Analysis of Airway Content and Subsequent Aspiration Pneumonia Following Pre-Hospital Intubation

A Major Qualifying Project Report

Submitted to the Faculty of Worcester Polytechnic Institute

In Partial Fulfilment of the Requirements for the

Degree of Bachelor of Science in Biology & Biotechnology

Submitted By

____

Stefanie Crovello

____

Haley Gustafson

Submitted and Approved on

April 28th, 2011

By

____

Jill Rulfs, Project Advisor

Abstract

Healthcare-Associated Pneumonia is a significant problem. Those who have been given an artificial airway are at risk for such an infection due to the possible aspiration of materials from the palatopharyngeal arch into the lungs. By reviewing videos of EMS intubations recorded with a video laryngoscope and retrospectively examining patient charts no correlation between aspirated material and pneumonia was discovered. However, with a larger data set, a significant correlation may be discovered.

Aknowledgements

The success of this project is due in part to the many people who volunteered their time and resources. We would like to acknowledge the following people for their contribution:

Ms. Virginia Mangolds, NP

Ms. Mangolds served as the primary liaison throughout the entirety of this project. She worked to collect patient data and presented it to us in a useful manner to be analyzed.

Stacy Weisberg, M.D.

Dr. Weisberg is the principle investigator on this project. She also helped to set forth the criteria to be included in the database. She allowed us to join this project, review data and put forth our interpretations.

Chad Darling, M.D.

Dr. Darling is a researcher on this project. He helped to set forth the criteria that needed to be recorded in the database and provided us with helpful suggestions for data presentation.

Mr. Jesse Volturo

Mr. Volturo organized the criteria set forth by the two main researchers into a useable database which was used to record the data found in the videos, run sheets and patient charts.

Mr. Rich Nydam

Mr. Nydam organized the videos collected from the GlideScope by the EMTs. He allowed us to access these videos for our researching purposes.

Ms. Roberta Sundstrom

Ms. Sundstrom helped this project get a start by administering an orientation quiz, and clearing us to work at the hospital by providing us with the necessary paperwork.

Professor Jill Rulfs

Professor Rulfs aided us in writing this paper in a clear and concise manner. She gave us helpful insight into how our data should be presented.

Table of Contents

Table of Figures

1 Introduction

Our research aims to determine the relation between pre-hospital intubation and subsequent aspiration pneumonia through the retroactive review of intubation videos and patient charts. By detecting a correlation, it may be possible to identify patients with a high-risk of aspiration pneumonia and ultimately improve the efficiency of healthcare. We expect to find a strong correlation between witnessed aspiration during pre-hospital intubation and the onset of pneumonia.

1.1 Assisted Breathing

Assisted breathing is used to reduce the amount of effort needed to breathe by patients suffering from respiratory distress or failure. There are various devices commonly used in the field of healthcare, such as Continuous Positive Air Pressure (CPAP) and Transport ventilators; however, not all of these are suitable for emergency medical services (EMS). Following trauma resulting in respiratory arrest, it is necessary to rapidly restore the patient's respiratory function until the patient is able to breathe independently. Since mechanical ventilators function only to aid breathing, a separate emergency device must first be used to restore it. The typical instruments used are hand-controlled ventilators, such as a Bag Valve Mask or T-Piece Bag. Following a patient's arrival to a hospital, he or she may be moved to a more stationary, mechanical device if aided breathing is necessary following restoration in the pre-hospital setting.

Often in the case of trauma resulting in respiratory arrest, the airway is obstructed and disallows the emergency medical technician (EMT) to successfully restore respiratory function with a ventilator. In order for an assisted breathing device to operate effectively, the obstruction must first be remedied and the airway must be made stable to allow the constant passage of air through it. Current practice employs the use of intubation to open an obstructed or collapsed airway such that successful ventilation is then possible.

1.2 Upper Respiratory Anatomy

The sections of the respiratory and digestive tracts situated above the trachea play a role in the prevention of aspiration in a physically stable person, but can cause complications in one suffering from respiratory distress. A paramedic's view of the palatopharyngeal arch during intubation can be seen below in Figure 1. In its typical position, the epiglottis obstructs the view of the glottic opening. This is raised upon the insertion of the blade and reveals the vocal chords, through which the paramedic places the artificial airway into the trachea. The pharynx and esophagus may contain materials capable of being aspirated during ventilation, and material from organs below the trachea may also be aspirated if it is regurgitated above the tracheal opening. The trachea, however, is a vital component of respiratory distress in that it is the part that must be reached by the endotracheal tube (ET tube) for effective ventilation to be possible, and therefore the part that must be opened via intubation, if obstructed or collapsed.

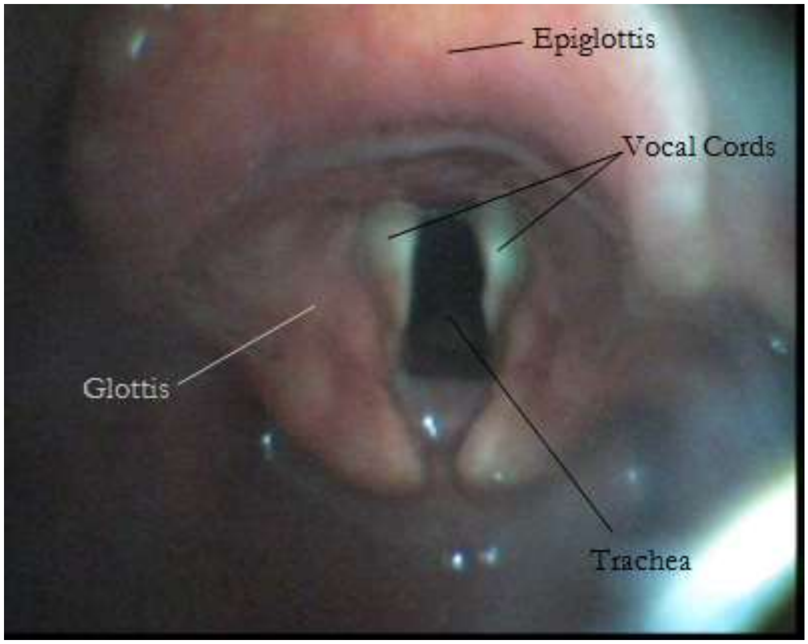

Figure 1: Upper respiratory anatomy as seen through video laryngoscopy
(Verathon, Video Laryngoscopy, 2009)

1.3 Intubation

Intubation is the process of opening an impassable airway, a condition that prevents the patient from breathing independently, such that air may be delivered to the lungs in the course of resuscitating the patient. To remedy the obstruction, a plastic tube, called an endotracheal tube, or ET tube is placed into the trachea of the patient to maintain a clear and open airway. A laryngoscope (shown in Figure 2) is used to place the ET tube into the trachea, moving the tongue out of the way and lifting the epiglottis upwards to make the glottis visible. Once the glottic opening is accessible (either through direct sight or a video feed, as with a video laryngoscope), the ET tube can be inserted through the vocal cords and hand-controlled ventilation, as with a T-Piece Bag or Bag Valve Mask, can begin. If the patient is breathing independently but requires aid, the medical professional may paralyze the cords in order to make the insertion of the tube easier. This also reduces the possibility of trauma associated with the ET tube. Once in the trachea, the tube is secured in place by a balloon cuff, which also prevents the loss of respiratory gases and the introduction of unwanted materials into the lungs. Through intubation and subsequent hand-controlled ventilation, air will be passed into the patient's lungs, allowing them to breathe.

Figure 2: Macintosh Laryngoscope Blades with conventional illumination
(EastMed Enterprises Inc., 2011)

Proper intubation technique allows a medical professional to complete the procedure efficiently and without damage to the patient's airway. Traditional intubation requires one to lean directly over the patient, such that the sternum of the paramedic is over the patient's forehead, and the blade to be inserted to the right of the tongue such that it is moved to the side and out of the way. The handle of the blade is then lifted to raise the tongue and epiglottis, making the glottis visible to the person intubating. When the blade is positioned correctly, the ET tube should be able to be inserted directly and quickly, with a typical intubation lasting approximately half a minute, through the cords and into the trachea.

1.3.1 Difficulties of Pre-Hospital Intubation

Inadequate airway management is a major contributor to pre-hospital morbidity and mortality. However, if treated properly, trauma patients may benefit from pre-hospital intubation. Successful pre-hospital intubation can be difficult based on a variety of circumstances, including inadequate equipment and blood, vomit, secretions, or debris blocking the upper airway. According to one study, 85% of patients who die with survivable injuries before reaching a hospital do so because of an airway obstruction (Helm, Hossfeld, Shafer, Hoitz, & Lampl, 2006).

In a patient with a clear airway, the efficiency of intubation relies on the technique of the medical professional. Adnet, et al. (1997), defined five conditions of an ideal intubation: it is performed without effort, it is successful on the first attempt, only one technique is used, there is a full visual of the laryngeal aperture, and the vocal cords are apart. To predict the difficulty of any given intubation, the medical professional can conduct a physical exam assessing the range of motion of the cervical spine and jaw, the shape of the upper and lower jaw, the size and shape of the tongue and palate relative to the size of the mouth, and the characteristics of the teeth. A medical history of difficulties in intubation, difficulty speaking or breathing, or of injury, surgery or radiation of the head, neck, or upper chest may also indicate the potential difficulty of the procedure. Three classification systems are used to predict the difficulty of the intubation in a given instance: the Cormack-Lehane Score, the Intubation Difficulty Scale (IDS), and the Mallampati Score (Zadrobilek, 1999), (Adnet, et al., 1997), (Yentis, 2002). These scales involve the specific visibility of pharyngeal structures, and the IDS includes other factors, such as the number of attempts and amount of force applied.

Several factors increase the difficulty of pre-hospital intubation that are not exhibited in a hospital. One that affects every paramedic is the space available to treat the patient. In an ambulance, an EMT may not be able to get into a proper position for intubation. Intubation may therefore be hindered, as the EMT must maneuver the blade and tube in a non-typical manner. The state of the patient may also cause difficulty, as large amounts of airway secretions, blood, vomit or debris often block or obscure the EMT's view of the vocal cords. In contrast to a more stable setting, an ambulance may not be an ideal setting for the suctioning and removal of these materials. This may lead to multiple intubation attempts, which may result in trauma to the patient if the tube has cut the glottis or epiglottis due to being repeatedly inserted incorrectly. The position of the vocal cords depends on if the patient is breathing, in which case they will be opening and closing. If the patient is in respiratory arrest, the EMT may find that the vocal cords are abducted (relaxed and open), or alternately could find that the cords are adducted (closed and impassable, as when a person speaks). If adducted, it may be necessary to paralyze the vocal cords. Called Rapid Sequence Intubation (RSI), using paralytics relaxes the vocal cords and also prevents the release of gastric contents into the pharynx. This will then allow for the cords to remain relaxed and the ET tube to be more easily passed through. Although this particular difficulty is evident in both pre-hospital and hospital settings, it may often make pre-hospital intubation more difficult because of limited resources.

1.3.2 GlideScope Ranger Video Laryngoscope

The GlideScope Ranger Video Laryngoscope (shown in Figure 3) is a relatively new tool used in emergency situations. A camera located at the end of the laryngoscope allows the medical professional to see further into the airway than they would during traditional intubation. It provides real-time video feedback with a small, portable monitor, allowing for a clearer view of the airway and subsequent tube placement (Verathon, GlideScope Video Laryngoscopes, 2011). When projected onto the screen, everything being visualized is also recorded via digital video recording (DVR) so that it can be reviewed later by the EMTs to further improve intubation techniques (Nydam, 2011).

Figure 3: GlideScope Ranger Video Laryngoscope
(Verathon, GlideScope Video Laryngoscopes, 2011)

Up to 25% of ET tubes are placed incorrectly in pre-hospital settings due to inadequate visualization and unforeseen difficulties, causing complications for the patient (Wang & Yealy, 2006). Video projection of the upper respiratory anatomy permits the medical professional to more easily pass an ET tube into the patient's trachea in difficult situations, providing ventilation to the person more rapidly. This technique is especially beneficial when the person in need of intubation cannot be moved for fear of further injury, and the Ranger can be used on people of any size, making it even more useful in emergency, pre-hospital circumstances, where paramedics must be prepared for any situation. It is also advantageous in reducing the spread of disease, because it puts the person intubating further away and not directly over the open mouth of the person being intubated. Therefore, if the person coughs or vomits, there will be a smaller chance that any illness they may be carrying will be transferred to the medical professional. A single unit can be used on an ambulance, leaving more room open for other important equipment.

Although this device makes many aspects of intubation easier, it doesn't eliminate all problems associated with intubation. The camera was designed with an anti-fogging mechanism, though studies have shown that this mechanism is not always functional, potentially due to the movement from a cold ambulance to a warm body, causing fogging of the camera (Mangolds, 2011). Since this technique is relatively new, many times the older medical professionals will then switch from this method to a more traditional intubation method, making reliable data for the GlideScope use alone scarce (Nydam, 2011).

In particular, two case studies have documented complications associated with the GlideScope. A 57 year old woman with hemifacial microsomia, which affects the development of the lower half of the face and consequently leads to breathing difficulties, required intubation for surgery. Due to the small size of her mouth, the GlideScope was utilized, but the ET tube could not be placed, so traditional intubation was used instead. It was observed then, that the ET tube had caused minimal bleeding in her palatopharyngeal arch, which then needed to be surgically repaired with two sutures.

The second case study involved an elderly woman that needed an aortic valve replacement. She presented with multiple predictors of difficult intubation. Two attempts were required to bring the ET tube into view on the monitor, and eventually it was discovered that the ET tube had perforated her palatopharyngeal arch, which caused bleeding but was controlled using electrocautery (Cooper, Complications associated with the use of the GlideScope videolaryngoscope, 2007).

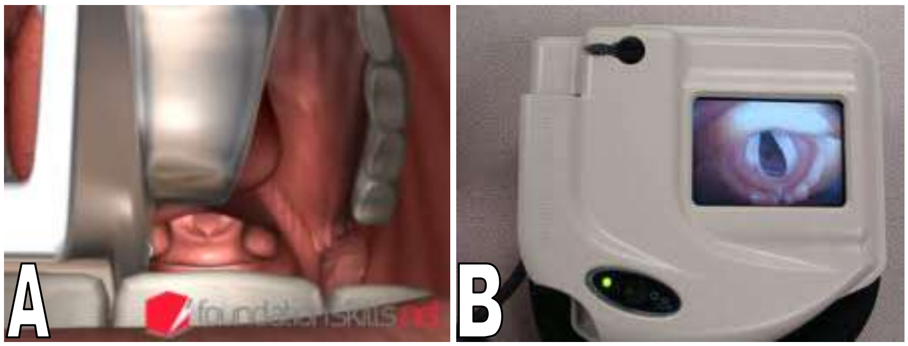

Figure 4: Views of upper respiratory anatomy as seen during a. traditional intubation and b. intubation with a video laryngoscope

(MedcomAnimation, 2008), (Wise County EMS, 2008)

1.4 Pneumonia

Pneumonia is an infection of the lung that causes respiratory distress. It consists of inflammation of the lungs, a cough, shortness of breath, fever, chest pain, and various other symptoms that range in severity. This infection can occur due to bacteria or viruses that spread to the lungs, are directly inhaled, or are transferred via the aspiration of bacteria- or virus-containing materials into the lungs. Due to the wide range of pneumonia-causing bacteria, such as *Streptococcus pneumoniae*, *Chlamydophila pneumoniae*, and *Neisseria meningitidis*, viruses such as adenoviruses and rhinoviruses, and fungi, as well as the variety of risk factors ranging from cystic fibrosis to a simple cold, the condition is common. However, the severity of the infection is dependent on which agent is causing infection and the state of the immune system of the affected person. In a hospital setting, pneumonia can be more severe since hospitals tend to harbor the more dangerous of infectious agents and the patients tend to already be immunocompromised. As a result, Healthcare-Associated Pneumonia (HCAP) is considered a serious problem (Medscape, 2007).

1.4.1 Healthcare- and Ventilator-Associated Pneumonia

Healthcare-Associated Pneumonia (HCAP) and Ventilator-Associated Pneumonia (VAP) are lung infections that result from hospital-related practices. Although HCAP covers many ways in which one may contract pneumonia in a hospital, the focus of this research is aspiration pneumonia, which is caused by the inhalation of materials into the lungs and is more greatly associated with the use of medical devices, such as those involved in intubation.

While many types of bacteria live harmlessly in some areas of the body, they can be pathogenic when spread elsewhere. In some cases, illness is caused by implanted devices like shunts, which can cause an infection at the site. In regards to VAP, infection results from the immediate transfer of agents into the lungs through aspiration. This occurs when the ventilating device is inserted into the airway and positive pressure is applied into the trachea, which can trigger the transfer of materials from the mouth or airway into the lungs. Depending on the content of the patient's mouth and airway, the volume of aspirated materials can vary. Since the number of infectious doses may be dependent on the amount of material, the likelihood of the onset of pneumonia may depend on the volume of material aspirated (Swaminathan, 2010). This may also depend on the type of material transferred. The aspiration of gastric contents may result in aspiration pneumonitis, which involves chemical damage to the lower airways, whereas other materials may lead to infection and aspiration pneumonia (Swaminathan, 2010). Pneumonitis can be a symptom of pneumonia, but if it is caused by a non-infectious agent (such as gastric contents), then it may not coincide with other symptoms of pneumonia and is treated differently.

The onset of VAP may be expected if the aspiration of a large amount of material is evidenced. However, infection can occur even following aspiration of trace amounts of material, which there may be no way of detecting unless there is a direct view of the tract. These trace amounts may be transported down into the airway when the ET tube has collected it from the pharynx and is then inserted into the trachea. When a patient is properly intubated, the tube should pass directly through the vocal cords; however, in some instances, the intubator will miss the trachea and poke the tube around in the pharynx in search of the glottic opening. It is in such a case that the tube may collect secretions and debris and eventually pass it into the trachea as the intubator becomes successful. These materials may then remain in the trachea or be aspirated further down into the airway and lungs, as air is forced through the tube.

If the onset of infection occurs after 48 hours of hospitalization, it becomes associated with healthcare, and more specifically ventilation, if the patient was intubated (Medscape, 2007). Given that HCAP is a secondary ailment, as a patient is usually admitted with a more severe problem, it is an obstacle in the treatment of the patient as it can cause complications. Further intensifying this problem, patients who acquire an infection during hospitalization are more likely to develop a multi-drug resistant (MDR) infection (Medscape, 2007). Treatment is therefore generally broad-spectrum, which may increase the resistance of the strain. Not only does this issue affect the patient, but also contributes to the development of antibiotic resistant bacteria.

1.4.2 Previous Research Conducted by UMass Memorial Healthcare

In a previous study by UMass Memorial Healthcare, recordings were used to establish paramedic intubation times following the introduction of the GlideScope Ranger Video Laryngoscope in ambulances. Researchers found that there was evident aspiration of materials in many of the recordings and that the aspirated material was often copious in amount (Weisberg, 2010). The current study, in which the charts of patients intubated in a pre-hospital setting are being retroactively examined to look for the onset of pneumonia during the patient's subsequent hospital stay, is an extension of this paramedic intubation timing study.

1.5 Effect on Quality of Healthcare

Should a correlation between aspiration, via intubation, and pneumonia be detected, the implications are beneficial to the fight against HCAP/VAP. Knowing that evidenced aspiration may lead to an infection independent of the primary purpose of hospitalization, steps can be taken to either prevent infection or pre-emptively treat it if it is predicted to occur.

Knowing that there is a possibility of pneumonia as a result of aspiration may be helpful when it comes to preventing it. First, a medical professional may be able to directly prevent aspiration by, for example, suctioning excess airway fluids and other debris, which is a practice that may become more common in a pre-hospital situation if it is expected that suctioning may be necessary. In this case, a suctioning device could be made more quickly accessible for the paramedics. Besides suctioning, paramedics may also be trained in proper intubation technique and how to avoid aspiration through the maneuvering of the tools. Second, future research may lead to modifications of the intubation devices that may decrease the likelihood of aspiration and, subsequently, pneumonia.

Another shortcoming of intubation tools is that their usage can result in superficial damage to the patient, either through the force of the blade when exposing the glottis, which can cause damage to the dentition, or through the inaccuracy of the paramedic when maneuvering the ET tube, which can cause lacerations in the palatopharyngeal arch. Since GlideScope laryngoscopy allows for a better laryngeal view than traditional intubation, injuries caused by the ET tube should be less frequent; this, however, is not evidenced in this study. While these situations are not directly related to aspiration or pneumonia, they are important problems that research into the improvement of blades may rectify. Also, any blood from lacerations or other damage can possibly be aspirated.

Where prevention is not possible, prediction is a secondary mechanism that can increase the quality of healthcare and the health of the patient. When aspiration is witnessed, it can be expected that pneumonia is more likely. A hospital protocol could be put in place that necessitates the pre-emptive treatment of intubated patients, which would lessen the severity or almost completely prevent aspiration pneumonia, and therefore eradicate the onset of major complications related to this infection. However, this sort of pre-treatment may simply add to the problem of antibiotic resistant organisms.

1.6 Case Studies

Many cases have been documented using the GlideScope in a variety of situations, showing both the benefits and the risks of using this device. The GlideScope Ranger Video Laryngoscope was developed for use in emergency and military medicine, able to withstand the difficult environment of the military. A certified nurse anesthetist with the United States Army in combat in Iraq used the GlideScope Ranger on a patient presented to him awake, alert and with no airway distress. After the patient was sedated, the Ranger was used to perform a laryngoscopy and secure an ET tube. Though it was not a case involving the management of a difficult airway, the GlideScope was utilized for several important reasons: the patient could be intubated in the exact position he was found, and the force required to obtain a glottic view was minimal. This shows that the GlideScope may be the optimal way to secure ET tubes in patients with suspected cervical-spine injuries or traumatized airways (Hawkins, 2011).

In another case study, an intubation was performed on an elderly man with known difficult direct laryngoscopy attempts due to gastroesophageal reflux. This made a clear view of the glottic opening difficult. Subsequent laryngoscopy using the GlideScope yielded a clear view, and intubation was accomplished in under 20 seconds (Cooper, GlideScope Video Laryngoscopes: Case Studies in Airway Versatility, 2008).

A larger study, which included 200 randomized patients, was performed over the course of approximately one year. The study had two main objectives: to see whether the GlideScope would provide an improved laryngoscopic view, and to compare it to direct laryngoscopy using the standard Macintosh blade, with respect to time taken for intubation. The patients were randomized into groups of six patients to be intubated with either the GlideScope or the Macintosh laryngoscope. In the GlideScope group, the majority of patients showed improvement in the level of difficulty taken to intubate, and 68% of the patients had an improved laryngoscopic grade. Using the Mallampati score as recorded by the intubators, there were six patients in which a clear airway view became a slightly difficult airway view with the use of the GlideScope, though this did not prevent successful intubation. Time taken to intubate was recorded from the time the blade entered the patient's mouth until end-tidal carbon dioxide was detected, meaning when the patient first exhales after beginning to breathe. The group being intubated via the GlideScope generally took longer than using direct laryngoscopy (i.e. Macintosh blade) to intubate because of the technique required to manipulate the blade and the ET tube through the vocal cords, increasing the intubation time by approximately 50%. This extra time may be advantageous if there was no harm to the patient due to the direct view of the glottis (Sun, Warriner, Parsons, Klein, Umedaly, & Moult, 2005). The time to intubate also was not increased in patients with difficult airways, further showing that for circumstances in which intubation will be difficult, the GlideScope is highly beneficial.

There have been many indirect intubation alternatives developed, including GlideScope Ranger Video Laryngoscopy (the focus of this study), McGrath and Airtraq. These three indirect laryngoscopy blades, along with the standard Macintosh control blade, were compared in one study using multiple simulated airway scenarios. All indirect methods were easier and more successful than the traditional Macintosh blade in each of the scenarios. However, use of the GlideScope to intubate took longer than other indirect methods, caused more dental problems, and according to study participants, did not allow for a very clear view of the laryngeal opening. After the study, only

3% preferred the GlideScope, though all participants stated that indirect laryngoscopy should be incorporated into medical practice (Savoldelli, Schiffer, Abegg, Baeriswyl, Clergue, & Waeber, 2008).

As seen from the studies presented, the GlideScope is a revolutionary tool in emergency medicine, though there are drawbacks among its benefits. Compared to traditional intubation techniques, such as with the Macintosh blade, the GlideScope, as well as other indirect methods, may be necessary in some emergency situations, but for years to come traditional intubation may be used in controlled situations. From these studies it is clear that having intubation options in all situations is the best way to ensure that all patients will be successfully intubated in a timely manner, thus minimizing the risk of morbidity.

There have been few studies, if any, attempting to correlate pneumonia with aspiration evidenced by GlideScope Video Laryngoscopy. This study sought to provide awareness to medical professionals for how best to treat patients using the GlideScope Ranger Video Laryngoscope. With no accurate correlations found, likely due to a limited data set, it is best for the medical professionals to further this study and form conclusions based on a larger data set as to how best deal with situations as they arise.

2 Methodology

The course of this study included the review of intubation videos recorded with the GlideScope Ranger Video Laryngoscope and the comparison of the data collected from the videos with the correlating patient charts.

2.1 Review of GlideScope Ranger Video Laryngoscopy

A collection of GlideScope Ranger Video Laryngoscopy videos, recorded between October 2010 and January 2011, were reviewed and analyzed with respect to a range of predetermined guidelines. Each video was reviewed by four people and the resulting analyses were organized into a database. Specific data from the videos, including clarity of the footage, visibility of the vocal cords, and airway content were recorded. Airway content as seen by the reviewers in the video recordings was recorded in the database. The timing of intubation, from the time the blade entered the patient's mouth to the time that the ET tube passed through the vocal cords was recorded. These bounds are considered one intubation attempt, and if the blade is removed from the patient without an ET tube in the trachea, it is regarded as unsuccessful. The number of intubation attempts, using these guidelines, as well as whether there was ultimately a successful attempt were also entered into the database. An example of the database format is shown in Figure 5.

Video Number	Study #	Reviewer 1	Reviewer 2	Reviewer 3	Reviewer 4	Final	Medical Record #
	1						
Intubation Successful Y/N							
Number of Intub attempts							
Image quality: C/FH							
Cords Visible: Y/N							
Start Time							
Stop Time							
Total Elapsed Time (seconds)							
Airway Condition (check all that apply)							
Normal Y/N							
Large amt clear/thin secretions Y/N							
Vomit or foreign material Y/N							
Blood in Airway Y/N							

Figure 5: GlideScope Video Laryngoscope Database
(Volturo, 2011)

Four independent reviewers watched the 29 videos, separately recorded data on each, and then a final decision was made as to the answer to each of the proposed topics in the database. Problems with the use of the GlideScope were noted during the video review, such as fogging of the camera. A few of the videos were difficult, if not impossible to review successfully due to fogging, which made anatomical structures, and thus the intubation, hard to see.

In some instances, a patient's intubation was recorded on two videos, as the first intubation was unsuccessful, the monitor was turned off, and the paramedic made a later attempt with the GlideScope. Another situation was that the patient was already intubated and the paramedic was simply using the GlideScope to view the airway. Incidents such as these were noted. Many intubation videos also were incomplete, meaning that when the video ended, the ET tube had not yet passed through the vocal cords. When this occurred it was also noted in the database so that the next method of intubation employed by the paramedic could be discovered from another source, if the GlideScope was not used a second time. In total, there were 19 usable videos for database entry, of which ten were able to be studied further.

2.2 Supplemental Data Collection from UMass Memorial Healthcare

Based on the time stamps on the GlideScope video recordings, each video was matched to a person's run sheet, which were collected from Worcester Emergency Medical Services (WEMS) by members of the UMass Memorial Healthcare hospital staff. Each patient's medical record number was obtained from the run sheets and applied to each video. WEMS run sheets contain information on the date and time of the intubation attempt, as well as the Mallampati grade of the airway for each patient, as determined by the intubator. The run sheets from WEMS also contained information regarding successful intubation and the type of blade that was utilized for each intubation (Macintosh, Miller, GlideScope). The reason for intubation and the number of attempts needed to successfully intubate were recorded as well, since not all intubations are initially successful.

After run sheets and medical record numbers were collected, patient charts were checked via Meditech by hospital staff. Meditech provided information including previous comorbidities afflicting patients, including asthma, COPD or a neurological disease, among others. Meditech was also useful to determine if each patient developed pneumonia, and how long after intubation it occurred. Hospital protocol is to take chest x-rays immediately after intubation to make sure that the tube is correctly placed, and then again every 24 and 48 hours in order to immediately discover any afflictions, like pneumonia. These x-rays either provided a diagnosis of pneumonia or noted that it had not been developed. A full medical history was also provided through Meditech, allowing the discovery of other potential correlations.

2.3 Aspiration and Pneumonia Correlation Discovery

Data collected from run sheets and medical records were visually analyzed for correlations found among the patient records, although the charts of patients that were taken to St. Vincent's, rather than UMass Memorial, were not available. Specifically, a relationship between visible aspiration and the development of pneumonia was investigated. With the limited patient data provided, various other correlations were explored based on patient age, intubation success rate and reason for intubation, among others. Microsoft Excel was used to generate bar graphs. For statistical analysis, an online McNemar calculator was used (GraphPad Software, Inc., 2005).

3 Results and Discussion

The goal of this project was to investigate whether there was a correlation between airway content during intubation and the onset of pneumonia. It was hypothesized that the likelihood of contracting pneumonia would be increased when the airway contained blood or debris. In a pre-hospital setting, there are various reasons for these debris to still be in the airway at the time of intubation. Among these are the limited time and resources the paramedics have to efficiently and effectively assist the patient, and sometimes improper training.

Although it was expected that there would be a relationship between airway content and the subsequent onset of pneumonia that would allow the presence of abnormal airway debris to be used as a predictor of pneumonia, the correlation coefficient found actually shows the opposite. With an r-value, or correlation coefficient, of -0.38, the data collected shows that a patient that does not have abnormal airway secretions or debris is more likely to develop pneumonia. This data is visualized in Figure 6.

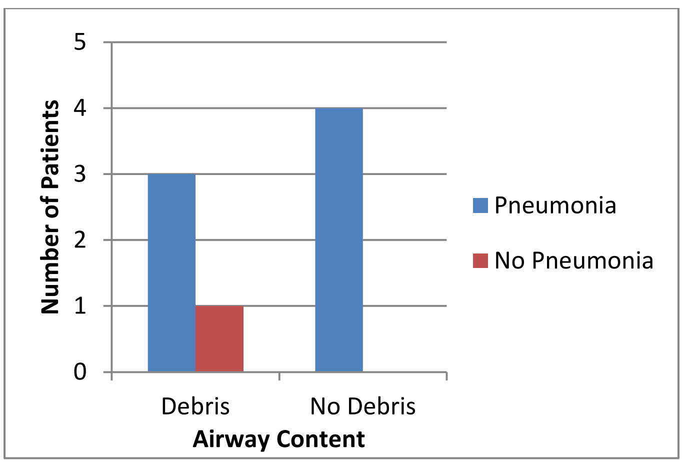

Figure 6: Overall Airway Content v. Onset of Pneumonia

However, the performance of logistic regression on this data set, using binary values for airway content (1=debris and 0=no debris) and the onset of pneumonia (1=pneumonia and 0=no pneumonia), yielded a p-value of 0.216, indicating that this data is not statistically significant, given that a p-value of ≤ 0.05 is required to demonstrate statistical significance.

3.1 Onset of Pneumonia versus Airway Content

While reviewing the GlideScope Video Laryngoscope videos, content of the airway was observed and recorded. Criteria set forth by the principle investigators were used for this purpose. Normal secretions, copious secretions (bubbles, froth), vomit, and blood were the four categories of airway content to choose from, and all that were applicable were recorded in the database, with normal and copious secretions being mutually exclusive. The database was then used to develop the figures presented here, as well as to determine the correlation coefficients and p-values for each criterion in relation to the onset of pneumonia.

In order to look further into the relationship between airway content and the onset of pneumonia, linear regression was performed on each debris-positive criterion of airway content in relation to the onset of pneumonia. These criteria – copious secretions, vomit or debris, and blood – resulted in r-values of 0, 0.38, and 0 and p-values of 1.0, 0.21, and 1.0, respectively.

3.1.1 Onset of Pneumonia versus Blood in the Airway

Blood was found in the airway of six patients. The patient data in relation to airway blood is shown in Figure 7.

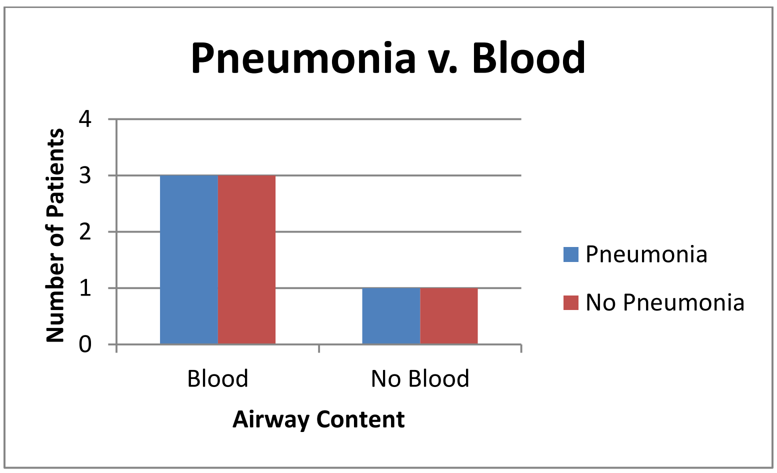

Figure 7: Onset of Pneumonia v. Blood in Airway

As seen above, the same number of patients that developed pneumonia had blood in their airway as those who did not, resulting in a correlation coefficient of 0 – no correlation. This indicates that a patient has the same risk of developing pneumonia as they do of remaining uninfected if they have blood in their airway during intubation. One explanation of this is that the blood witnessed in the recordings often occurred as a result of lacerations caused by the ET tube when a paramedic missed the airway. There may not be a sufficient amount of blood by the time the paramedic has completed the intubation to cause infection. For future research, one may look solely at the amount of blood in relation to the onset of pneumonia, or perhaps the source of the blood. Since blood in circulation is sterile (unless a patient is septic), blood released from the airway may not introduce infection. However, blood resulting from an accident, for example, which has become external and then introduced to the airway, may not be free of pathogens.

Given that the p-value of this set of data is 1.0, the relationship evidenced is not significant.

3.1.2 Onset of Pneumonia versus Debris in the Airway

Vomitus was found in the airway of a single patient, and this patient developed pneumonia (Figure 8). Three other patients also developed pneumonia, meaning that if vomit relates to the onset of pneumonia, it is not the only factor.

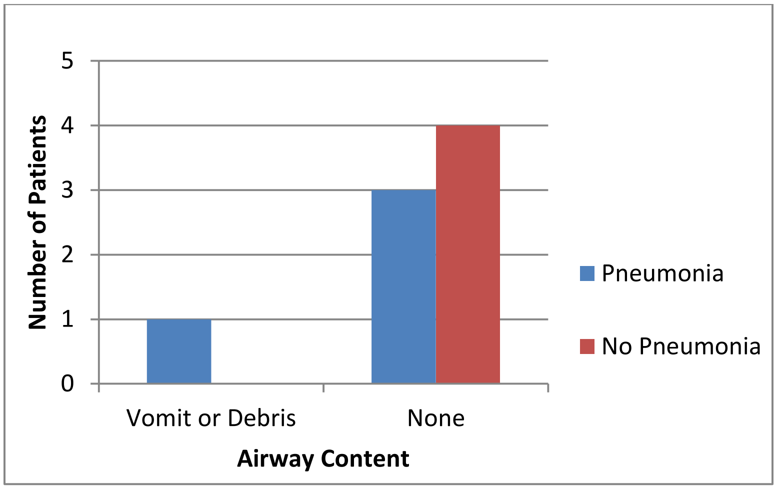

Figure 8: Onset of Pneumonia v. Airway Debris

The calculation of a correlation coefficient of this data resulted in an r-value of 0.38, indicating a weak correlation between vomit and the onset of pneumonia. Given that only one patient had vomit in their airway, further studies should be conducted concerning the relationship between vomit or debris in the airway and pneumonia. It was expected that patients who did develop pneumonia were more likely to have developed it as a result of vomitus or debris, as it is more copious in amount than other types of airway content and seems more likely to promote the growth of bacteria. However, the p-value resulting from logistic regression of the data is 0.21, indicating that the relationship detected here is not significant.

3.1.3 Onset of Pneumonia versus Normal and Copious Airway Secretions

Of the categories of airway content that could be selected while reviewing the GlideScope videos, normal secretions and copious secretions were mutually exclusive. Since one or the other had to be chosen, not both together, it is easier to visualize in the same figure. As seen in Figure 9, there were two people with normal secretions who developed pneumonia and two who did not, and two people with noted copious airway secretions who developed pneumonia and two who did not develop pneumonia after intubation.

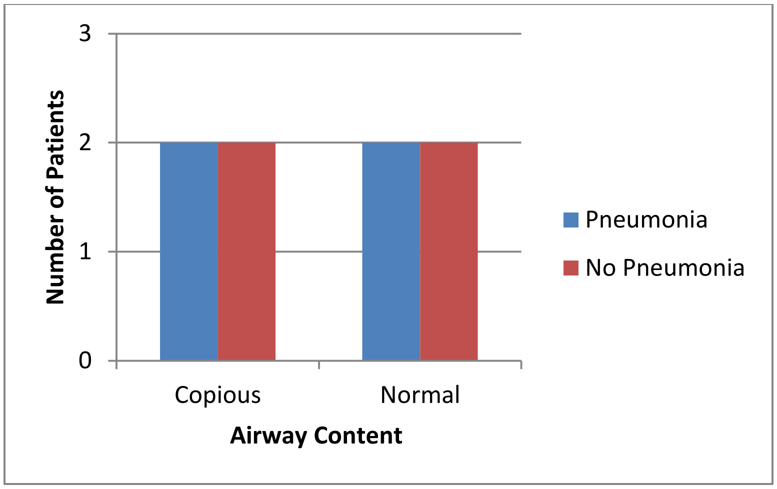

Figure 9: Onset of Pneumonia v. Airway Secretions

This data resulted in a correlation coefficient of 0, indicating that there is no relationship between the amount of secretions and the onset of pneumonia. The p-value that resulted from logistic regression is 1.0, meaning that the relationship evidenced here is not significant.

3.1.4 Pneumonia versus All Types of Airway Secretions

The onset of pneumonia, as evidenced by the recorded GlideScope Laryngoscopy videos, is not significantly related to any of the airway content categories, given that all three r-values were in the weak range of correlation and the p-values were greater than 0.05. In respect to blood in the airway, there were an equal number of patients that developed pneumonia as those that did not, showing no relationship. Among the data presented for normal or copious secretions, no conclusion can be made as to which patients are more likely to develop pneumonia. What may be the most indicative in later experiments is the visualization of vomit or debris in the airway and the subsequent onset of pneumonia in these patients. In future compilation of videos and patient data, it is presumed that those with debris in their airway will most often acquire pneumonia.

With the continuation of this project through the collection of more videos, run sheets, and patient charts, a more conclusive outcome between airway content and the onset of pneumonia may be seen. If so, hospital protocol could be altered in the hope of limiting the number of patients that develop pneumonia after intubation. This could be achieved through the mandatory suctioning of the airway before intubation, if visible aspiration is seen. Though suctioning is a technique utilized in some situations already, it may be used more often to offset the number of cases of aspiration pneumonia of patients intubated in a pre-hospital setting. If a correlation were to be found between vomitus or debris and pneumonia, but not copious secretions or blood, then paramedics could be trained to suction only in the presence of vomitus or debris. This could reduce the likelihood of pneumonia while also keeping the process rapid for patients for whom suctioning is not necessary.

3.2 Pneumonia versus Success

Intubation success is defined as placement of the ET tube through the vocal cords, and expanding the balloon cuff on the tube to hold it in place. Depending on the situation, success can be attained with varying levels of difficulty. It was uncertain whether successful intubation would increase the likelihood of pneumonia, presumably due to the aspirated material pushed farther into the airway.

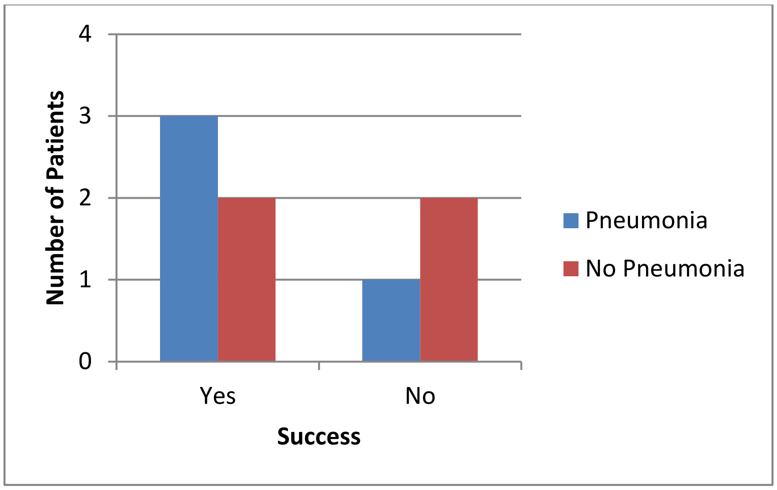

Figure 10: Onset of Pneumonia v. Intubation Success

Showing those patients that developed pneumonia, those that did not, and those that died, it can be seen that in those patients that developed pneumonia, more intubations were successful than not (Figure 10). The resulting correlation coefficient is 0.26, indicating a weak correlation between the success of the intubation and the onset of pneumonia. It can be postulated that materials in the airway of these patients were moved farther into the airway, causing pneumonia. For those patients that did not develop pneumonia, there were an equal number of successful intubations as unsuccessful intubations. There are a variety of reasons that could make intubations unsuccessful, especially in the pre-hospital setting, that do not result in aspiration (and therefore not pneumonia). Major reasons for not successfully intubating a patient include not securing a clear view of the vocal cords, which is needed in order to successfully intubate, as well as material in the airway, which could make the placement of the tube difficult due to the material obstructing the view of the vocal cords as well. If the tube is not inserted into the airway, then materials in the airway are not likely to be aspirated. An unsuccessful intubation may also lead to aspiration through the faulty insertion and subsequent removal of the ET tube. Further research would have to be conducted in order to find a stronger correlation. However, with a p-value of 0.46, this data did not show a significant relationship.

Given that a patient may not develop pneumonia following a successful intubation or that they may following an unsuccessful intubation, it seems necessary to note what type of secretions, if any, are located in the airway of the patient when analyzing this aspect of the data. The previous discussion assumes that all patients had materials in their airway. As seen in Figure 11, this is untrue.

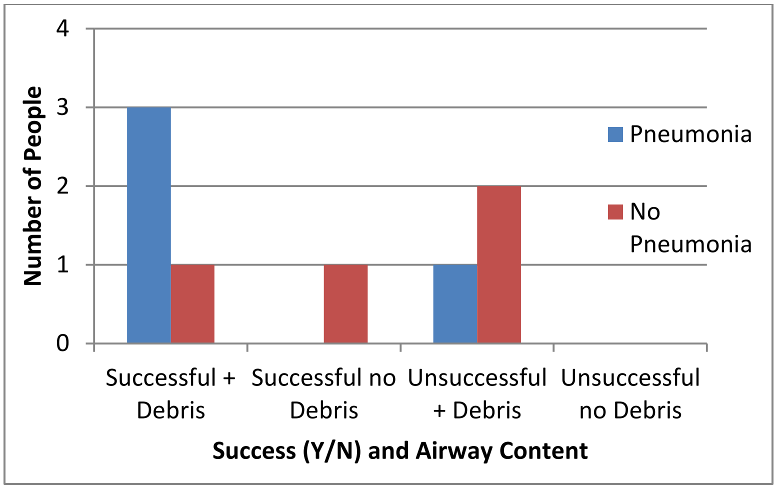

Figure 11: Outcome of Patients with Debris in their Airway

Given that one patient with a successful intubation did not develop pneumonia despite copious secretions and blood in the airway, it would be beneficial to look into this aspect further. When analyzing airway content versus the onset of pneumonia, future researchers may want to look at the success of intubation, as it may be useful in confirming the accuracy of the data if they do not know if aspiration of the materials actually occurred.

3.3 Pneumonia versus Reason for Intubation

There are many reasons for an airway to be impassable and for intubation to be necessary. These reasons exist both in and out of the hospital and must be dealt with accordingly. Reasons for in-hospital intubation include surgery, which is controlled, as well as instances in which patients being monitored suddenly crash and require an artificial airway. Pre-hospital intubations involve many intense situations in which the medical professionals need to intubate quickly and efficiently to restore or assist breathing for the patient while transferring them to a hospital, where they can be effectively treated. A few reasons pre-hospital intubation may be necessary are cardiac arrest, respiratory arrest and drug overdoses.

In this study, four reasons for intubation are witnessed: arrest (cardiac/respiratory), unresponsiveness, drug overdoses, and falls. There were four overdoses, five arrests, one fall and one person was unresponsive. The outcome of their intubation attempt, whether they developed pneumonia or not, can be seen below in Figure 12. The unresponsive patient died and therefore remains unmarked for both possibilities.

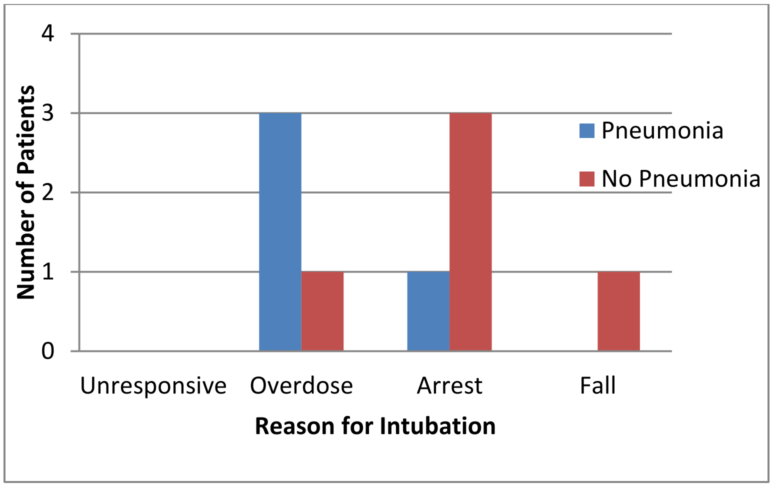

Figure 12: Onset of Pneumonia v. Reason for Intubation

The person found to be unresponsive died, while the person that fell did not develop pneumonia after their intubation. The five people intubated due to arrest had varying outcomes: one died, one developed pneumonia and three did not develop pneumonia. However, what may be the most interesting out of this data set is the correlation that seems to exist between drug overdoses and the development of pneumonia after intubation. Seventy-five percent of the people intubated for drug overdoses developed pneumonia. If given more time and a larger data set, this result in particular would be explored further. It would be interesting to see whether the drug overdose patients continue to develop pneumonia in a much higher percentage than those intubated for other reasons.

Further exploration of this topic would have included dividing the patients into categories relating to the method of drug use (inhaled, injected, etc) to see if this correlated with anything. We predict that if studied, it is more likely that those patients who inhale drugs would be more likely than those people taking in drugs other ways to subsequently develop pneumonia. This is expected because particles that are taken into the body through the nose or mouth would result in an unclean or possibly damaged airway, leading to a greater risk of infection. With intubation, the particles that are stuck to the lining of the airway may also be made loose and get pushed farther down into the airway, subsequently making the patient more prone to pneumonia. If the drugs were injected, rather than inhaled, it is expected that intubation would less likely cause pneumonia in these patients, as these drugs would be unrelated to the airway.

3.4 Onset of Pneumonia versus Number of Intubation Attempts

As defined by the principle investigators of this project, successful intubation is passing the ET tube through the vocal cords, and then blowing up the cuff that holds the tube in place in the trachea. Not all intubations are successful on the first attempt. It is possible that if the vocal cords are not visible to the paramedic the intubation will be unsuccessful on the first attempt. In order to be counted as another intubation attempt, the principle investigators decided that the blade of the laryngoscope would have been removed from the mouth, and reinserted. This was necessary in some of the videos, due to the lack of a clear view of the vocal cords because of debris in the airway, or fogging of the camera lens. The blade may have been removed in order to immediately reposition it or to halt intubation while treating the patient in another manner before returning to the task. In some instances, the vocal cords spasm, opening and closing in a manner that increases the difficulty of passing the tube into the airway, so the paramedic may paralyze them in order to intubate more easily. In Figure 13, below, it is shown that more patients did not develop pneumonia than did in the category of 0-2 intubation attempts, and the opposite can be said in the category of 3+ attempts. With an r-value of 0.26, the correlation evidenced is weak, but a p-value of 0.46 indicates that this is not significant.

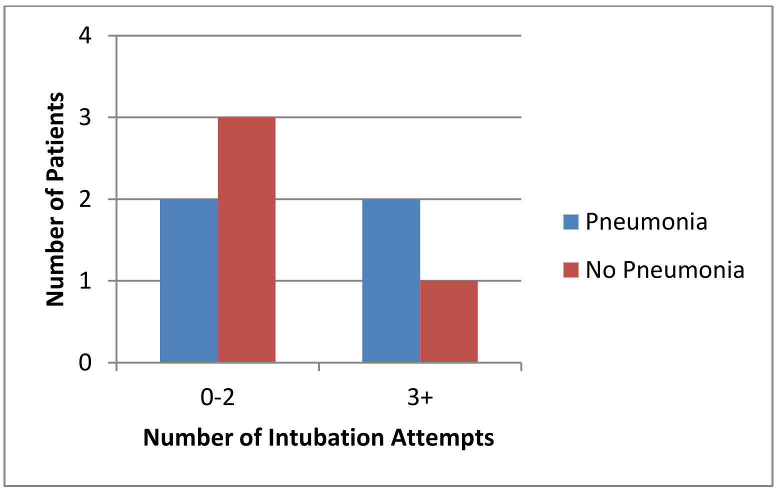

Figure 13: Onset of Pneumonia v. Number of Intubation Attempts

Of the patients with two or fewer intubation attempts two developed pneumonia, three did not develop pneumonia, and two died. It was expected that with increasing numbers of intubation attempts, the likelihood of the onset of pneumonia would be higher as well. This result was expected because with more than one intubation attempt, the blade would have been inserted, removed, and reinserted into the patient's mouth, possibly picking up bacteria from the ambulance while outside of the mouth. Also, it is possible that with increasing attempts, the ET tube has a longer amount of time to break debris loose from the patient's airway, and then push them down into the airway, increasing the patient's odds of developing pneumonia within 48 hours of their intubation. However, the correlation detected was weak and, regardless, insignificant.

3.5 Onset of Pneumonia versus Age of Patient

With patients, there are many possible underlying conditions that could affect the ease and success of intubation. Conditions such as neurological disorders can affect any patient. Generally, however, the older a person is, the more underlying conditions there are that they are prone to and that could afflict them, including, but not limited to, respiratory conditions such as COPD, asthma, or heart failure. These conditions can make it more difficult for EMTs to intubate patients. For example, a patient with asthma will have a tightened airway or a chronic smoker may have discolored vocal cords that are difficult to see. Due to these conditions and the likelihood of their distribution among age, it also seems that the older the patient is, the more likely it is that the patient will develop pneumonia after intubation. Figure 14 shows groups of patients by age, separated by teen, middle aged (20-59) and senior (60+).

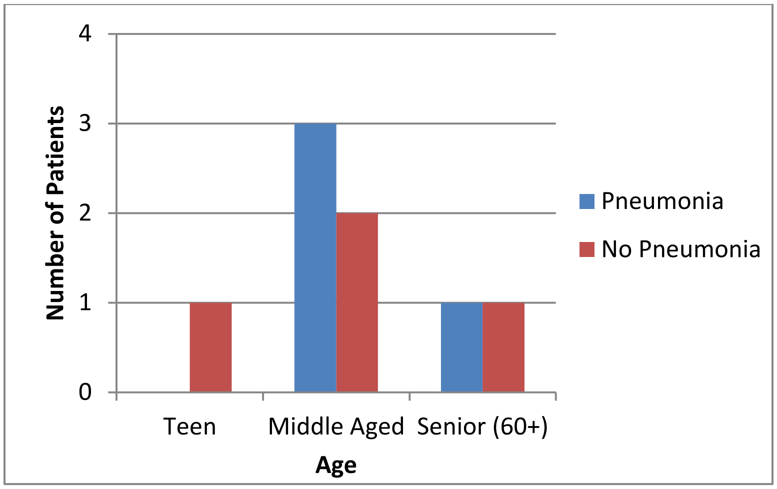

Figure 14: Onset of Pneumonia v. Patient Age

The patients that seemed more likely to contract pneumonia were the patients in the middle aged group. Two of the senior patients died while in the hospital, while the only teen patient did not develop pneumonia after intubation. From this data, it seems likely that the age of the patient affects their odds of contracting pneumonia from the intubation or soon after, while in the hospital. If a correlation were found with a larger data set, possible precautionary measures could be taken when intubating older patients with underlying conditions.

3.6 Intubation Success versus Patient Age

Success of intubation depends largely on the patient's anatomical structures and the trauma they have sustained. The older the patient, generally, the more difficult it is to intubate. This is due to a variety of ailments the person may have, or changes in the person's anatomy from weight gain, or previously sustained injuries. The elderly comprise a large number of patients presented for intubation, and have alterations in autonomic function, an increased incidence of coexisting health problems such as cardiovascular disease, and an increased sensitivity to anesthetic drugs, such as those used to paralyze the vocal cords (Habib, Parker, Maguire, Rowbotham, & Thompson, 2002). For these reasons, it would seem as though the older the patient, the more difficult successful intubation would be.

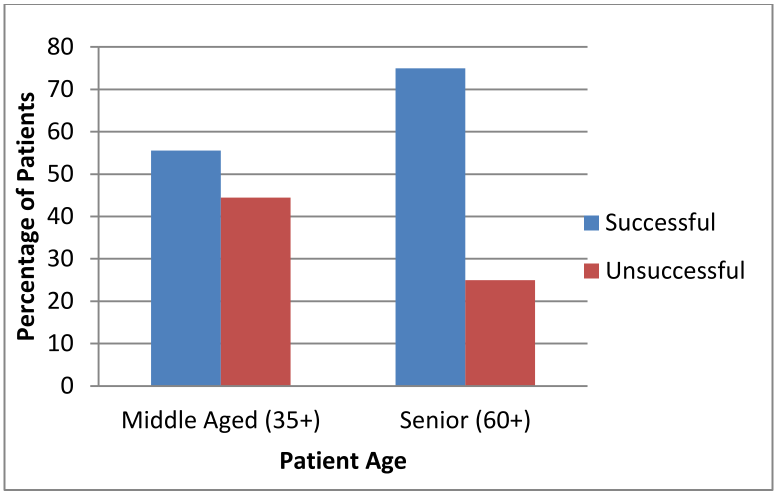

Figure 15: Intubation Success v. Patient Age

From this data it appears as though the senior patients were easier to intubate than the middle aged patients. This data set is larger than those in all of the previous analyses since the information was acquired solely from the run sheets and patient charts were unnecessary. What the data shows is that approximately 45% of the middle aged patients had unsuccessful intubation with the GlideScope, while merely 25% of those that were over 60 years of age had unsuccessful intubations with the same tool (Figure 15). This data resulted in an r-value of 0.20, indicating a weak correlation between age and intubation success. It is possible that some of the patients that were not successfully intubated with the GlideScope could have been with a more traditional method. However, a p-value of 0.41 indicates that the data is not significant, so further research would have to be conducted to determine the true relationship between age and the success of intubation.

3.7 Intubation Success versus Reason for Intubation

The final point of analysis is the comparison of intubation success versus the reason for it. Of 19 patients, ten suffered from cardiac/respiratory arrest, five suffered from drug overdoses, two were found unresponsive, one suffered an asthma attack, and one fell. Although this data set is larger than in previous analyses, the patients who suffered from asthma and a fall were disregarded because there is absolutely no way to know what a trend may look like when there is only one patient in a category. The other categories and the success rates of intubation are shown in Figure 16.

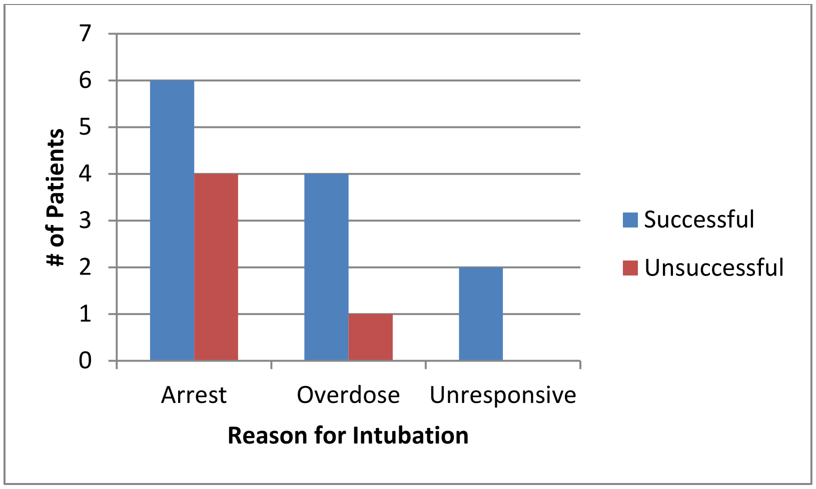

Figure 16: Reason for Intubation v. Success of Intubation

The two unresponsive patients were both successfully intubated, as seen in Figure 16, possibly due to a lack of trauma. Both the arrest and overdose categories, however, showed more success than not, although less so in the arrest category. It may be beneficial to research further into why patients suffering from cardiac/respiratory arrest appear to have a nearly 50/50 chance of successful intubation. However, this proportion may appear differently with more data.

4 Conclusions and Future Research

First and foremost, more data is required to draw any conclusions from these analyses. However, the comparisons made provide a template for the analyses that should be done once more data is available. Also, the data collected, despite the lack of significance demonstrated, provided insight into the topic in a way that could direct future research into specific facets of it. While the initial concern was the airway content of a patient and their subsequent potential to develop pneumonia due to aspiration, other points of interest are now the possibility of drug overdoses making a patient even more prone, or how the success rate of intubation may correspond with the likelihood of aspiration.

Hospital- and Ventilator-Associated Pneumonia are significant and noted problems in hospitals and may begin in the pre-hospital setting. Searching for the situations that make it more likely to occur is an important area of research – and from what has been witnessed in the comparisons made in this paper, the reason for intubation and the success of the intubation seem to be some of the most important categories. While any patient may be found with secretions or debris in their airway, it is possible that other aspects of their condition may be more important to note when it comes to preventing VAP.

To further analyze the topics presented here for use in the hospital, several factors need to be considered. First, the patients presented in the hospital setting would generally not be intubated for emergency reasons, and therefore a complete medical history and exam could be performed. Also, when considering patients in this setting are often examined prior to their surgery or other medical procedure, potential issues such as those discovered in the pre-hospital setting will not arise as often (lack of space or materials). For these reasons, some of the factors, such as debris in the airway, can be eliminated through the use of a suctioning tool, or fasting before extensive medical procedures, which is routine. However, for those patients in a hospital, topics for investigation could include more vast studies relating to co-morbidities, such as asthma or COPD. These afflictions may result in pneumonia due to extended intubations of the patient, rather than due to the process of intubation itself. Other in-hospital studies could include information concerning a patient's behavior, such as smoking or drug use, which could be lent to further investigation of intubation and how it may relate to aspiration pneumonia.

Although the data presented here is not significant, it provides a model for future research in this area and an insight into the extent of variables present. Regardless, research such as this is never absolute, and such ambiguous areas in healthcare must be continuously and thoroughly explored in order to provide the best care.

5 References

Adnet, F., Borron, S., Racine, S., Clemessy, J., Fournier, J., Plaisance, P., et al. (1997). The intubation difficulty scale (IDS): proposal and evaluation of a new score characterizing the complexity of endotracheal intubation. *Anesthesiology*, 1290-1297.

Cooper, R. M. (2007). Complications associated with the use of the GlideScope videolaryngoscope. *Anesthesia*, 54-57.

Cooper, R. M. (2008). *GlideScope Video Laryngoscopes: Case Studies in Airway Versatility*. Retrieved March 15, 2011, from The Science Behind Patient Outcomes: http://www.anesthesiologynews.com/download/ANSE08_GlideScopeWM.pdf

EastMed Enterprises Inc. (2011). *Conventional Reusable English Macintosh Laryngoscope Blades*. Retrieved April 26, 2011, from DiscountLaryngoscope.com: http://www.discountlaryngoscope.com/smallbuttonaidzipperpull-3-1.aspx

GraphPad Software, Inc. (2005). *QuickCalcs*. Retrieved April 26, 2011, from http://www.graphpad.com/quickcalcs/mcnemar1.cfm

Habib, A. S., Parker, J. L., Maguire, A. M., Rowbotham, D. J., & Thompson, J. P. (2002). Effects of remifentanil and alfentanil on the cardiovascular responses to induction of anaesthesia and tracheal intubation in the elderly. *British Journal of Anaesthesia*, 430-433.

Hawkins, M. R. (2011). *The GlideScope Ranger - A Unique Case Study*. Retrieved March 13, 2011, from Verathon: http://verathon.com/language/en-us/contentpages/glidescoperangercasestudy.aspx

Helm, M., Hossfeld, B., Shafer, S., Hoitz, J., & Lampl, L. (2006). Factors influencing emergency intubation in the pre-hospital setting - a multicentre study in the German Helicopter Emergency Medical Service. *British Journal of Anaesthesia*, 67-71.

Mangolds, V. (2011, March 7). GlideScope Intubation. (S. Crovello, & H. Gustafson, Interviewers)

MedcomAnimation. (2008, August 19). Endotracheal Intubation Animation Sample. England: foundationskills.net.

Medscape. (2007, June 25). *Healthcare-Associated Pneumonia*. Retrieved February 23, 2011, from Medscape Pulmonary Medicine: http://www.medscape.org/viewarticle/558518

Nydam, R. (2011, March 8). GlideScope Intubation in Emergency Settings. (S. Crovello, & H. Gustafson, Interviewers)

Savoldelli, G. L., Schiffer, E., Abegg, C., Baeriswyl, V., Clergue, F., & Waeber, J. L. (2008). Comparison of the GlideScope, the McGrath, the Airtraq and the Macintosh laryngoscopes in simulated difficult airways. *Journal of the Association of Anaesthetists of Great Britain and Ireland*, 1358-1364.

Sun, D., Warriner, C., Parsons, D., Klein, R., Umedaly, H., & Moult, M. (2005). The GlideScope Video Laryngoscope: randomized clinical trial in 200 patients. *British Journal of Anaesthesia*, 381-384.

Swaminathan, A. (2010, March 15). *Pneumonia, Aspiration*. Retrieved February 27, 2011, from emedicine: http://emedicine.medscape.com/article/807600-overview

Verathon. (2009). *Video Laryngoscopy*. Retrieved March 21, 2011, from http://videolaryngoscopy.com/illustrations_gallery.htm

Verathon. (2011). *GlideScope Video Laryngoscopes*. Retrieved February 20, 2011, from Verathon: http://verathon.com/language/en-us/products/glidescope.aspx

Volturo, J. (2011, February). GlideScope Video Laryngoscope Database. Worcester, Massachusetts, USA: UMMMS.

Wang, H., & Yealy, D. (2006, October 11). *Verathon Inc. Introduces GlideScope Ranger Video Laryngoscope for Fast Intubations in Military and Emergency Settings*. Retrieved February 27, 2011, from Verathon: http://verathon.com/Portals/0/Uploads/Press_Releases/0900-1333-01-86.pdf

Weisberg, S. (2010). *Protocol Summary*. Worcester: UMMMC.

Wise County EMS. (2008). GlideScope Ranger. Texas, USA.

Yentis, S. M. (2002). Predicting difficult intubation--worthwhile exercise or pointless ritual? *Anaesthesia*, 105-109.

Zadrobilek, E. (1999, October 1). *Internet Journal of Airway Management*. Retrieved April 26, 2011, from http://www.adair.at/ijam/default.asp