Smart Anatomical Airway Training Modules Conformable Sensor Technology

7-SIGMA, Inc UMN SimPORTAL CREST

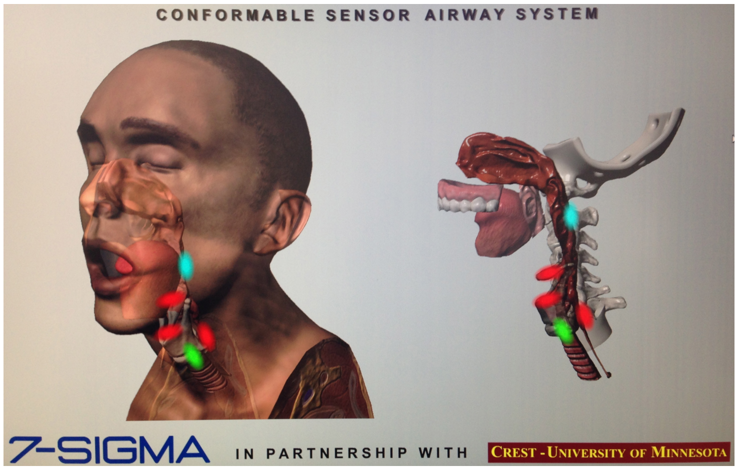

FIG 1. Sensor location and response to forces applied to airway model.

INTRODUCTION

Smart Anatomical Reproductions (SAR) utilizing Conformable Sensor Technology are being developed for medical training. These newly developed SAR training modules exhibit realistic fidelity with digital measurement output for educational assessment. Airway intubation training is enhanced with SAR modules by providing measured force feedback to the trainee in critical areas of the intubation procedure. Realistic fidelity of the esophagus model is accomplished by creating rubber models from digitized Nuclear Magnetic Resonance (NMR) and Computer Aided Tomography (CAT) scan images. 3D printing of tissue or skeletal components of the airway are used to construct rubber molds of the anatomy. Realistic physical properties of the tissue can be applied to the material properties of the rubber model for enhanced realism. Conformable sensors are applied, composed of the same rubber that is used in the model, providing stress force measurements induced during the training exercise. The measurement information from each sensor is displayed in a graphical display and output into a CSV formatted executable file for training evaluation purposes. Educational metrics would then be applied to evaluate the student's performance for the learning exercise.

Device design and development incorporates many disciplines spanning technical, artistic and educational arenas. Medical imaging technologies, coupled with the artist's eye, provide realistic models for the medical training experience. Tissue material properties are measured and characterized as the foundation for the rubber material properties to better emulate real tissue. The sensor measurement and recording of the forces applied to the model give the educator the assessment tools necessary to change the assessment from an judgmental observation of correct procedure to a quantifiable metric of correct procedure performed.

Realistic sensory perception and physical response of the material is important in the training experience. The conformable sensor technology integrates seamlessly into the realistic model, providing tensile and compression force measurements from micro-Newton to hundreds of Newtons from a single sensor design. This wide range of force measurement capability from a single sensor, enhances the fidelity and the educational aspect of the SAR airway model.

DEVICE DESCRIPTION

The esophagus airway training module is manufactured of silicone rubber that is molded with molding forms derived from NMR and CAT scans. The silicone rubber used may be a room temperature vulcanized (RTV) rubber or a two part Platinum cured liquid injection (LIM) rubber. LIM rubber is preferable for its rapid curing, lending to volume production capabilities. The conformable sensors, developed for medical device applications by 7-SIGMA, are integrated into the SAR. The models are manufactured with the same LIM rubber used in the sensor construction, providing real "feel" and response to the deformation forces generated by the insertion of a medical device, such as a laryngoscope, into the airway model. Sensors are placed at critical locations within the esophagus wall and within critical components of the airway. Locations are at the ***throat, epiglottis, vocal cords, trachea and esophagus***. Figure 1 shows an airway training model with a graphical display of the sensor's output at those locations. In this display the color brightens depending upon the force exerted.

The forces applied to the esophagus by inflation of a balloon, expand the trachea wall in proportion to the air pressure inflating the balloon. Figure 2 shows the sensor response, embedded within the trachea wall, to the expansion of the balloon within the trachea. The 2nd order polynomial plot describes the elliptical expansion of the trachea tube by the expanding balloon. From the sensor response, determination can be made as to the proper inflation, location, and functionality of the medical balloon device within the trachea. Figure 3 shows the response of the conformable sensor to excessive compressive forces that may be applied to tissue at the throat or on the epiglottis.

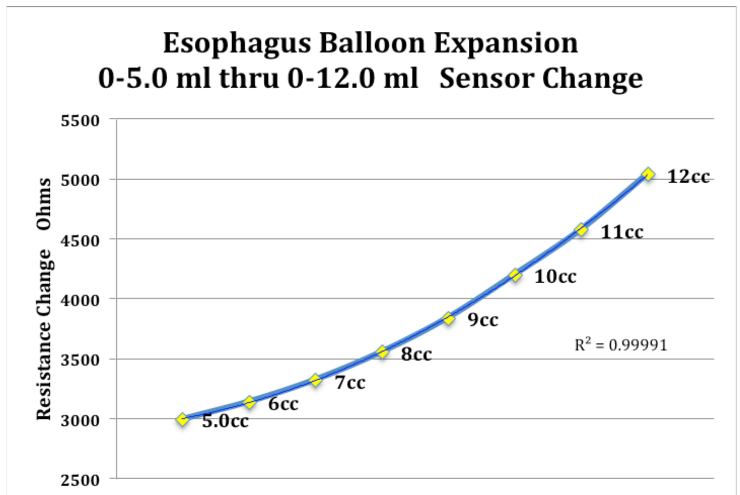

FIG 2. Sensor response, given in resistance change (Ohms), to the volume of air inflating the balloon device within the trachea of the training model.

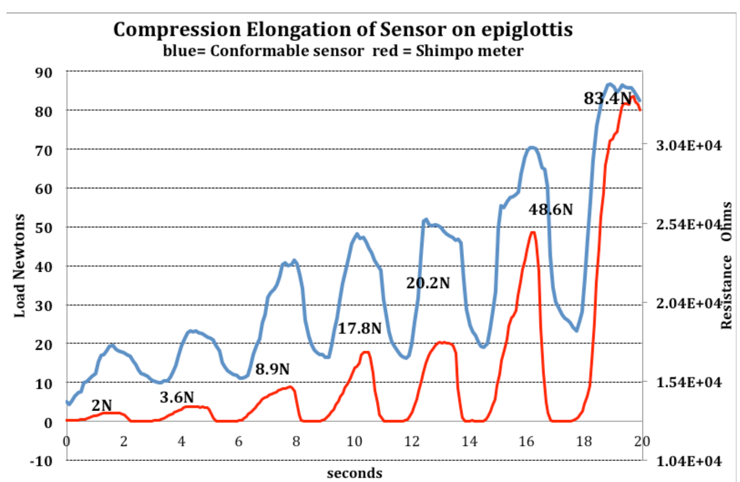

FIG 3. Sensor response, given in resistance change (Ohms), of compressive force against the throat or epiglottis of the model.

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