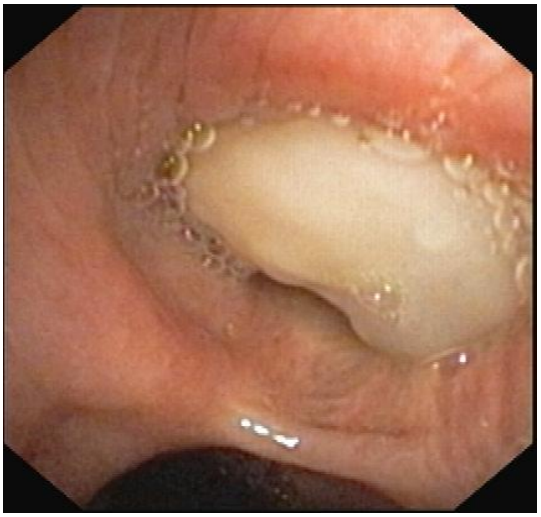

Fig.3 Endoluminal obstructive lesion in right main bronchus in FOB

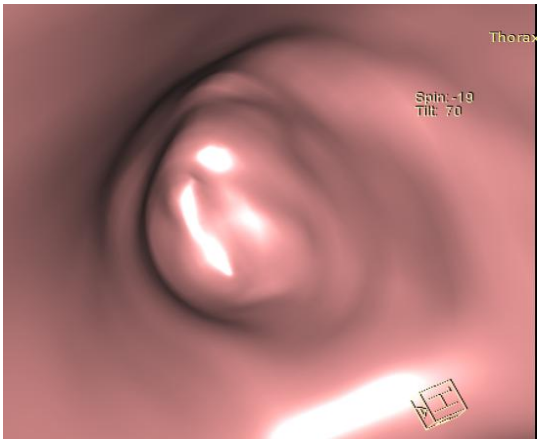

Fig.4 Endoluminal obstructive lesion in right main bronchus in CT Virtual Bronchoscopy

VB had a sensitivity of 95.83 % for detection of endoluminal obstruction. VB could detect 23 of 24 sections with endoluminal lesion in FOB. One lesion was not detected with VB. No false positive

cases were there making the specificity for endoluminal lesions 100%. In 576 out of 600 sections analysed both FOB and VB were negative for endoluminal lesions.

Table 6.3 Endoluminal obstruction VB vs FOB

		FOB		Total
		Positive	Negative	
VB	Positive	23	0	23
	Negative	1	576	577
Total		24	576	600

Table 6.4 Endoluminal obstruction VB vs FOB

Diagnostic statistics	%
Sensitivity	95.83
Specificity	100
PPV	100
NPV	99.8

VB was found to have 99.83 % specificity and only 4% sensitivity for mucosal lesions. Out of 25 sections with mucosal lesions in FOB, VB could detect only one. In one section where VB was positive for mucosal lesion FOB turned out to be negative. In remaining 574 sections analysed VB and FOB were negative for mucosal lesions.

Virtual bronchoscopy did not pick up any case of secretion detected by FOB

For detection of lesions VB was found to have an overall sensitivity of 57.32% and specificity of 99.86%. An overall accuracy of 98.7% was there for detection of lesions in the tracheobronchial tree. In comparison with FOB, VB was found to have 81.82% sensitivity and 100% specificity in diagnosing abnormalities detected with FOB. In all the 45 cases where VB diagnosed some abnormalities FOB was also abnormal. But VB could not pick 10 cases with FOB abnormality. In remaining 5 cases where FOB was normal VB also proved to be normal.

DISCUSSION

Regarding the part involved in Virtual Bronchoscopy, in the present study, 75% (45 cases) showed involvement of trachea, main stem bronchi or lobar bronchi. In a study conducted by Naidich et al [5] 84.6% cases had involvement of these structures. Left upper lobe bronchus (16 cases, 26.67%) was the most common part pathologically involved in VB followed by right main bronchus (7cases, 11.67%). The least common site involved was noted to be carina (1case, 1.67%). A study by Hoppe et al[6] revealed left upper lobe bronchus (35%) to be the most common site involved in VB followed by right upper lobe bronchus(20%).

Regarding the part involved in FOB, in our study, 91.67 % (55 cases) showed involvement of trachea, main stem bronchi or lobar bronchi. In a study by Fulya Adali et al [4], 19 of 22 cases (86%) had abnormalities on FOB which was comparable with the current study. The most common site involved in FOB was left upper lobe bronchus (20 cases, 33.33%) followed by right upper lobe and middle lobe (11 cases, 18.33%).The least common site involved was carina (2 cases,3.33%). Five patients (8.3%) had no abnormalities in FOB in the current study, whereas Fulya Adali et al.'s study had normal FOB in 3 cases (14%).

In the present study, VB had detected abnormality in 45(81.81%) out of the 55 cases positive on FOB. In the study by Fulya Adali et al[4] ,VB detected tracheobronchial abnormalities diagnosed by FOB in 17(89%) of the 19 cases.

In this study VB detected tracheobronchial lesions with a sensitivity of 57.32% and specificity of 99.86% and an overall accuracy of 98.7%. In the study by Fulya Adali et al[4] VB detected tracheobronchial lesions with sensitivity of 89%, specificity of 33% and overall accuracy of 81%. The sensitivity was found to be lower compared to the above mentioned study probably due to the fact that detection of secretions were also analysed in the present study. Secretions in the tracheobronchial tree was not made out with VB. This may either be due to technical inadequacy or due to time lag between VB and FOB examinations.

VB detected endoluminal obstruction as effectively as FOB, except for one case, with a sensitivity of 95.83 % and PPV of 100%. Statistics in Finkelstein et.al's[7] study in this regard was a sensitivity of 91.5% for endoluminal obstructive lesions. Liewald and coworkers [8] evaluated 30 patients with lung

cancer using VB and FOB. In that study thirteen endoluminal lesions were seen equally well with VB and FOB. [8]

VB was found to be effective in detecting extraluminal compression with a sensitivity of 95.83% and PPV of 92%. 23 out of 24 extraluminal compression was correctly detected with VB in the present study. Naidich et al[5] in their study showed a sensitivity of 90% for detecting peribronchial (extrinsic) disease.

VB was found to be less sensitive than FOB in detecting mucosal abnormality (sensitivity 4%, specificity 99.83%) and in picking up tracheobronchial secretions(not detected by VB). This was slightly higher compared to previous study by Finkelstein et al [7] (0% sensitive for detecting mucosal lesions). This may point towards the fact that VB need not be fully ignored in mucosal lesion.

VB was found to be 81.82% sensitive and 100% specific in the diagnosis of tracheobronchial pathologies with FOB as a gold standard. That is, in all the cases (5cases) where FOB was normal VB was accurate in diagnosing them as normal. In a previous study by Finkelstein et al, [7] of the 20 patients who had correlative FOBs, 7 (35%) had normal examination results. In all patients with normal anatomy, results of VB accurately correlated with results of FOB. PPV of VB was 100% and NPV was 33.33% in the present study.

CONCLUSION

Progress in computer technology has permitted unprecedented advances in diagnostic imaging. VB, one of the latest additions to the various modalities used for evaluation of tracheobronchial tree is one such utilisation of computer technology. Although there are multiple advantages stated for VB over FOB, the most prominent one still remains that VB is a noninvasive technique. Further, VB can visualize areas inaccessible to the flexible bronchoscope.

The present study demonstrates the high sensitivity and specificity rates of VB in detecting endoluminal and extrinsic compressive tracheobronchial lesions. However, VB has less sensitivity in detection of mucosal lesions and secretions.

Although VB in the current stage is an excellent modality, it still has scope for further improvement. The major avenues for improvement include decreasing the radiation exposure, better resolution to increase the accuracy in detecting mucosal lesions and secretions and mathematical models to reduce inter-observer bias.

CONFLICT OF INTEREST

No conflict of interest

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