Abstract: Computerized Volumetric Analysis Systems (CVAS) can be used to create a stereoscopic virtual tour of a patient’s airway anatomy using the information from standard fine cut computed tomography images. This has been useful to both otolaryngologists and anesthesiologists for intubation and interventional planning. Preoperative characterization of the location, length, and degree of stenosis can have a significant impact on the selection of the endotracheal tube. Identification of additional distal lesions, the need for thoracic surgical assistance, and the custom tailoring of tracheal stents should all be determined prior to any intervention. This information can easily be obtained from 3D reconstruction of standard CT imaging without the risk of sedation or procedural complication, and can be invaluable in patients unable to tolerate awake tracheoscopy. Methods: We present 23 patients with the presence of laryngotracheal stenosis that were preoperatively evaluated by the Department of Otolaryngology and Anesthesia in a multidisciplinary approach using three-dimensional (3D) CT volumetric rendering and endoscopy. Results: Volumetric rendering supplemented the evaluation with the following data: presence of multiple stenotic lesions in 6 patients (26%), the search for additional strictures in 15 (65%), preoperative determination of resection length in 10 patients (44%), and the precise location of distal stenosis in 4 patients (17%). All patients were additionally evaluated using 3D-CT preoperatively for endotracheal tube diameter and length. Conclusion: This investigation demonstrates the ability to noninvasively establish landmarks and metrics that preoperatively characterize the complex airway thereby affecting endotracheal tube selection and surgical intervention.

Background

Throughout the past decade the introduction of rapid, multi-detector CT has made it possible to image the upper, central, and segmental airway better than before. High resolution CT data can be processed into three-dimensional (3D) depictions to create virtual bronchoscopic renderings that resemble actual images obtained from endoscopy. This new 3D imaging has been increasingly applied for the evaluation of the airway to detect both benign and malignant disease and numerous studies have compared the efficacy of virtual bronchoscopic images with axial CT slices, coronal reformatted images, and sagittal images. The 3D noninvasive imaging has produced images that accurately depict stenoses with both high sensitivity and specificity minus the associated discomfort and risks associated with endoscopy. In addition 3D imaging can provide additional information regarding the extraluminal extent of disease and may in fact be superior in the assessment of airway patency distal to high-grade stenoses. In close collaboration with the Department of Anesthesia, we offer a noninvasive mechanism for preoperative evaluation of patients with known complex laryngotracheal anatomy in order to best characterize disease severity and to determine both operative and anesthetic plans prior to entering the operating room.

Materials and Methods

We present data obtained from all patients seen and evaluated by the senior authors from the Departments of Otolaryngology (TM) and Anesthesiology (WB) at the University of Maryland School of Medicine (UMSOM). Between 2000 and 2010, 23 patients had at least one stenotic segment involving the larynx proximally down to the level of the carina. Flexible tracheoscopy was performed in the clinic as well as in the operating room on all patients. CT scans were obtained on a multi-detector Philips 64 slice CT. Both three-dimensional surface and volume renderings were performed with AQNET version 1.6.2 (Terracene, San Mateo, CA). Imaging and endoscopic data were reviewed pre and postoperatively.

Results:

Between the dates of evaluation, 23 patients with complex airway anatomy were seen and evaluated preoperatively. Operations generally including dysphonia and hoarseness. Following an endoscopic examination and subsequent 3D CT included: tracheal stenosis in 16 patients (71%), subglottic stenosis in 5 patients (21%), posterior glottic web in 2 patients (9%). 3D CT imaging was found to supplement evaluation by providing the following: the presence of multiple stenotic lesions in 6 patients (26%), the ability to search for additional strictures in 15 patients with subglottic stenosis (65%), preoperatively determining resection length in 10 patients with severe stenosis (44%), and the absolute location of distal stenosis in 4 patients (17%) possibly requiring thoracic surgical involvement. All patients were reviewed with anesthesiologist preoperatively for optimal ETT selection.

Discussion

Multidetector CT virtual bronchoscopy has proven to be a reliable noninvasive method that allows accurate grading of tracheobronchial stenoses with comparable sensitivities and specificities for central airway disease. Volume rendering can be used for realistic depiction of the airway and provides information that is comparable to flexible bronchoscopy in assessing the precise length of a stenotic segment. In patients with high-grade stenosis that prevent passage of the endoscope, virtual bronchoscopy enables evaluation of the airway distal to the segment. Although all patients were evaluated in the ENT clinic with flexible tracheoscopy, the ability to visualize the larynx and trachea in its entirety was limited by patient tolerance. We found in numerous cases the additional information provided by 3D CT prepared us for an optimal resection length in 10 patients (44%), and the precise location of distal stenosis in 4 patients (17%).

Conclusion:

Laryngotracheal stenosis is a complex surgical disease that often occurs in critically ill patients. Maximizing preoperative and preinterventional data is essential to minimizing perioperative risk. Three-dimensional CT data is noninvasive and provides useful data to supplement the characterization of stenotic disease without procedural discomfort or risk. It permits the otolaryngologist to preoperatively determine the precise character of stenosis and plan accordingly for optimal resection or custom stent selection. Anesthesiologists can use this data to formulate a plan and select the ideal endotracheal tube for a complex airway prior to entering the operating room. The use of 3D volumetric CT data can in no way replace flexible bronchoscopy and bronchody by but provides important information in a risk-free manner to optimize patient safety and operative intervention.

References: