Assessment of Laryngeal Ultrasound Feasibility in Evaluating Subglottic Stenosis

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Abstract

Objective: The study was conducted to assess the feasibility laryngeal ultrasound in evaluation of subglottic stenosis as regard diameter, length and nature of the stenotic segment.

Subjects and Methods: This study included 26 patients with age ranging from 17 to 58 years, who had subglottic stenosis diagnosed by endoscopy and computed tomography (CT). The relationship between superficial laryngeal ultrasonography (US) and endoscopic grading of subglottic stenosis (as regard diameter) and CT grading (as regard length) were assessed. In 13 cases that required surgical intervention, the tissue nature of the stenotic segment was assessed both by US and direct endoscopy. US, CT and fibreoptic endoscopic evaluations were also performed for ten controls.

Results: The same grade score was interpreted in US and endoscopy in 23/26 patients (88.5%). The grading score by US as regard length was the same that has been interpreted by CT in 21/26 (80.7%). The nature of the stenotic segment was found to be the same in 12 out of those 13 operated patient (92.3%).

Conclusion: Superficial laryngeal US is a reliable, safe, non invasive diagnostic imaging tool to evaluate diameter, length, and nature of subglottic stenosis.

Key Words: Ultrasound – Subglottic stenosis – Endoscopic examination.

Introduction

SUBGLOTTIC stenosis is a type of laryngeal stenosis that occurs below the glottis and above the first tracheal ring [1]. It may be congenital or acquired. With congenital subglottic stenosis, varying degrees of stridor are usually present after birth. The stridor becomes worse as child grows, and is precipitated when there is an upper respiratory infection [2].

The most common causes of acquired subglottic stenosis are prolonged intubation and tracheostomy, especially a high tracheostomy. Other causes include tumors, inflammatory conditions, cricoid fractures, burns or ingestion of caustic substance [3].

Diagnosis of subglottic stenosis can be made easily by conventional radiography and computed tomography (CT). Ultrasonography (US) is an appealing technique for this purpose [4,5].

Among children and adults, the transverse diameter of the trachea in the neck can be visualized by US. In contrast, the anteroposterior diameter cannot be assessed because the acoustic shadow generated by the air column obscures the location of the posterior wall, while the sides of the ring are easily visualized in both sagittal and transverse planes [6,7].

The aim of this study was to assess the feasibility of laryngeal superficial US in evaluation of subglottic stenosis as regard diameter, length and nature of the stenotic segment.

Patients and Methods

This study was conducted in the Department of Otorhinolaryngology Head and Neck Surgery and Radiodiagnosis Departments, Zagazig University Hospitals over the period from August 2010 to May 2012. Twenty six patients with age ranging from 17 to 58 years who were diagnosed with subglottic stenosis have been evaluated by US, CT and endoscopy (patient group). Additionally, ten controls who required thyroid gland assessment for other purposes were similarly evaluated (control group).
All patients included in the study had previous history of endotracheal intubation in the Intensive Care Unit (ICU). Tracheostomy was also performed in 18 patients. Thirteen patients presented with stridor interfering with their daily activities and required surgical intervention. History taking as well as full general and ototrinolaryngological examination were performed for each case included in the study.

Exclusion criteria were the presence of active inflammatory process of the airway or the presence of endotracheal tube or laryngotracheal stents since their presence is known to interfere with appropriate US evaluation.

Video laryngoscopy:
Diagnosis of subglottic stenosis was documented by video laryngoscopic examination either by flexible fiberoptic endoscopy or rigid endoscopy under general anesthesia for assessment of subglottic stenosis. This procedure was digitally recorded for purpose of interpretation.

The stenosis diameter was graded according to the Myer-Cotton criteria [8]:
- Grade I: Obstruction of 0-50% of the lumen obstruction.
- Grade II: Obstruction of 51-70% of the lumen.
- Grade III: Obstruction of 71-99% of the lumen.
- Grade IV: Obstruction of 100% of the lumen (no detectable lumen).

During surgery of the thirteen operated patients in the study group, the nature of stenotic segment was assessed by palpation, biopsy and histopathological examination.

CT technique and interpretation:
CT of the neck (axial and sagittal cuts) was performed for every patient in the study group. The McCaffrey [9] system was used to classify the stenosis based on the length of the stenosis. Four stages were described: Stage I lesions are confined to the subglottis and less than 1cm long, stage II lesions are isolated to the subglottis and greater than 1 cm long, stage III are subglottic/tracheal lesions not involving the glottis, and stage IV involve the glottis.

US technique:
All patients were subjected to laryngeal high resolution superficial US using a Pro Focus GE ultrasound LOGIO 3 USA equipped Expert machine with small linear probe of 6-12 MHZ frequency and with a high resolution monitor and thermal page printer. Laryngeal US was done while the patient was lying in supine position with the neck slightly extended. The patient was instructed to take slow inspiration at constant flow to avoid respiratory-induced changes in the upper airway dimensions. Gel was then applied on the examination linear probe. External identification of the thyroid cartilage was done and the examination started by placing the probe transversely on the mid part of the thyroid cartilage. The probe moved upward and downward until the imaging of the subglottic region was obtained.

US findings were recorded then interpreted by the authors. The relationship between US and endoscopic Myer-Cotton [8] grades, and CT McCaffrey [9] grades of subglottic stenosis was analyzed. Additionally, the nature of stenotic segment reported by US was compared to that documented during surgical intervention.

Results
Of the 26 patients included in this study, 21 were males (87.5%) and 5 were females (12.5%). The age ranged from 17 to 58 years with a mean age of 34 years (Table 1).

Table (1): Sex and age distribution the study.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>26</td>
</tr>
<tr>
<td>Gender:</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>21 (81.8)</td>
</tr>
<tr>
<td>Female</td>
<td>5 (19.2)</td>
</tr>
<tr>
<td>Age (years):</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>34 years</td>
</tr>
<tr>
<td>Age range</td>
<td>17 to 58 years</td>
</tr>
</tbody>
</table>

The relationship between US and endoscopic grading scores is summarized in Table (2). The same grade score was found in US and endoscopic grading in 23 (88.5%) patients (Figs. 1, 2). Conversely, US reported a one grade lower than that found by endoscopy in three patients (11.5%). All subjects in the control group had normal subglottic diameter on US examination. Accordingly, sensitivity of US was 88.5%, specificity was 100% and accuracy was 91.7%.
The relationship between US and CT grading scores is summarized in Table (3). The same grade score was found in US and CT grading in 21/26 (80.7%) patients. Conversely, US reported a one grade different than that found by endoscopy in five patients (19.3%) (Fig. 3). All subjects in the control group had normal subglottic area on US examination. Accordingly, sensitivity of US was 80.7%, specificity was 100% and accuracy was 86.1% (Table 4).

Of the thirteen patients undergoing surgical intervention, the nature of stenotic segments was found by inspection and palpation to be fibrous tissues in 8 cases and nonspecific granulation tissue in 5 cases. US reported the same nature in all but one patient (92.3%).

<table>
<thead>
<tr>
<th>Number (%)</th>
<th>Endoscopic grading score</th>
<th>US grading score</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 (46.1)</td>
<td>Grade I</td>
<td>Grade I</td>
</tr>
<tr>
<td>2 (7.7)</td>
<td>Grade II</td>
<td>Grade I*</td>
</tr>
<tr>
<td>8 (30.8)</td>
<td>Grade II</td>
<td>Grade II</td>
</tr>
<tr>
<td>2 (7.7)</td>
<td>Grade III</td>
<td>Grade III</td>
</tr>
<tr>
<td>1 (3.85)</td>
<td>Grade III</td>
<td>Grade II*</td>
</tr>
<tr>
<td>1 (3.85)</td>
<td>Grade IV</td>
<td>Grade IV</td>
</tr>
</tbody>
</table>

Total: 26

*US reported a one grade lower than that found by endoscopy.
Laryngeal Ultrasound in Subglotic Stenosis

Table (3): CT and US grading scores for subglottic stenosis length.

<table>
<thead>
<tr>
<th>Number (%)</th>
<th>CT grading score</th>
<th>US grading score</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (69.2)</td>
<td>Grade I</td>
<td>Grade I</td>
</tr>
<tr>
<td>2 (7.7)</td>
<td>Grade I</td>
<td>Grade II*</td>
</tr>
<tr>
<td>1 (3.85)</td>
<td>Grade II</td>
<td>Grade I*</td>
</tr>
<tr>
<td>2 (7.7)</td>
<td>Grade II</td>
<td>Grade II</td>
</tr>
<tr>
<td>1 (3.85)</td>
<td>Grade II</td>
<td>Grade III*</td>
</tr>
<tr>
<td>1 (3.85)</td>
<td>Grade II</td>
<td>Grade II</td>
</tr>
<tr>
<td>Total: 26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*US reported a one grade different than that found by CT.


<table>
<thead>
<tr>
<th>US grading</th>
<th>Sensitivity</th>
<th>Specify</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>88.5%</td>
<td>100%</td>
<td>91.7%</td>
</tr>
<tr>
<td>**</td>
<td>80.7%</td>
<td>100%</td>
<td>86.1%</td>
</tr>
</tbody>
</table>

Discussion

Subglottic stenosis is narrowing of the airway below the true vocal cords and is either congenital or acquired. Subglottis is the area lying 10mm inferior to the anterior commissure and 5mm inferior to the posterior commissure [10].

Because of multiple associated comorbidities and varied etiologies, subglottic stenosis remains a challenging disease for otolaryngologists to diagnose and treat [11]. The primary difficulty for the surgeon is demonstrating the diameter and length of the stenotic segment.

Direct endoscopy and CT scanning were considered the preferred methods for subglottic stenosis assessment [12]. However, during laryngoscopy, the exact extension of laryngeal lesions can sometimes be hard to assess as in non penetrated subglottic stenosis (e.g. Myer-Cotton [8] grade IV). Thus, laryngoscopy alone may not be sufficient in some cases. For this reason, CT is often used to supplement laryngoscopy as an additional tool in the estimating laryngeal pathologies [13]. However, CT has many limitations as CT is not portable, cannot be used in pregnancy, cannot accurately define nature of lesions, and needs patient immobility.

US was reported to be helpful in assessment of the upper airway diameter before endotracheal intubation and to assess laryngeal stenosis after prolonged tracheal intubation [5,14]. Moreover, Lakhalk et al., [5] reported that laryngeal US was feasible in examination of the larynx in infants and children since it did not require strict immobility as opposed CT scans.

In current study, subglottic stenosis occurred after endotracheal intubations and/or tracheostomy which were reported to be the most common causes of adult subglottic stenosis in the modern era [10].

On evaluating the diameter of the subglottic stenosis, we have found that both US and endoscopy scores were the same in 23 out of 26 patients (88.5%), and this reflects the reliability of US in assessment of subglottic stenosis (Table 3). As regard length of the subglottic stenotic segments, both US and CT have also categorized the same grade in 21 out of 26 patients (80.7%).

The region of stenosis may involve soft tissue scaring, granulations, or cartilage remodeling [11]. In this study, US was able to correctly detect the nature of the lesion when compared to operative findings in most cases (92.3%).

Our results reflect the great value of laryngeal US in evaluating cases of subglottic stenosis since it can give a reliable and valuable data about the diameter and length of the stenotic segment besides its nature. The findings support the use US in evaluation of subglottic stenosis. In fact US, is highly useful in certain situations. It is well known that not all patients can tolerate the rigid laryngoscope especially those with limitation of jaw or neck mobility or patients suffering from stridor. It is also difficult in most infants and children [15,16].

US is a noninvasive modality and is available at almost all institutions. It can be also used safely during pregnancy, is portable, and can be easily transferred to patients with difficult mobilization.

The current study shows that US provides nearly full data for the subglottic stenosis (diameter, length and nature). However, it has to mentioned that endoscopy remains the gold standard method to diagnose and visualize surface characteristics of stenotic segments such as irregularity, keratosis, mucosal cover, and blood vessels pattern under magnification.

Conclusion:

US is a reliable, safe, non invasive diagnostic imaging tool to evaluate cases of subglottic stenosis as regard diameter, length and also nature of the stenotic segment.


References


