Executive Summary: Tong BME Design Award, BME 301

Neonatal Intubation Simulation with Virtual Reality and Haptic Feedback

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Respiratory distress syndrome (RDS) is characterized by difficulty breathing and is the leading cause of death for newborns (“Respiratory Distress Syndrome”, 2018). In the U.S. in 2015, infant mortality rates were nearly 6%, with 13.4% of those deaths attributable to RDS (“"Infant Mortality”, 2018). Around 7% of infants experience respiratory distress worldwide, with domestic rates closer to 1% (Reuter et al., 2014). Given the current state of medical technology, these numbers seem surprisingly high.

Currently, RDS is treated via a variety of methods including surfactant replacement therapy, oxygen therapy, and breathing support from a nasal continuous positive airway pressure (NCPAP) machine. For each of these methods, it is often required that a neonatal intubation procedure be performed ("Respiratory Distress Syndrome (RDS)”, 2018). While each method is accompanied by its own difficulties, neonatal intubation is a challenging procedure to perform. Neonatal intubation must be performed quickly, precisely, and gently. Failure to comply by these guidelines can result in suffocation, tissue damage, or even head trauma ("Neonatal Tracheal Intubation", 2016). According to a variety of studies, neonatal intubation attempts are often unsuccessful, especially among residents. One study listed success rates of resident intubations as low as 24%, while that of fellows and consultants was closer to 80% (Kumar et al., 1996).

Current methods are mainly restricted to video demonstration and intubation practice on neonate mannequins (O’Shea et al.,2018). Based on the low success rates in residents, it is obvious that these methods are not sufficient, and effective training comes primarily from experience. Due to the high risk nature of the procedure, it is preferred that physicians are able to perform this procedure correctly on their first attempt. Thus, it would be extremely beneficial to develop more effective and accessible training methods that could improve patient outcomes.

Virtual reality (VR) is an emerging tool in clinical medicine with functionalities ranging from medical training to pain management (Pourmand et al., 2017). Current methods are usually limited to VR alone, but 3D Systems produces cutting edge simulations which incorporate haptic feedback devices (“3D Printers…”, n.d.). The use of haptic feedback motor arms allows developers to give virtual objects apparent physical properties by providing force feedback when an individual “touches” an object in virtual space with the motor arm stylus. VR with haptic feedback provides a possibility to create a wide variety of advanced medical training methods, which will allow for the development of realistic and effective medical training. Haptic feedback has already been successfully implemented in laparoscopy (Pinzon et al., 2016) and prostatectomy (“Radical Prostatectomy”, n.d.) procedures, and is rapidly expanding as a tool to train prospective clinicians. In summary, VR with haptic feedback is already on its way to reduce medical training costs, improve patient outcomes, and advance medical treatments.

We have set out to simulate a neonatal intubation procedure which incorporates a haptic feedback device. This is a long term project which we plan on continuing through several semesters. We spent the semester researching and testing haptic devices, and have decided which device we will purchase. In the meantime we have began creating a proof of concept environment which we will use to simulate the procedure, including an operating room with realistic surroundings and acoustics.