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Effect of probe rotation and position on in vivo OCT imaging of the neonatal airway

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Abstract

Subglottic stenosis continues to be a diagnostic challenge for clinicians, especially in neonates, whose airways can be as small as 2 mm in diameter. Optical coherence tomography has been investigated as a less invasive and thus potentially safer method of imaging the neonatal airway. However, imaging quality and ultimately, diagnostic accuracy, can be impacted by probe positioning and rotation.

Introduction

Subglottic stenosis, or the narrowing of the upper airway, can result in respiratory distress and can be life-threatening. Neonates' small airways are particularly susceptible to subglottic stenosis, especially if they undergo prolonged intubation. Previous studies have investigated the use of optical coherence tomography (OCT) as a safe and noninvasive imaging modality to analyze the thickness of the laryngotracheal airway wall in neonates over time during intubation. However, there exist limitations in the quality of OCT images acquired in the airway and therefore the translatability of the data to clinical measures. This study examines the impact of probe positioning and rotation on the quality of images taken in vivo in the neonatal airway.

Methods

An in-lab-built OCT system was used in conjunction with a flexible fiber optic probe with gradient refractive index (GRIN) lens of 0.5 mm OD to capture cross-sectional images in a neonatal airway. This study was approved by the human subjects Institutional Review Board at the University of California, Irvine. All subjects' families provided written informed consent for

participation. Encased in a sterilized plastic sheath, the probe entered the patient's airway via the endotracheal tube (ETT). The probe continuously rotated as it was pulled superiorly through the trachea and larynx at a constant rate.

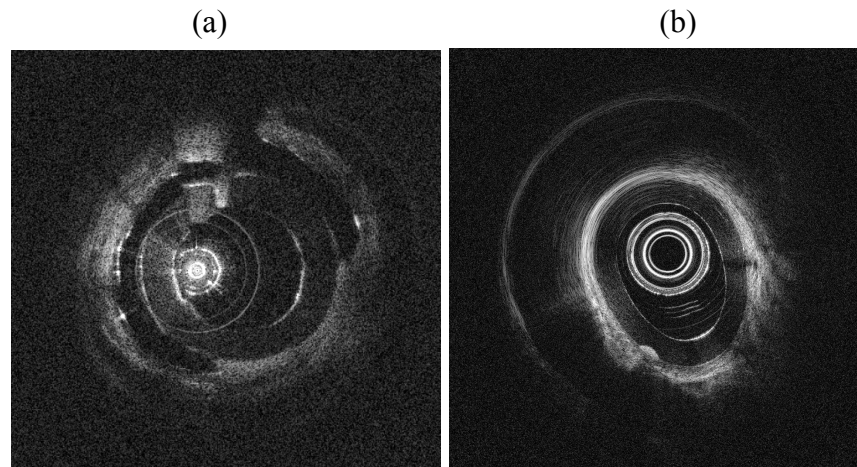


Figure 1. OCT images acquired from neonatal airway.

Results

The images showed a stronger signal on the side of the airway that the probe was closer to, resulting in nonuniform illumination of the airway (Figure 1a). On some images, there was also apparent shape distortion shown by the elliptical visualization of the circular ETT (Figure 1b).

Discussion

The ETT generally maintains a concentric position relative to the airway because its outer diameter is roughly equivalent to the inner diameter of the airway. However, our probe's outer diameter is smaller than the ETT's inner diameter, leaving open space that allows for airflow to travel through the ETT. While this is essential for successful mechanical ventilation to continue during imaging, it also results in non-uniform probe positioning. Further, due to the J-shaped curvature of the airway, the probe does not stay concentric to the ETT as it travels from the oral cavity to the trachea. The resulting signal is stronger on the side of the airway that the probe is closer to. The non-circular ETT is an artifact of non-uniform rotation resulting from friction of the probe against the sheath as it travels through a curved pathway.

Conclusion

OCT is a noninvasive and non-radioactive imaging technology that can be used to image neonatal airways and to quantify the geometry of the laryngotracheal layers, making it easier to assess injury from intubation and properly diagnose patients. To consistently achieve high-quality images, future experiments can investigate more comprehensive methods to keep the probe concentric to the airway during image acquisition.

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