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Comparative Study of Virtual Versus Conventional Bronchoscopies as Assistive Diagnostic Tools for the Thoracic Surgeons

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Abstract

Objective: We aim of this work to evaluate the diagnostic accuracy of virtual bronchoscope(VB) compared to conventional bronchoscopies (CB) (fiberoptic (FOB) or rigid (RB)) and the viability of their use by thoracic surgeons.

Background: Virtual Bronchoscopy is a recent method that permits visualization and evaluationdown to the fourth order branches. In comparison with CB, VB can analyze extra luminal compressions and also evaluate areas beyond even high-grade stenosis, even more mapping the route for scoping by FOB or RB which may be troublesome or distressing to the patient.

Methods: This randomized study included five hundred patients with different lesions of thethorax. All of them were admitted to Benha university hospitals from October 2012 to October 2019. All cases were examined with either FOB or RB then reviewed by radiologists and thoracic surgeons. These results were compared with each other's.

Results: FOB and RB time has been decreased by VB which guide the thoracic surgeon evenmore facilitate transbronchial needle sampling for the extraluminal pathology.

Conclusion: VB is currently used in clinical practice and seems valuable to review its potentialclinical diagnostic indications. Both VB and CB might be considered as complementary modalities for confirmation of this diagnosis.

Keywords: CT=computed tomography, FOB=fiber-optic bronchoscopy, CB=conventionalbronchoscopy, RB=rigid bronchoscopy, VB=virtual bronchoscopy.

Introduction

Virtual bronchoscopy is the descriptive term given to images created of the trachea, bronchi and surrounding structures from spatial information derived from imaging sources other than the bronchoscope. The virtual bronchoscopy techniques accuracy with CB findings is high and will be more as CT scanning protocols improve[1].

Multidetector computed tomography-generated Virtual Bronchoscopy (VB) is a novel noninvasive Computed Tomography (CT)-based imaging technique which is a recent technical development that permits complete evaluation of an intraluminal, luminal and extraluminal structure down to the fourth order of bronchial orifices and branches. The morphology of the carinas can be visualized accurately and the images look close to seen with CB[1, 2].

VB has the ability to evaluate high grade stenoses and areas beyond it with unlimited view of extra luminal causes of lumen compressions in the cross-sectional images in comparison with CB[3].

Rigid bronchoscopy has many limitations including general anesthesia, not fit for many elderly patients, complications of the procedure itself (airways or vocal cords damage) or failure to reach the region of interest. While Fiberoptic bronchoscopy is less troublesome in these regards but both cannot go beyond high grade stenoses [1].

Virtual bronchoscopy has an advantage of inaccessible lesions to either select between FOB and RB as another diagnostic tool or mapping the route for both.

VB is a noninvasive imaging tool and we use it in our hospital for clinical practice and hopping for more clinical trials to prove its clinical use.

Methods

This study included five hundred Patients (360 adults and 140 children). All patients were with different lesions of the pulmonary airways, pleura and mediastinum. All of them were admitted to cardiothoracic surgery, chest diseases and pediatric departments, Benha university hospitals from October 2012 to October 2019. Our study was approved by Institutional Research

Board (IRB).

From all patients undergoing a Multidetector CT (MDCT) examination of the chest for different reasons, only 500 patients randomly enrolled in our study and examined with either fiberoptic or rigid bronchoscopies or both. The results of both techniques were reviewed and compared by thoracic surgeons and radiologists.

All patients enrolled to our study were subjected to complete history and physical examination, radiological examination (Postero-anterior and lateral views chest x-ray, Spiral CT chest and Virtual bronchoscopy) The data acquired after scanning were reconstructed using 180º interpolation algorithm and the soft reconstruction algorithm then transferred to a workstation for V.B. All CT images were of sufficient quality for diagnostic interpretation and for performing V.B.

Table 1: Examination protocol of VB [23]

First examination (routine chest CT technique)	
Slice thickness	5-10 mm
Pitch factor	1:1 to 1.5:11
Scanning direction	Bottom to top
Non-ionic contrast material (if indicated)	80ml
Reconstruction kernel	Sharp
Tube load (according to indication)	50-200mAs
Breath-hold	Inspiration
Field-of-view	Full
Select area of interest	
Second examination (dedicated virtual bronchoscopy technique)	
Slice thickness	1-2mm
Pitch factor	1:1 to 2:1
Scanning direction	Bottom to top
Non-ionic contrast material (if indicated)	-
Reconstruction kernel	-
Tube load (according to indication)	-
Breath-hold	Medium
Field-of-view	25-50mAs
	Inspiration
	Enlargement

Fiberoptic or Rigid Bronchoscopies

They were done in cardiothoracic surgery department, pediatric or chest diseases department, Benha university hospitals.

Statistical Analysis

The collected data were tabulated and analyzed usingSPSS version 20 software (Spss Inc, Chicago, ILL Company). Categorical data were presented as number and percentages while quantitative data were expressed as mean and standard deviation. Chi square test (X2), Fisher's exact test and Analysis of Variance (F) test were used as tests of significance, significant ANOVA was followed by post hoc multiple comparisons using Bonferroni test to detect the significant pairs. The accepted level of significance in this work was stated at 0.05 (P <0.05 was considered significant)[4]. P value >0.05 insignificant<0.05 significant<0.001 highly significant.

Results

This study included five hundred patients, 220 males (44%), 160 females (32%) and 120 children (24%), their age ranged between 2 and 72 years with the mean age 44.1.

In our study, the radio-opaque foreign body aspiration was the most common finding in plain CXR among the studied cases; it was more in the Lt. main bronchus (although unusual) than in the Rt. and trachea, then pulmonary opacity (66%), associated lung collapse (34%), pleural effusion (26%), Hilar mass (18%) , Mediastinal mass (14%) and Solitary pulmonary nodule (10%) Table 2.

The C.T. findings among the studied cases revealed pleural effusion in (26%), mediastinal lymphadenopathy in (32%), pulmonary collapse in (34%), endobronchial mass in (8%), tracheal web in (2%), chest wall infiltration in (6%), and foreign body aspiration in (70%)Table 3.

The findings of which bronchoscopy was done (Fiberoptic or Rigid) show pulmonary collapse in (4%) , foreign body aspiration in (70%) and tracheal/bronchial stenosis in (6%)all with rigid one while with F.O.B. findings were bronchial obstruction and endobronchial tumor mass in (12%) for each of them, bronchial stenosis in (10%) & extraluminal compression in (8%)Table 4, 5.

The V.B. findings were bronchial obstruction, extraluminal compression and endobronchial tumor mass in (8%) for each of them and bronchial stenosis in (14%)Table 6.

VB and CB were applied for all patients; VB revealed 4 cases of bronchial obstruction (8%), 4 cases of endobronchial tumor mass (8%), 7 cases of bronchial stenosis (14%) and 4 cases of extraluminal compression (8%). FOB was done to some indicated cases to compare the results of VB aiming at evaluating the diagnostic value of VB. Bronchial obstruction was observed in 6 cases (12%), the same results obtained in the endobronchial tumor mass while bronchial stenosis presented in 5 cases (10%) and extraluminal compression in 4 cases (8%) Table 7.

Table 2: Plain chest x-ray findings among the studied cases

Plain x-ray finding	No.	%
Tracheal foreign body aspiration	101	20.20%
Lt. main bronchus foreign body aspiration	122	24.40%
Rt. main bronchus foreign body aspiration	70	14%
Pleural effusion	130	26%
Associated lung collapse	166	33.20%
Hilar mass	91	18.20%
Mediastinal mass	72	14.40%
Pulmonaery opacity	329	65.80%
Solitary pulmonary nodule	49	9.80%

Table 3: C.T. finding among the studied cases

C.T. finding	No.	%
Pleural effusion	132	26.40%
Mediastinal lymphadenopathy	158	31.60%
Pulmonary collapse	166	33.20%
Endobronchial mass	40	8%
Tracheal web or tracheo-esophageal fistula	9	1.80%
Chest wall infiltration	30	6%
Tracheal foreign body aspiration	120	24%
Lt. main bronchus foreign body aspiration	135	27%
Rt. main bronchus foreign body aspiration	90	18%

Table 4: Number and findings of cases according to which bronchoscopy was done (Fiberoptic or Rigid)

Fiberoptic		Rigid		Finding
No.	%	No.	%	
10	2%	--	0%	Pulmonary collapse
20	4%	20	4%	Endobronchial mass
10	2%	--	0%	Tracheal web o TOF
--	0%	350	70%	Foreign body aspiration
20	4%	30	6%	Tracheal or bronchial stenosis
40	8%	--	0%	Extraluminal compression
Total No.=500 cases				

Table 5: F.O.B. findings among the studied cases

Findings *	No.	% of all cases (no.=500)	% of positive cases
Bronchial obstruction	60	12%	28.60%
Endobronchial tumor mass	60	12%	28.60%
Bronchial stenosis	50	10%	23.80%
Extraluminal compression	40	8%	19%

* Findings are not additive (presence of one lesion does not exclude presence of other)

Table 6: V.B. Findings among the studied cases

Findings *	No.	% of all cases (no.=500)	% of positive cases
Bronchial obstruction	40	8%	19%
Endobronchial tumor mass	40	8%	19%
Bronchial stenosis	70	14%	33.33%
Extraluminal compression	40	8%	19%

* Figures are not additive (Presence of one lesion does not exclude presence of other)

Discussion

Patients with variable clinical features that indicate doing bronchoscopy include dyspnea, weight loss, anorexia and malaise, chest pain and F.B. aspiration were also present in the study done by Tammilehto et al. In our study the most frequent clinical picture was foreign body aspiration (70%) followed by cough and expectoration then dyspnea, weight loss and hemoptysis. The least encountered symptoms were chest pain and hoarseness of voice, similar incidence reported by Peter et al. where the most frequent clinical feature was F.B. aspiration (85%) followed by cough (70%), weight loss (38%) while chest pain and hemoptysis were uncommon[5, 6].

In the present study, VB detected bronchial stenosis in (14%) of all cases while FOB detects it in (10%), also the sensitivity of VB in detecting the bronchial stenosis was (100%), specificity was (93.1%) and accuracy was (94.4%) which means that VB was superior to FOB invisualization of bronchial stenosis. This could be explained by that VB could bypass the stenosis and detect any stenosis or obstruction behind it, and also if there is tumor mass not completely obstructing the bronchial tree can appeared as bronchial stenosis. Kauczor et al. reported that the bronchial stenosis was revealed equally well by both virtual and fiberoptic bronchoscopy, while Salvolini et al. reported that VB was superior to FOB in visualization of bronchial stenosis in (20%) of their cases and FOB was superior to VB in (12.5%) of

Table 7: Comparison between conventional (fiberoptic or rigid) bronchoscopies and V.B. findings

V.B. / C.B.	0		3		1,2		3,4		1,2,3		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	
0	350	100	--	--	--	--	--	--	--	--	350
3	--	--	50	83.33	--	--	--	--	10	16.67	60
1,2	--	--	20	33.33	30	50	--	--	10	16.67	60
3,4	--	--	--	--	--	--	10	100	--	--	10
1,2,3	--	--	20	100	--	--	--	--	--	--	20
Total	350		90		30		10		20		500

0 = Foreign body aspiration

1 = Bronchial obstruction

2 = Tumor mass.

3 = Bronchial stenosis

4 = Extraluminal compression

Test of significance is McNemar test

P = 0.68, Kappa = 0.73, P = 0.011

cases. McAdam's et al. reported that the accuracy of V.B for the diagnosis of bronchial stenosis was (97%)[7-9].

During present study VB could bypass the stenosis and detect patent carina in one case and tumor mass obstructing the right upper lobe bronchus in the other case. Similar advantage was recorded by Fleiter et al.who assessed VB offered the advantage of viewing the airway beyond the site of stenosis in 5 of 20 patients. In addition, for every position of VB in the tracheobronchial tree, it is also possible to refer to the corresponding axial image of MPR to evaluate the structures outside the lumen. Also, El-Desoky et al. reported that VB could bypass the stenosis as 8 patients showed the presence of proximal stenosis followed by distal obstruction while FOB detected only the proximal stenosis. Also, one patient presented by polyp like (endobronchial mass in the bronchus intermedius) behind which the bronchi could not be evaluated by FOB while VB could pass behind the mass and detect stenosis of the middle and right lower lobe bronchi[10, 11].

In our study, VB detected bronchial obstruction in (8%) while FOB detected it in (12%). Viningreported that bronchial obstruction can be revealed equally well by both virtual andfiberoptic bronchoscopy [12].

External indentation upon the wall of the tracheobronchial tree caused by parenchymal mass or lymph node is important sign that indicate tumor infiltration. In this study external indentation on the reconstructed tracheobronchial tree was encountered by VB in (8%) of all cases, also the same result was obtained by FOB. In a previous study, external indentation upon the reconstructed airway by VB was observed in (20%) of their cases Fleiter et al. Similar result were reported by Haponik et al. Also, El-Desoky et al. reported that extraluminal compression presented equally in both VB and FOB findings. In this study, the sensitivity of VB for tumor mass was (8%), while sensitivity of FOB was (12%), Xiong et al. reported that the sensitivity of V.B in detecting bronchial masses was higher than that of FOB combined with multiplanar reconstruction (MPR)[13].

In our study, the sensitivityof VBwas (70.5%), specificity (100%) while accuracy(86.1%).Xiong et al.reported that the sensitivity of VB was (93.3%) while accuracy was(93.5%). Polverosi et al. reported that the accuracy was (85.1%)[13, 14]. In our study the percent of false positive was (2%) while Polverosi et al. reported thatin one patient among 27 patients with tracheobronchial neoplasms they interpreted the obstruction as neoplastic instead of mucus inside the bronchi [14].

In our study the reference "gold standard" was the CB (rigid and FOB). In tracheobronchial lesions detection by VB, the sensitivity and accuracy were (70.5% - 86.1%) respectively. Also, VB and FOB was close in endoluminal lesions detection, but the sensitivity of VB in endoluminal lesions detection was related to the size of the lesions (pathologies >5 mm easily detected). In a similar study done by Chinn RJ et al., it was reported that the sensitivity and specificity of FOB were (47-88%) and (58-90%), respectively, for lesions of 3 to 10 mm in size and its sensitivity increased when only lesions larger than 5 mm in diameter were considered[15].

There was (88%) agreement of both CB and VB in exclusion of endobronchial lesion so, VB could be used to exclude endobronchial lesion in cases unfit for FOB. Some authors have suggested that VB may replace FOB, but this has been unlikely to occur, because direct airway visualization has remained the gold standard and has generally achieved at low cost risk, with definitive results[1]. Haliloglu and colleaguesreported that chest X-ray has a sensitivity of (68%) and aspecificity of (67%). The absence

of radiological alterations does not exclude a diagnosis of FB aspiration. In order to increase radiological accuracy, fluoroscopy imaging can be conducted in inhalation and exhalation, in lateral decubitus. However, conventional bronchoscopy cannot be ruled out based exclusively on these findings, principally in patients in whom there is a high suspicion of FB aspiration[16].

Martinot et al.used the VB in pediatric patients who FB aspiration was suspected.They found that was beneficial in FB localization .also, they recommended that CB use was not superior if the VB result was normal[17].

Hsu et al.found in their study on FB aspiration that RB can be done in less time andFB can be accurately located if VB done before the bronchoscopy[18].

Summary

The combined use of cross-sectional images and virtual reconstructions permits evaluation of extraluminal impressions with one examination. This may, in turn, offer new perspectives for selective transbronchial biopsy of mediastinal processes, because VB together with the corresponding cross-sectional images can help preoperatively to select an optimal biopsy site. Furthermore, data obtained using this method can simplify decision making regarding suitable operative techniques when both the cause of an impression and its relation to important mediastinal structures, such as the great vessels, are known. Finally, follow-up examinations after interventions such as stent placement are feasible without additional risk for the patient.In this study, we concluded that VB is simple to be carried out as a special 3D reconstruction of CT scan of the chest. It is an easy, noninvasive technique enables the surgeon to see as if doing bronchoscopy. This may aid in the understanding of complex tracheobronchial anatomy as a training of the thoracic surgeon before doing a true bronchoscopy. V.B can display the level of the stenosis and determine the length of the stenosis. So, it has enabled surgeon to reduce time of bronchoscopy also the imager is able to view the extraluminal structure and showing the best way for biopsy, resection, or palliative treatment.

Limitations of the Study

Our study has some limitations, one of them; we did not perform a stratification of the subjects regarding localizations of thoracic lesions. However, V.B image quality depends on the radiologist experience and computer power also any mucous bulge in the airways may simulate an endobronchial lesion. V.B required during a single breath hold for about 30 seconds which not met with some of our patients. Also, V.B has the risk of radiation exposure as the virtual image is based upon a CT examination. V.B has a great disadvantage as it cannot evaluate themucosal surface and factors related to the underlying tumor as color, friability of the tissues. V.B can be done in patients who cannot tolerate rigid or FOB and for follow up of cases with endobronchial therapy, so both V.B and C.B might be considered as a complementary modality.

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