Development of a Device for Magnetically Guided Intubation

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Introduction: Although direct laryngoscopy is a reliable method for endotracheal intubation, there are situations when direct visualization of the vocal cords may be difficult or impossible. For example, if blood or gastric secretions have compromised the airway, it may be impossible to visualize the vocal cords using any optical means. Another method of endotracheal intubation involves using a lighted stylet. The light transilluminates through the tissues of the anterior neck to help guide the endotracheal tube into the trachea. This technique can also be useful in the setting of suspected or known neck injury, where neck manipulation should be avoided. Despite its benefits, the transillumination technique does have some limitations, which include 1) need for a dark or dimly lit environment, 2) impaired transillumination in obese patients with significant redundant neck tissue, and 3) impaired transillumation in patients with darkly pigmented skin. To overcome these limitations, a device was developed that detects and visually represents the location of a magnetic intubation sylet and helps guide the stylet into the trachea via magnetic field sensing.

Methods: A prototype device was designed, built, and tested. The device was developed on a flexible PCB, such that the apparatus could easily conform around the anterior neck. The device has an array of Hall sensors capable of detecting the magnetic field produced by an external magnet that is incorporated into the tip of the intubation stylet. An array of accelerometers is also incorporated into the device, such that the neck circumference (and thus expected tracheal depth) could be determined and the device could auto-calibrate in real-time. A microcontroller aggregated sensor data and controlled a series of LEDs that visually represented the location and depth of the magnetic intubation stylet. The device was tested on an intubation mannequin.

Results: A prototype device was successfully developed and tested in a simulation environment. The visual LED-targeting array accurately represented the 3-dimensional location of the intubation stylet. The intubation stylet could be guided into the trachea using the magnetic guidance system. Ambient room lighting, skin tone, or neck size did not affect guidance.

Conclusion: A novel method for endotracheal intubation using magnetic guidance was developed. This technique potentially offers several advantages over conventional intubation techniques, which include: 1) insensitive to blood or other fluids in the airway, 2) neck manipulation is not required, 3) not affected by ambient room lighting, 4) not affected by skin tone, and 5) not affected by neck size. Future studies will aim to optimize the firmware and incorporate additional sensing modalities to further increase the reliability of the guidance system.