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ORIGINAL ARTICLE

Role of Multi-Slice Computed Tomography Virtual Bronchoscopy and Multiplanar Reformatting in Evaluation of Post-Intubation Laryngotracheal Stenosis

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Abstract:

Background: Accurate assessment of stenosis site, degree, and length in post-intubation laryngotracheal stenosis patients is crucial for procedure selection and prognosis prediction. Despite being the preferred method, bronchoscopy has its drawbacks in severely ill patients, with potential complications and limitations in evaluating airway features beyond high-grade stenosis. Computed Tomography (CT) scans with multiplanar reconstructions are suggested as a safer and alternative diagnostic tool to overcome these limitations. The present work aims to compare the diagnostic performance of CT virtual bronchoscopy (VB) and multiplanar reformatting (MPR) with conventional bronchoscopy (CB) in post-intubation laryngotracheal stenosis patients.

Methods: This prospective comparative study, enrolled 30 patients with post-intubation laryngotracheal stenosis from October 2020 to October 2022. All patients were subjected to detailed history taking, thorough clinical examination, endoscopic and radiological investigations. All patients went through CT examination, rigid bronchoscope and underwent tracheal resection anastomosis operation. The evaluated parameters were the length, diameter, and cranio-caudal extent of stenosis in all settings, and the results were compared.

Results: No statistically significant differences between computed tomography virtual bronchoscopy and MPR with crico-tracheal resection operation results regarding length (p-value = 0.943), diameter (p-value = 0.939), and craniocaudal extent (p-value = 0.988). Regarding conventional bronchoscopy and crico-tracheal resection, a statistically significant difference in lumen diameter (p-value = 0.024) was noted. No significant difference in length (p-value = 0.943). No statistically significant difference (p-value = 0.951) as regards cranio-caudal extent.

Conclusions: CT multiplanar reformatting and virtual bronchoscopy offer accurate, noninvasive assessment of laryngotracheal stenosis, surpassing conventional bronchoscopy. They prove beneficial for precise evaluation of lesion length and lumen diameter, especially beyond high-grade stenosis where conventional bronchoscopy faces limitations. These techniques serve as dependable alternatives for patients at risk for anesthesia, providing a safer diagnostic approach.

Keywords: Multi-Slice Computed Tomography; Virtual Bronchoscopy; Post-Intubation Laryngotracheal Stenosis

INTRODUCTION

Laryngotracheal stenosis (LTS) is a narrowing or constriction of the larynx, trachea, or both. [1] Prolonged endotracheal intubation can result in tracheal stenosis secondary to injury from endotracheal tube cuffs. Also, patients with

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tracheostomies might develop stenosis at the level of the stoma.[2]

Laryngotracheal stenosis develops due to a number of factors and has several recognized causes, including iatrogenic (such as an endotracheal intubation complication), traumatic, viral, autoimmune, infectious, neoplastic, and idiopathic. LTS can be caused by autoimmune diseases, including systemic lupus erythematosus, vasculitis, scleroderma, sarcoidosis, and rheumatoid arthritis. Tuberculosis, viral papillomatosis, and bacterial tracheitis are examples of infectious causes. Narrowing of the airway can also result from neoplasms at the laryngeal or tracheal levels; adenoma and squamous cell carcinoma are the most common tumors in these cases. Traumatic LTS can result from direct trauma, radiation exposure, or burns to the trachea [3].

The most common reason for laryngotracheal (LT) surgery is post-intubation LTS. Management strategies rely on precise lesion mapping [4].

Management of laryngotracheal stenosis is a challenging problem that demands a multidisciplinary approach. The appropriate treatment option should be discussed depending on the degree, the location and the length of the stenotic segment [5].

Because bronchoscopy allows a thorough examination of the airway lumen, it is regarded as the "gold standard" for the diagnosis and determination of tracheobronchial pathological conditions. Nevertheless, bronchoscopy has certain technical restrictions, such as failure to assess airway caliber and morphology beyond bronchial lumen in high-grade stenosis, and potentially dangerous complications in critically ill cases (severe oxygen desaturation in hypoxemic cases, arrhythmias, tachycardia, endoscopy-induced inflammation of the immunocompromised). Additionally, not all cases tolerate this examination well [6].

Axial computed tomography (CT) images can be used to evaluate most of the airway abnormalities; however, there are some limitations when it comes to the assessment of the airways. These limitations include the inability to detect subtle cases of airway stenosis, the underestimation of the craniocaudal extent of the disease, challenges in evaluating the airway interfaces and surfaces that lie parallel to the axial plane, and the creation of a huge number of images for assessment [7].

Multi-slice CT is a well-tolerated, non-invasive method. It allows for quick data collection in just a single breath hold, and the images obtained offer comprehensive details about the tracheobronchial tree and its pathological conditions. In addition, CT data-generated two- and three-dimensional (2D, 3D) pictures offer more details about airway pathology. Numerous processing techniques, like virtual bronchoscopy (VB) and multiplanar reformatting (MPR), can be used with CT collected data. Views acquired are similar to those acquired with a traditional bronchoscopy. It can assess airway caliber beyond high-grade stenosis [8].

The present work aims to evaluate the diagnostic performance of virtual bronchoscopy (VB) and MPR compared to conventional bronchoscopy (CB) in post-intubation laryngotracheal stenosis patients taking intra-operative findings as our reference.

METHODS

Patients:

This study was a prospective comparative study, enrolled 30 participants with post intubation LTS from the outpatient clinics of otorhinolaryngology departments of Zagazig university hospitals in the period from October 2020 to October 2022. Twenty were male (66.7%) and ten were female (33.3%). The age of cases ranged from 18 years to 45 years. Verbal and written informed consents were obtained from all participants after an explanation of the procedure and medical research. The research was conducted under the World Medical Association's Code of Ethics (Helsinki Declaration) for human research. This study was carried out after the approval of the Institutional Review Board (IRB). IRB#: 6369-23-9-2020.

Cases with the following criteria were included; patients had laryngotracheal stenosis grades III and IV, limited to subglottic and upper trachea (or upper trachea only) due to endotracheal intubation.

Cases with the following characteristics were excluded; patients with laryngotracheal stenosis which include glottic, supraglottic area and distal trachea. Patients with grades I and II stenosis. Patients with laryngotracheal stenosis due to causes other than endotracheal intubation as: inflammation (scleroma, granuloma), tumors (benign, malignant), idiopathic and trauma. Any patient with any cause to be unfit for general anesthesia was excluded from the study.

Methods:

All participants were subjected to detailed history taking, thorough clinical examination, endoscopic and radiological investigations.

Radiological investigations:

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Plain x-ray of the neck and chest with anteroposterior and lateral views to evaluate upper and lower airway, to identify subglottic and upper tracheal stenosis and to distinguish upper from lower airway obstructive pathologies.

CT imaging:

Using a 128-channel MDCT scanner, multidetector CT investigations were performed on individuals who were not sedated (Philips inventiveness 128). Cases were scanned from the caudal to the cranial regions in supine position, head extended, and arms raised. The scanning settings were as follows: reconstruction interval of 1 mm; pitch of 1.375; detector row design of 128 x 1 mm; collimation of 1 mm; slice thickness of 1.25 mm; 300 mAs; 120 kVp. The process took about 20 seconds to finish on a single breath hold. First, a frontal scout image was acquired, from the larynx level to the diaphragm dome.

Image processing:

After creation, the axial source pictures were moved to the workstation. 3D, VB, and multiplanar reformations (sagittal and coronal views) were among the postprocessing image techniques used for each scan. The latter was positioned in the trachea's proximal region and assessed through a fly-through mode. Each VB image simulated a coned-down view, with a 45-degree cone angle. For each investigation, the post-processing duration varied from 25 to 35 minutes. Digital files containing all images for each patient were saved and assessed collectively.

Image analysis:

A radiologist conducts a thorough examination of all CT studies, analyzing axial images, multiplanar reformations, and VB images. Axial images were analyzed first after that coronal and sagittal reformatted images and VB views were analyzed. Standard lung window settings (level, 450H; width, 1850H) and standard soft-tissue window settings (level, 50H; width, 450H) were used to evaluate the axial and multiplanar reformatted images. Diagnosis of each tracheal stenotic segment was made based on these parameters.

Stenosis Characteristics (Morphology)

Site: In this study, there are three possible locations of stenosis within the central airways. Laryngeal (mainly subglottic); tracheal (cervical trachea); and multiple sites (laryngeal and tracheal).

Grading: A program ruler is used to compare the diameter of the maximal tracheal luminal narrowing to the diameter of the normal trachea in order to determine the grade of stenosis. The four grades in the Myer Cotton grading system are as follows: grade I, 0-50%; grade II, 51–70%; grade III, 71–99%; and grade IV, no residual lumen.

Length of stenotic segment: We employed the techniques presented by Morshed et al. [9], utilizing the program ruler to measure the maximum projection length of the tracheal luminal narrowing.

Shape of stenosis: Grade III stenosis may be circumferential cicatricial stenosis patients or eccentric cicatricial stenosis. While grade IV the whole lumen is completely obstructed.

Endoscopic evaluation (Conventional Bronchscopy):

Under general anaesthesia, Benjamin-Lindholm or Parsons laryngoscopes were used for obtaining a panoramic view of the pharyngolarynx and subglottis. Telescopes are used to measure the exact length and site of the stenosis in the cranio-caudal direction. The telescope is inserted through the laryngoscope and further advanced to the level of the vocal cords. The recorded distance is marked on the shaft of the telescope. The degree of stenosis is measured by passing telescopes, bougies or endotracheal tubes of different given sizes through the stricture.

Statistical Analysis:

Data was analyzed statistically with IIBM SPSS, version 24.0 (IBM Corporation, Armonk, New York). Quantitative data were described utilizing the mean, standard deviation, and range, while qualitative data were expressed using the number and percentage. To compare two groups of normally distributed variables, the t-test was used. When applicable, Mann–Whitney U test: was used when comparing between two means (for abnormal distributed data). The Chi-square test was employed to compare percentages of categorical variables. A p-value < 0.05 is considered significant.

RESULTS

Thirty patients with clinically suspected subglottic and upper tracheal stenosis were included in this study with male to female ratio of 2:1. The age of participants was ranged from 18 years to 45 years (mean 26.2 years). All cases were subjected to prolonged endotracheal intubation following ICU admission due to accidental polytrauma (n = 28) and cardiac cause (n = 2). The duration of intubation ranged from 10 days to 1 month (mean 17 days). 25 patients (83.3%) discharged from ICU and came after that by stridor and respiratory distress to emergency unit in Zagazig University Hospital. The mean time period from ICU discharge to admission in emergency unit with was 1.5 month.

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The stenosis was grade III in 24 cases (80%) and grade IV in 6 cases (20%). The stenosis affected the subglottic and upper trachea areas in all patients. The grade III stenosis was circumferential cicatricial stenosis in 20 patients (66.6%) and eccentric cicatricial stenosis in 4 patients (13.3%). (Table 1).

There was no statistical significant difference between computed tomography and virtual bronchoscopy and crico-tracheal resection operation as regard length, lumen diameter & extent cranio-caudal (Table 2).

There was statistically significant difference (p-value = 0.024) between conventional bronchoscopy and crico-tracheal resection operation as regard lumen diameter. The mean lumen diameter determined by conventional bronchoscopy was (3.4 ± 0.8 mm) while the mean lumen diameter determined by crico-tracheal resection operation was (4.06 ± 1.04 mm) (Table 3).

Case 1 : 29 year old male patient with tracheal stenosis measuring 25mm in length and 2 mm in diameter at maximum narrowing point (80%) (Fig. 1).

Case 2 :A 20-year-old female case showing laryngotracheal stenosis (arrow). In this patient the stenotic segment measured 29mm in length and 3mm in diameter at narrowest point (Fig. 2).

Case 3 : 24-year-old male case with subglottic stenosis measuring 22 mm of length and 3 mm in diameter at maximum narrowing point. Tracheostomy is noted (star) (Fig. 3).

Table 1. Preoperative patients' demographics

	Number	Percentage
Sex		
Male	20	66.7%
Female	10	33.3%
Age		
Mean	26.2	
Range	12 – 45	
Cause of intubation		
Polytrauma	28	93.3%
Cardiac cause	2	6.7%
Comorbidities		
Cardiac disease	2	6.6%
Maxillofacial trauma	2	6.6%
Orthopedic fractures	6	20%
Brain insults (SAH)	2	6.6%
Previous pneumothorax	2	6.6%
Grade of stenosis		
Grade III	24	80%
Grade IV	6	20%
Upper extent of stenosis		
Upper half of cricoid	8	26.7%
Lower half of cricoid	16	53.3%
1st tracheal ring	6	20%
Length of stenosis		
1.5 - 2 cm	14	46.7%
> 2 - 3 cm	16	53.3%

Table 2: Comparisons of length, lumen diameter & extent cranio-caudal between CT and crico-tracheal resection operation

		CT (N = 30)		Crico-tracheal resection operation (N = 30)		Stat. test	P-value
Length (mm)	**Mean**	27.03		27.1		T = 0.07	0.943 NS
	±SD	5.4		5.3			
Lumen diameter (mm)	**Mean**	4.03		4.06		MW = 445	0.939 NS
	±SD	0.9		1.04			
cranio-caudal extent	**1st to 2nd tracheal ring**	5	16.7%	5	16.7%	X^2 = 0.25	0.988 NS
	1st to 3rd tracheal ring	9	30%	9	30%		
	1st to 4th tracheal ring	1	3.3%	1	3.3%		
	Cricoid to 1st tracheal ring	2	6.7%	2	6.7%		
	Cricoid to 2nd tracheal ring	9	30%	8	26.7%		
	Cricoid to 3rd tracheal ring	2	6.7%	3	10%		
	Cricoid to 4th tracheal ring	2	6.7%	2	6.7%		

MW: Mann Whitney U test. X^2: Chi-square test

Table 3: Comparisons of length, lumen diameter & extent cranio-caudal between conventional bronchoscopy and crico-tracheal resection operation

		Bronchoscopy (N = 30)		Crico-tracheal resection operation (N = 30)		Stat. test	P-value
Length (mm)	**Mean**	24.9		27.1		T = 1.5	0.133 NS
	±SD	5.9		5.3			
Lumen diameter (mm)	**Mean**	3.4		4.06		MW = 304.5	0.024 S
	±SD	0.8		1.04			
cranio-caudal extent	**1st to 2nd tracheal ring**	6	20%	5	16.7%	X^2 = 1.61	0.951 NS
	1st to 3rd tracheal ring	6	20%	9	30%		
	1st to 4th tracheal ring	1	3.3%	1	3.3%		
	Cricoid to 1st tracheal ring	4	13.3%	2	6.7%		
	Cricoid to 2nd tracheal ring	9	30%	8	26.7%		
	Cricoid to 3rd tracheal ring	2	6.7%	3	10%		
	Cricoid to 4th tracheal ring	2	6.7%	2	6.7%		

T: independent sample T test. MW: Mann Whitney U test. X^2: Chi-square test.

Table 4: comparisons of length, lumen diameter & extent cranio-caudal between CT and conventional bronchoscopy

		CT (N = 30)		CONVENTIONAL BRONCHOSCOPE (N = 30)		Stat. test	P-value
Length (mm)	**Mean**	27.03		24.9		MW = 355	0.158 NS
	±SD	5.4		5.9			
Lumen diameter (mm)	**Mean**	4.03		3.4		MW = 305.5	0.024 S
	±SD	0.9		0.8			
cranio-caudal extent	**1st to 2nd tracheal ring**	5	16.7%	6	20%	$X^2 = 1.35$	0.968 NS
	1st to 3rd tracheal ring	9	30%	6	20%		
	1st to 4th tracheal ring	1	3.3%	1	3.3%		
	Cricoid to 1st tracheal ring	2	6.7%	4	13.3%		
	Cricoid to 2nd tracheal ring	9	30%	9	30%		
	Cricoid to 3rd tracheal ring	2	6.7%	2	6.7%		
	Cricoid to 4th tracheal ring	2	6.7%	2	6.7%		

T: independent sample T test. MW: Mann Whitney U test. X^2: Chi-square test.

Table 5: Diagnostic performance of CT in relation to bronchoscope

(n = 30)	CT		Conventional bronchoscope	
	length	Lumen diameter	length	Lumen diameter
True positive	24	25	22	20
False positive	0	0	2	3
False negative	2	1	3	4
True negative	4	4	3	3
Sensitivity	92.3%	96.1%	88%	83.3%
Specificity	100%	100%	60%	50%
PPV	100%	100%	91.6%	86.9%
NPV	66.7%	80%	50%	42.8%
Accuracy	93.3%	96.7%	83.3%	76.6%

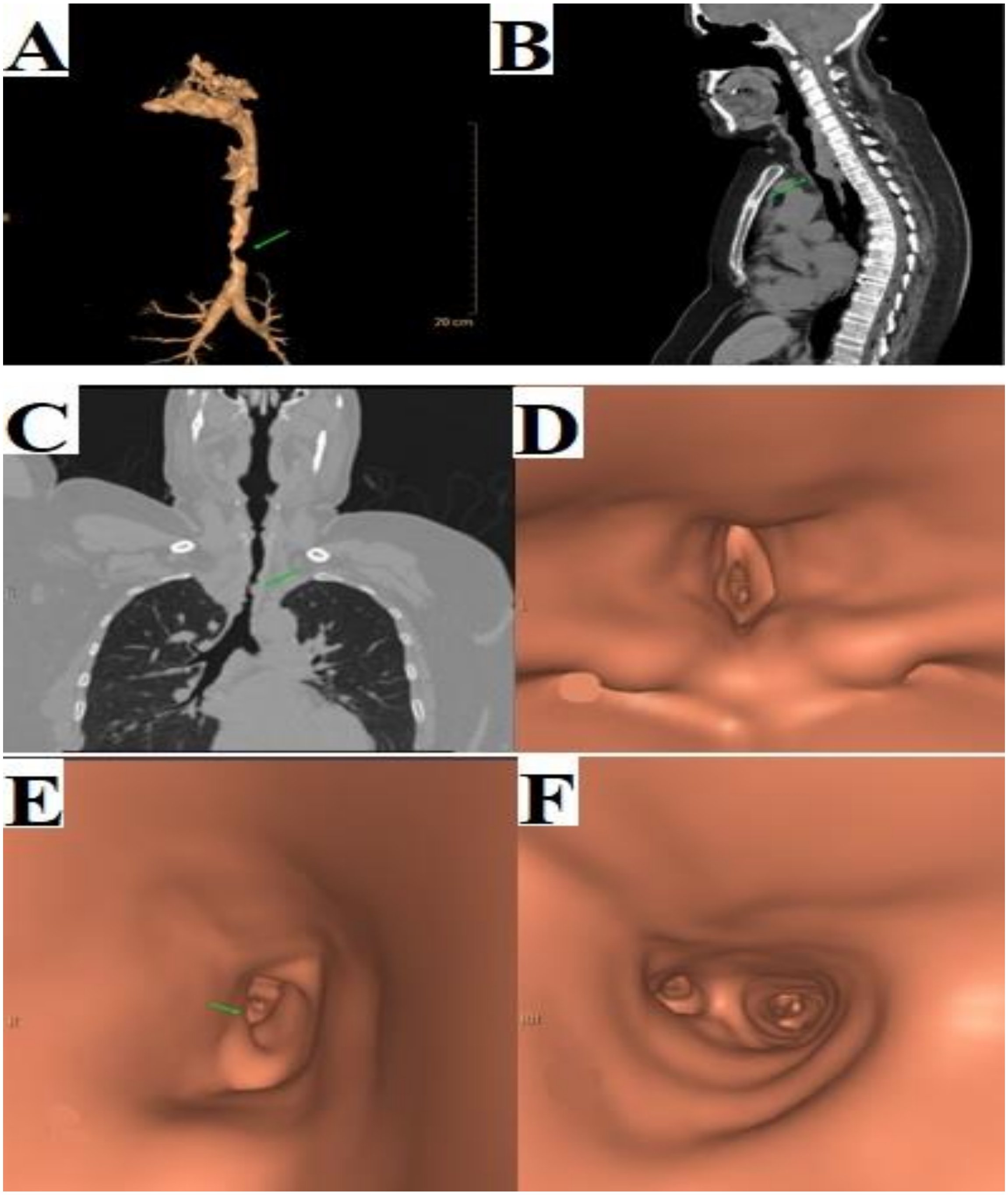

Fig. 1. Case (1) (A) 3D external volume rendering cut, (B) CT scan, sagittal minimum intensity cut, show a subglottic stenosis (arrow). The subglottic stenotic segment measuring 25 mm of length and 3 mm in diameter at maximum narrowing point (80%). (C) CT scan, coronal cut and (D-F) virtual bronchoscopy show the subglottic stenosis (arrow). Virtual bronchoscopy cuts were taken at the glottic view above the stenosis (D), at the level of the stenosis (E) and normal trachea after the stenotic segment (F).

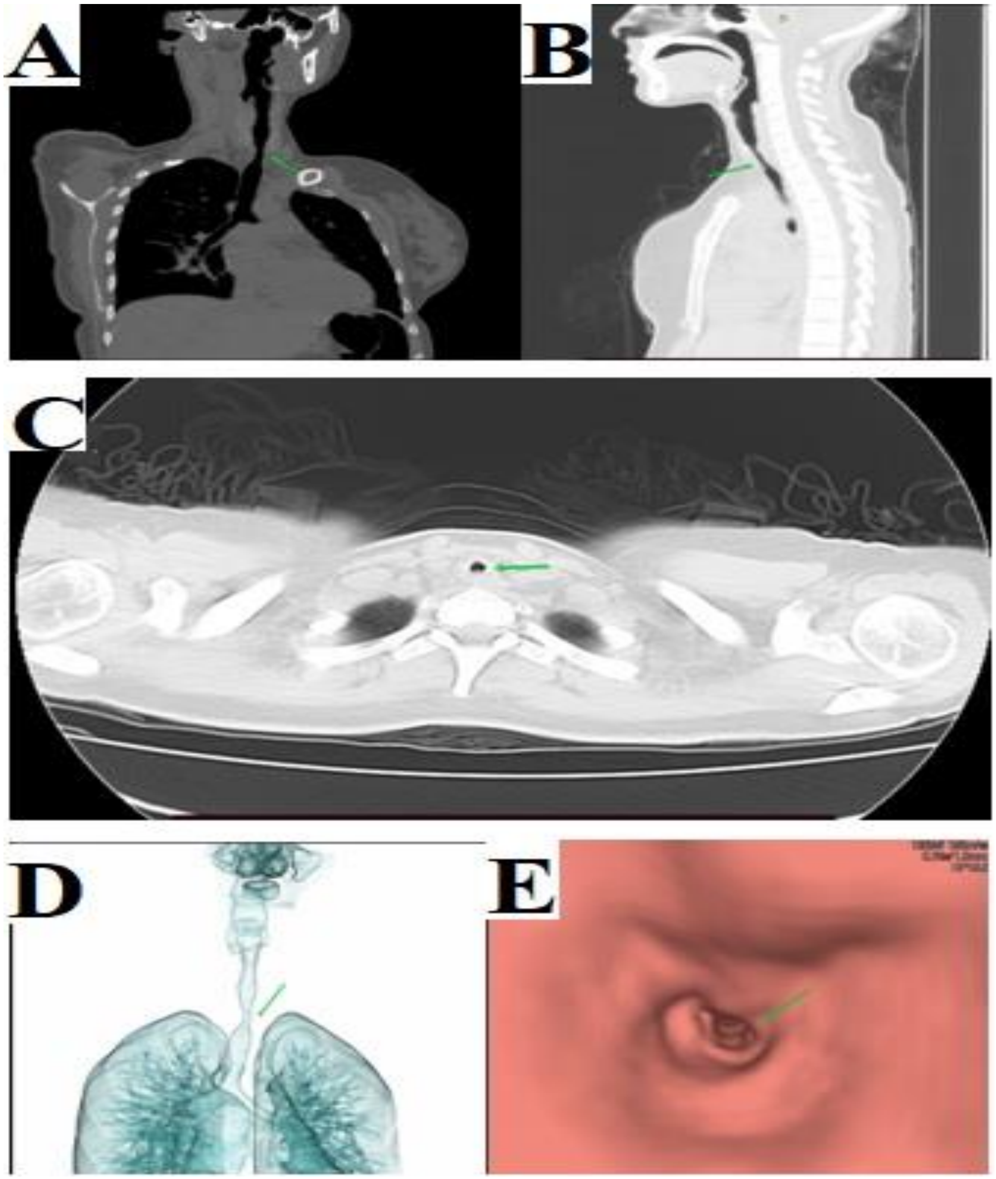

Fig. 2. Case (2) (A) CT image, curved planer reformat CPR ,(B) CT image, sagittal minimum intensity ,(C) coronal minimum intensity of a 20-year-old female patient showing laryngotracheal stenosis (arrow). In this patient the stenotic segment measured 29mm in length and 3mm in diameter at narrowest point. (D) 3D external volume rendering, (E) virtual bronchoscopy at the level of stenosis.

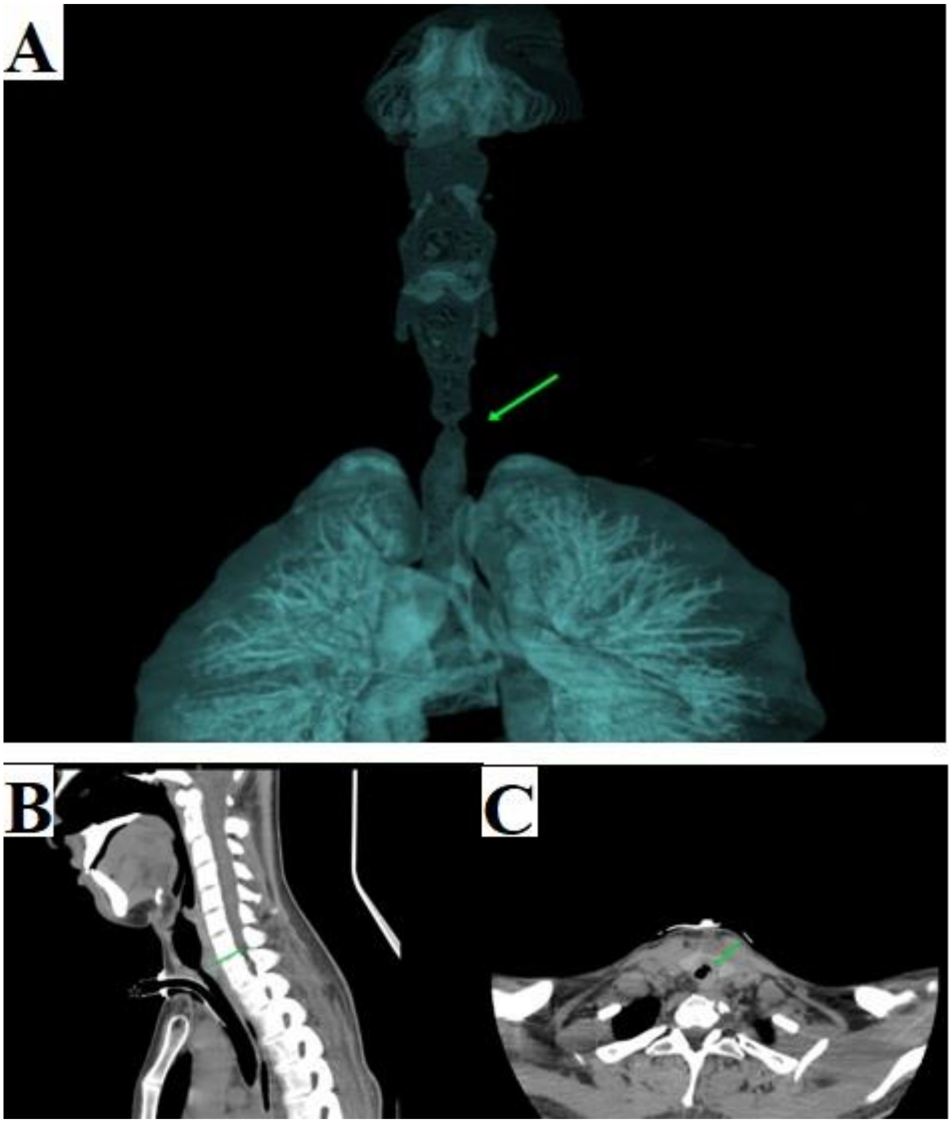

Fig. 3. Case (3) (A) CT- scan of the larynx and trachea for a 24-year-old male patient with subglottic stenosis. External volume rendering view shows the stenotic segment (arrow). (B,C) Multislice CT with sagittal (B) and axial (C) cuts. There is a long segment of proximal tracheal stenosis (arrow) measuring 22 mm of length and 3 mm in diameter at maximum narrowing point. Tracheostomy is noted (star).

DISCUSSION

Due to its capability for direct visualization of the airway lumen, bronchoscopy is regarded as the "gold standard" for the identification and diagnosis of tracheobronchial pathological condition. It enables the direct assessment of respiratory tract mucosal and endoluminal lesions and can direct biopsies for histologic examination. Nevertheless, there are certain technical restrictions with bronchoscopy, such as the incapacity to assess airway morphology and diameter beyond a high-grade stenosis of the bronchial lumen, as well as potentially dangerous consequences in medically critical patients [6].

In contrast, spiral CT allows for quick data collection during a single breath hold and is a well-tolerated procedure for all cases. The obtained images offer comprehensive details about the pathophysiology of the tracheobronchial tree. In addition, CT data-generated 2D and 3D pictures offer more details about airway pathology. Diverse computer processing algorithms, including multiplanar reformatting, shaded surface presentation, maximum or minimum intensity projection, volume rendering approaches, and, more recently, virtual endoscopy, can be added to the CT acquired data [10].

Virtual endoscopy specifically for the tracheobronchial tree is known as VB. It can create views that resemble those from conventional bronchoscopy and is non-invasive. It can be carried out on cases who are unable to endure bronchoscopy and it can assess the airways beyond a high-grade stenosis. Because of the advantages mentioned earlier, computer-generated images are always required for these cases' evaluation [11].

The current study is designed to assess the utility of VB and MPR in preoperative mapping of LTS and compare the results with CB and taking intraoperative data as our reference for evaluation.

This study included 30 patients, all had laryngotracheal stenosis caused by prolonged endotracheal intubation, affecting subglottic and upper trachea. 80% (24 cases) had grade III stenosis while 20% (6 cases) had grade IV stenosis.

The grade III stenosis was circumferential cicatricial stenosis in 20 patients (66.7%) and eccentric cicatricial stenosis in 4 patients (13.3%). The stenotic segment extended from upper half of cricoid to the trachea in 8 patients (26.7%), lower half of cricoid to the trachea in 16 patients (53.3%) and 1st tracheal ring to 4th tracheal ring in 6 patients (20%). The length of stenosis ranged from 1.5 cm to 3 cm (mean 2.1 cm).

Our study included 30 patients, other studies that share similarities with ours in terms of the patient population are El-Naga et al. [12], Morshed et al. [9], and Sun et al. [13] with 26, 37, 32 patients respectively while some studies offered a lower number of patients as Carretta et al. [14] and Taha et al. [15] with 12 and 14 patients respectively.

In our study, the mean age of cases with subglottic and upper tracheal stenosis was 26.2 years. Comparing this to other studies, there is notable heterogeneity in the age distribution. Our study primarily involves a younger population, with a focus on individuals aged between 18 and 45 years. Koletsis et al. [6] focused on a relatively older population, with a mean age of 62.3 years. Carretta et al. [14] reported a range from 16 to 75 years.

Prolonged endotracheal intubation following ICU admission was the only cause for stenosis in our study (100%), similar to our study were Taha et al. [15], Morshed et al. [13] and Carretta et al ‘s [14] cases, who also evaluated only post intubation laryngotracheal stenosis patients. Other studies also had the same cause along with other causes such as Shweel and Shaban [16] included other post-traumatic causes, and Koletsis et al. [6] categorized their cases into tumoral and non-tumoral tracheal stenosis.

Precise assessment of subglottic larynx involvement holds significant importance, as it plays a crucial role in determining the appropriate course of management decisions.

Regarding localization of the site of stenosis, our study showed that there is no significant difference between CT images& virtual bronchoscopy VB and intraoperative findings. As well as no substantial difference between conventional bronchoscope and intraoperative findings.

Similarly, Shweel and Shaban [16] showed 100% sensitivity and accuracy in the site of stenosis detection. Taha et al. [15] reported that concerning identifying subglottic post-intubation tracheal stenosis, the sensitivity and specificity of both CT and conventional bronchoscopy were 100%.

El-Naga et al. [12] also found VB's sensitivity, specificity, and diagnostic accuracy in locating the stenosis site were 100% for all.

On the other hand, Hoppe et al. [17] assumed that VB exhibited a 96.6% specificity, 95.5% accuracy, and 90% sensitivity rate in identifying 32 cases with central airway stenosis. The lower values in these studies can be explained by the use of flexible bronchoscopy as the gold standard for assessment of the airway not comparing their results with intraoperative findings.

Accurate measurement of the stenosis length and the remaining airway is crucial to ascertain whether a sufficient amount of healthy airway is present to perform a well-vascularized and tension-free anastomosis. [14].

Our study showed no statistically significant difference between CT and intraoperative findings as well as no statistically significant difference between conventional bronchoscope and intraoperative findings regarding length of the stenotic segment in post-intubation patients. Taha et al. [15] found that virtual bronchoscopy has a more accurate estimation of length than conventional bronchoscope with diagnostic accuracy 87% to 73% respectively.

Disagreeing with us Carretta et al. [14], which stated that intraoperatively measured stenosis length showed a substantial correlation ($p < 0.001$) with results from rigid, but not with CT scan ($p = 0.08$).

In our study, while grading of tracheal stenosis (lumen diameter) in post-intubation patients using conventional bronchoscope compared to intraoperative measurements a substantial variance ($p= 0.024$) was observed. Conversely, no notable variance ($p= 0.939$) was found in terms of lumen diameter between CT virtual bronchoscopy & MPR in correlation to postoperative grading.

Agreeing with our study, Taha et al. [15] found that when grading LTS, CT measurements are more superior than conventional bronchoscopes because they accurately estimate 93.75% of lesions and allow for precise assessments of the stenotic segment as well as proximal airway segments, and distal airway segments. Bronchoscopy was only able to correctly grade 86% of lesions.

According to Shweel and Shaban [16] in comparison with the intraoperative results, analysis of MDCT (axial, MPR and VB). It revealed 96% sensitivity and 88.8% accuracy regarding stenosis grading. Although their study didn't involve data from conventional bronchoscopy.

We presume that CT virtual bronchoscopy and multiplanar reconstruction (MPR) outperform conventional bronchoscopy in assessing the grade of stenosis in patients with post-intubation laryngotracheal stenosis. This superiority is attributed to the operator-independent nature of CT virtual endoscopy [18]. In the case of virtual endoscopy and MPR, findings are precisely measured using a program ruler. In contrast, conventional bronchoscopy relies on a comparison of stenosis diameter to the diameter of rigid tracheo-bronchoscope [9], lacking the use of any graded tool. This method proves unreliable for obtaining exact measurements in such a confined area, emphasizing the inherent advantages of CT virtual bronchoscopy and MPR in ensuring more precise and consistent assessments.

While our study contributes valuable insights into the accuracy of imaging modalities, it is essential to acknowledge its limitations. The sample size is relatively small, and our focus on only post-intubation stenosis grades III and IV may limit the generalizability of our findings to other causes of airway stenosis.

Certain authors have suggested that the information obtained from a spiral CT scan with MPR and VE could be regarded as an alternative to a direct endoscopic examination. [18,19] and we agree based on our findings. By using this policy, patients can have less morbidity and can be spared an extra anesthetic throughout their evaluation. For patients undergoing endobronchial procedures, CT VE and MPR may also be used in place of traditional bronchoscopy in situations where it is necessary to monitor alterations in the degree of stenosis and subsequent bronchoscopy is uncomfortable for the patient [19,20].

These results suggest that MPR and VE to be used as a first line of inquiry to precisely describe stenotic lesions in terms of duration, grade, and site and to choose the best course of treatment.

In conclusion, our findings revealed that CT virtual bronchoscopy and MPR is an excellent, dependable, and objective method, and can be considered a substitute to conventional bronchoscopic examination. VE with MPR is important in diagnostic assessment and management planning in cases with post-intubation LTS.

While our study contributes valuable insights into the accuracy of imaging modalities, it is essential to acknowledge its limitations. The sample size is relatively small, and our focus on only post-intubation stenosis grades III and IV may limit the generalizability of our findings to other causes of airway stenosis.

Conclusions:

Although conventional bronchoscope offers direct visualization of the lumen and can assess vocal cord mobility, CT multiplanar reformatting and virtual bronchoscopy offer a high fidelity, noninvasive, and repeatable assessment of the LTS. CT VB and MPR were more accurate than conventional bronchoscopy in determining the lumen diameter (degree) of the lesion. These techniques serve as a dependable alternative for patients with postintubation stenosis grades III and IV in preoperative assessment.

Conflict of interest: None

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