Evaluation of Tracheobronchial Lesions with Virtual Bronchoscopy; Correlation with Fiber Optic Bronchoscopy

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Abstract: The aim of this study was to compare the diagnostic accuracy of 3-D virtual bronchoscopy (VB) with that of Fiber-optic (FB) bronchoscopy in patients who had symptoms of respiratory disorders. Thirty patients underwent VB examination. Thin section helical computerized tomography (CT) image were obtained. The volumetric data was downloaded to a workstation equipped with software for surface shaded rendering technique to achieve interactive 3-D virtual "fly-through" examinations of the tracheobronchial tree. Comparison was made between the results of 3-D virtual bronchoscopy, along with multiplanar reconstruction examination with the findings of conventional FB. This information was correlated with the surgical and pathological outcome wherever possible. Virtual bronchoscopy was true positive in twenty-four lesions. Further analysis revealed six cases were with strictures due to tracheobronchial tuberculosis or infection, eight were strictures due to carcinoma**,** five were endoluminal growths or polyps, three cases had nodes compressing the bronchi, one case had carcinoma of esophagus with tracheal extension and one had a congenital stricture. Virtual bronchoscopy was found false positive in one case, in which a polyp was misdiagnosed. Two endoluminal growths/ polyps were not appreciated on virtual bronchoscopy due to their small size and mild mucosal irregularity. Sensitivity, specificity, positive and negative predictive values were 96%, 50%, 92% and 66% respectively. To conclude VB represents a noninvasive method for evaluating helical CT findings. Further trials with larger sample size are needed on patient populations with any respiratory tract pathology, who do not have any gross findings on conventional examinations and are thus indicated for conventional bronchoscopy.

Keywords: Virtual Bronchoscopy, 3-D CT Bronchoscopy, Strictures

1. Introduction

The tracheobronchial tree's first inspection and therapeutic intervention were performed by Gustav Killian in 1897. Introduction of flexible bronchoscopy (FB) led to a paradigm shift in pulmonary diagnostic landscape. Bronchoscopy produces excellent images of the internal surfaces and is perfect for detecting mucosal or epithelial lesions. However, bronchoscopy may be uncomfortable and may need sedation or anesthesia. Furthermore, bronchoscopes display only the inner surface of hollow organs and no information is provided about the anatomy within or outside the wall.

Advances in CT scanning with rapid imaging and volumetric data acquisition have resulted in significant improvement in imaging of the tracheobronchial tree. This data may be reconstructed into three-dimensional (3-D) images, including internal virtual endoscopic version that closely resembles broncoscopic images. [1-4] Virtual bronchoscopy or "fly-through" methods combine the features of endoscopic display and cross-sectional volumetric imaging. This presentation of volumetric data allows not only studying the inner wall surfaces but also allows navigating

inside the virtual organs. It may be helpful for detection of foreign bodies [5] or for detection of cause of bleeding. [6] However; a virtual bronchoscopy can't provide any information on the color or texture of the airway mucosa.

The aims of our study were to compare the effectiveness of virtual bronchoscopy with the conventional bronchoscopy and to determine if this noninvasive procedure is feasible in our society and can provide adequate information for diagnostic utilization.

2. Material and Methods

This study was conducted at the Radiology and Imaging Department of Liaquat National Hospital. The patients were referred by a chest physician with suspected tracheobronchial lesion in whom either the fiber-optic bronchoscopy had already been performed or it was performed following virtual bronchoscopy within a period of seven days. All virtual examinations were compared with fiber-optic endoscopies performed on the same patients. At the time of evaluation of virtual examinations the axial CT images were also evaluated along with multi-planar reconstruction images.

Conventional bronchoscopy was performed by a pulmonologist who recorded his findings on a picture of the airways after bronchoscopy. Bronchoscopy was used as the "gold standard" technique for detection of airway disease.

The CT scan of all the patients was performed on Toshiba Xpress XG Helical and Toshiba Asteion Multislice CT scanners. Axial helical CT scan of the chest from the level of the proximal trachea to the lung bases were obtained at end-inspiration. The images were then downloaded from Xpress XG Helical to an independent SUN™ "Ultrasparc" workstation and from Asteion Multislice CT scanner to Vitrea™ workstation. These were equipped with "Toshiba Virtual Flythrough" software where interpolation and segmentation of the raw data was performed. An exoscopic i.e outer view of the bronchial anatomy was used for anatomic localization. All of these findings were then compared determining the value of virtual bronchoscopy in the diagnosis of diseases of the respiratory tract.

Analysis was performed using SPSS version 17 software to determine the sensitivity, specificity, positive and negative predictive values relative to a "gold standard." of bronchoscopy. Patients suspected of having tracheo-bronchial stenosis, focal lesion (polyps & cancers), mediastinal / hilar tumors, lymphadenopathy or those with a strong suspicion of tracheobronchial lesion but negative bronchoscopy were included. Patient who couldn't lie straight, had difficulty in holding breath or had severe cough were excluded.

3. Results

Our study included thirty patients. The most common symptom for which patients were referred was shortness of breath (76%, n=23) followed by cough (60%, n=18) and fever (36% n=11) respectively. 30 % (n=9) of the patients had hemoptysis while 10 % (n=3) complained of dysphagia.

On FB, the most common lesion was a stricture due to a carcinoma (30%, n=9). This was followed by polyps which were found in 23% of the patients (n=7). A stricture due to tuberculosis/infection was found in 20% of the patients (n=6). 3 patients had a nodal mass (10%). An esophageal cancer with a tracheal extension and a congenital stricture was present in one patient each. 10 % of the patients (n=3) had no identifiable lesion (Figure 1).
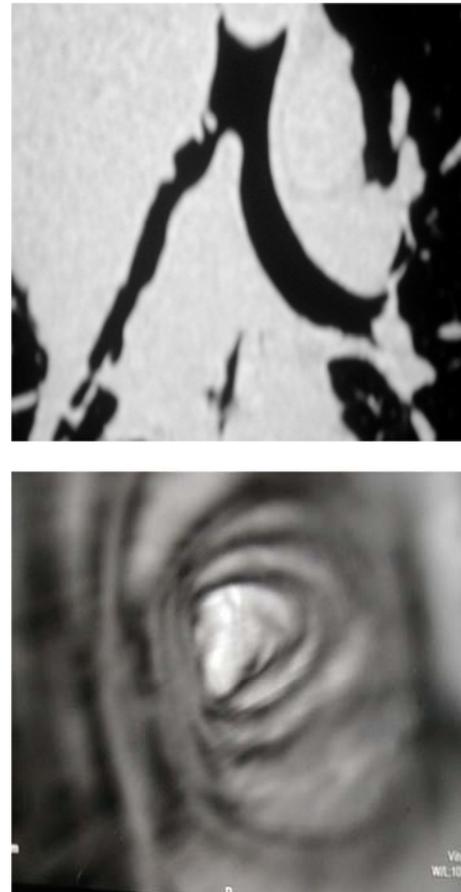
Figure 1. *Coronal and virtual bronchoscopic showing endoluminal growth projecting into the lumen.*
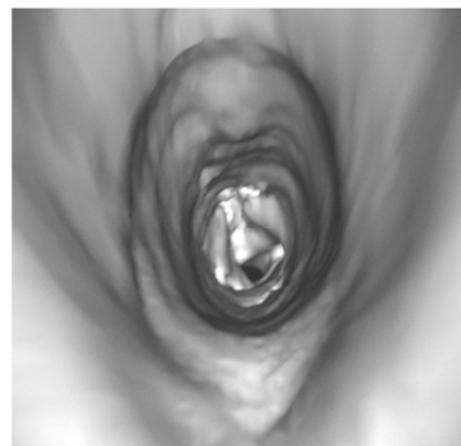
Figure 2. *Virtual bronchoscopy image showing narrowing of tracheal lumen due to tumor.*

Virtual bronchoscopy could not be completed in one patient due to motion artifact because of tachypnea; this patient was diagnosed with a neoplastic lesion on FB bronchoscopy. Virtual bronchoscopy was true positive in twenty-four lesions. In which six were strictures due to tracheobronchial tuberculosis or infection, eight were strictures due to carcinoma, five were endo-luminal growths or polyps, three cases had nodes compressing the bronchi, one case had carcinoma of esophagus with tracheal extension and one had a congenital stricture. FB bronchoscopy showed strictures and was limited to the proximal extent due to narrowed segment; however biopsies of these lesions were obtained which confirmed the results. Pathological confirmation was obtained with biopsy in twenty lesions.

Virtual bronchoscopy was true negative in two; these were out of the seven cases, which were examined prior to FB bronchoscopy with suspicion of tracheobronchial abnormality. FB bronchoscopy also showed no mass or abnormality in these cases. Virtual bronchoscopy was found false positive in one case in which a polyp was diagnosed but retained mucous was found on FB bronchoscopy. Virtual bronchoscopy showed only two false negative results. These were of the seven-endo-luminal growths, which were not appreciated on virtual bronchoscopy due to their small size and mild mucosal irregularity.

In summary, virtual bronchoscopy was able to identify 24 of the true positive cases from a total number of 27 whereas it detected 1 positive case from the total number of 3 negative cases. Therefore, it had a sensitivity of 96% whereas specificity was only 50%. The positive predictive value was 93% whereas the negative predictive value was 66%.

4. Discussion

In our study, virtual bronchoscopy showed a high sensitivity of 96% in detecting a multitude of pathologies with just one false positive case. Half of the patients had a stricture due to cancer or infection and VB was able to diagnose this in 100% of the cases. Previously, reported sensitivities for stenosis detection with VB range from 94 to 100%. [7]

In a number of cases virtual bronchoscopy images alone were not adequate and axial images, external rendered images and multiplanar reformatted images provided significant information for diagnosis confirmation [8].

Remy-Jardin et al [9] performed CT imaging including axial and 3-D external rendered images in 47 patients with benign tracheobronchial stenosis and found that the 3-D images provided important additional information in about 30 percent of cases for a more precise evaluation of the shape, length, and/or degree of the airway stenosis.

Kauczor et al [10] assessed the accuracy of 3-D rendering in 36 patients with airway stenosis and reported agreement between the results of CT scanning and bronchoscopy in the detection of stenoses involving the trachea, main stem bronchi, and proximal segmental bronchi.

Ferretti et al found that airway stenosis were depicted in 39 out of 41 total cases by VB simulation. [11] Many authors describe that VB provides important supplemental information by allowing a more accurate assessment of the length, shape and degree of the airway stenosis. [12, 13] In one study, malignancies of the mediastinum and lungs were evaluated in twenty patients with both virtual and fiber-optic bronchoscopy.

In a study by Fleiter et al [14] assessment of virtual and conventional bronchoscopy was carried out in 20 cancer patients with airway stenoses, high-grade stenoses were viewed equally well with both techniques, but virtual bronchoscopy offered the advantage of viewing the airway beyond the site of stenosis in 5 of 20 patients (25%) in whom the bronchoscope could not pass through the lesion. which suggests that it is an excellent alternative to FB bronchoscopy when a stricture was suspected.

Stenosis were detected by VB without any significant difference in extend, location and grading as compared to FOB. Visualization beyond stenosis was possible only with VB.

Edema, inflammation and color change are not appreciated on VB however cause of indentation as lymph nodes or lesion extent is better appreciated on VB suggesting that each procedure has its advantages and disadvantages

In a study done on patients with tracheobronchomalacia who underwent dynamic multi-detector CT imaging and bronchoscopy, a strong correlation was seen between bronchoscopy and CT scan findings. VB images were often preferred over axial images by clinicians. Furthermore this sometimes reduced the need for bronchoscopy, especially in patients who were poor candidates for this procedure. [15]

The false positive case in our study a polyp diagnosed by VB whereas FB showed that it was in-fact retained mucus. Summers et al previously assessed the accuracy of VB for detection of polypoidal lesions in the airway. [16] They reported a high sensitivity (> 90%) for lesions that were larger than 5 mm in diameter. In another study, false positive results were caused by posterior indentation of the proximal trachea due to esophagus, an irregular bronchial wall, and presence of various artifacts, vascular impression, mucus or bronchial web. This suggests that VB is not appropriate for the diagnosis of smaller lesions and when there might be any irregularity in the bronchial tree.

5. Conclusion

Virtual bronchoscopy presents a noninvasive method for evaluating helical CT findings. It offers the advantage of being able to visualize areas beyond even high-grade stenosis. Although FB remains the standard modality for evaluating airway patency and mucosal lesions, VB may provide valuable additional information that may not be obtained otherwise. Further large scale studies will help in better establishment of this modality as standard practice.

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