QUANTITATIVE ASSESSMENT OF ASPIRATION: A NOVEL PORCINE MODEL

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Introduction

• Ventilator associated pneumonia (VAP) in the intensive care setting is often due to pulmonary aspiration.
• Current techniques for reducing aspiration in these patients include elevating the head of the bed, frequent suctioning of secretions and antimicrobial prophylaxis.¹
• At present, it is difficult to develop and test novel methods of reducing aspiration because bench top models have not captured the complex dynamics of the human (trachea and animal models have only looked at indirect markers of aspiration (i.e. tissue inflammation on histopathology or macrophages on bronchial alveolar lavage) or static points in time (i.e. detection of methylene blue dye in lungs after placement in the oropharynx).²³

Purpose

• To create a novel animal model for the quantitative assessment of aspiration based on pH monitoring. We wanted to develop a model that was easily reproducible and provided a continuous real-time assessment of aspiration.

Methods

• Institutional ethics approval for animal research was obtained.
• N = 5 sus scrofa piglets. Mean weight = 18.6 ± 1.5 kg (range 16-20 kg).
• Piglets were positioned supine on a table in reverse Trendelenburg and placed under general anesthesia (Figure 1).
• Figures 2-11 delineate the experimental protocol.

Results

• Prior to the introduction of vinegar(pH=2.7), the mean voltage was 916.6 ± 24.5 mV (range 891.0 - 945.7 mV). After deflation of the ETT cuff (i.e. introduction of vinegar) the mean voltage drop was 419.3 ± 32.6 mV (range 368.9 - 465.3 mV).

Discussion

• This aspiration model detected a drop in pH (mean voltage drop = 419.3 ± 32.6 mV) following intratracheal aspiration of an acidic solution in all 5 experimental animals, proving that results are reproducible.
• Using ventilated live animals simulates the complex dynamic movements of the human airway better than previous static bench top models and dynamic animal studies looking only at indirect measures of aspiration.
• The pH probe was extremely sensitive, making it able to detect micro aspiration.

Conclusions

We developed a novel animal model for the quantitative assessment of aspiration based on pH monitoring. This model is easily reproducible, sensitive, and provides a continuous real-time assessment of aspiration.

References


Figure 1. Experimental setup

Figure 2. Piglets were intubated with a cuffed endotracheal tube (ETT) modified by attaching a catheter for delivery of an acid solution outside of the ETT and proximal to the cuff.

Figure 3. A pH probe (Endosonic Medical, B. Uh) was passed through the ETT down to the carina.

Figure 4. A vertical tracheotomy was performed to verify that both pH probe electrodes were in the tip of the ETT and to saburte the probe to the posterior tracheal wall using one of 6 silk sutures.

Figure 5. This probe position was confirmed again by flexible bronchoscopy.

Figure 6. The pH probe was connected to a pH meter which was connected to a multifunctional data acquisition device (DAQ, NI USB-6009, National Instruments, USA) that converts analogue waveforms to digital values.

Figure 7. This formula describes the relationship between measured cell voltage (mV), pH and temperature (K). Since the voltage and pH are linearly related with a slope of 59.16 mV/pH value at room temperature, any fall in voltage indicates a fall in pH signifying aspiration.

Figure 8. The pH probe was connected to a pH meter which was connected to a multifunctional data acquisition device (DAQ, NI USB-6009, National Instruments, USA) that converts analogue waveforms to digital values.

Figure 9. Digital signals were processed using NI LabVIEW SignalExpress. This software measures the electrical potential (mV) between the two electrodes in the pH probe.

Figure 10. When the ETT cuff was deflated at the end of the experiment and the vinegar was aspirated, there was a drop in voltage.

Figure 11. The range of voltage drop (maximum – minimum) indicated the extent of aspiration.

Table 1. Results of the porcine animal model for aspiration

<table>
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<tr>
<th>Pig 1</th>
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<th>Pig 3</th>
<th>Pig 4</th>
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<td>Mean</td>
<td>Range</td>
<td>Mean</td>
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<td>± 24.5</td>
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Figure 12. Graph showing a fall in voltage after deflation of the cuff.