# Augmented Reality for Teaching Endotracheal Intubation: MR Imaging to Create Anatomically Correct Models

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*Clinical procedures have traditionally been taught at the bedside, in the morgue and in the animal lab. Augmented Reality (AR) technology (the merging of virtual reality and real objects or patients) provides a new method for teaching clinical and surgical procedures. Improved patient safety is a major advantage. We describe a system which employs AR technology to teach endotracheal intubation, using the Visible Human datasets, as well as MR images from live patient volunteers.*

**INTRODUCTION** Traditionally, clinicians learn medical procedures by exposure to a large volume of patients, practicing on the newly dead, and by using cadavers, animals, and plastic mannequins. This brings up issues of ethics as well as patient safety and random case-mix scenarios. The AR training system includes a head mounted projection device (HMPD), a Human Patient Simulator (HPS) mannequin, and a Linux based PC for image generation. An optical tracker locates the movements of operator, HPS and endotracheal tube by means of tracking probes.

**METHODOLOGY** The Visible Human Male dataset was used for segmentation and reconstruction of key anatomy involved in endotracheal intubation: trachea, larynx, mandible and vocal cords. The Visible Human cadavers were not frozen in a "tracheal intubation-correct" position, therefore virtual and physical 3D models were created. The "phantom" physical models correspond exactly to the virtual models. We used MR scans of the larynx of one volunteer as a pilot study. The MR scanner used was the Phillips INTERA Gyroscan 1.5T. Images were acquired using 3D fast field echo during several scanning sessions with the built in body coil. A sagittal view from head to upper chest was used in order to determine the ideal head and neck position for intubation. We obtained four final MR images, three incorrect (hyperflexion of the neck, hyperextension and neutral), and one correct ("sniffing position," or slight flexion of the neck and extension of the head). Correct or incorrect positions were determined visually by the relative patency of the airway passage from oropharynx to trachea. We then rearranged the Visible Human virtual 3D scene, that in the original dataset, did not represent the "intubation-correct" position, to depict the mandible and trachea in the correct intubation position.

**PRELIMINARY CONCLUSIONS** We learned that it was nearly impossible to achieve a perfect "sniffing position". In addition, using photographs of the subject on the MR table, we discovered that the position of the head and neck on the table did not correlate well with the MR image of the larynx. Simple extension of the neck was almost as good a position to open up the larynx as the "sniffing position". Hyperflexion of the neck was the worst position for airway patency.

Our next step is to use the rearranged Visible Human 3D scenes to 1) generate images of the airway for superimposition in the AR scenario, and 2) for creation of a more anatomically correct, flexible latex HPS (with structures made of materials reflecting the true elasticity of the tissue). In addition, we need to create a study to demonstrate the validity of this system.

We look forward to the continued development of AR technology, which will allow real-time integration of haptics, along with improved graphics and optics. We envision the use of AR technology in the future, not only to teach basic clinical procedures, but also to provide refresher courses for experienced clinicians, and for patient-specific imaging in general surgery, tumor location and for minimally-invasive procedures.

We wish to make clear that we do not advocate dispensing with the tradition of medicine being taught in real time by seasoned practitioners. The AR system is envisioned as supplementary to, not a replacement for, current methods of training.