# RISK FACTORS FOR DYSPHAGIA IN CRITICALLY-ILL PATIENTS WITH PROLONGED OROTRACHEAL INTUBATION

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# ABSTRACT

## RISK FACTORS FOR DYSPHAGIA IN CRITICALLY-ILL PATIENTS WITH PROLONGED OROTRACHEAL INTUBATION

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Dysphagia after prolonged orotracheal intubation is reported to increases a patient's risk for aspiration, leading to increased risk for morbidity and mortality. Identification of specific risk factors that may predispose a patient to post-extubation dysphagia and aspiration risk is important. However, previous studies have not consistently identified concrete risk factors of post-extubation dysphagia in critically-ill patients. This two part study sought to identify specific risk factors for post-extubation dysphagia and increased aspiration risk in critically-ill patients. Study A retrospectively and Study B prospectively examined 70 medical and surgical ICU patients who endured mechanical ventilation for >/= 72 hours. Study A participants underwent either a Modified Barium Swallow Study (MBS) or Fiberoptic Endoscopic Evaluation of Swallowing (FEES) examination to objectively identify swallowing disorders. Two independent reviewers analyzed charts from a Speech Pathology database for post-extubation dysphagia. Study B participants underwent a FEES examination to objectively assess swallowing function. Two expert Speech-Language Pathologists (SLPs) that were blinded to the patient's medical diagnoses and purpose of the study conducted the FEES examinations and interpreted their outcomes. A third rater analyzed an additional 20 percent of randomly selected swallows. In both studies, participants were clustered into one of 7 admission diagnoses groups, and one of 5

reasons for intubation groups. Duration of intubation, gender, reintubation, Penetration Aspiration Scale (PAS outcomes) and 4 Point Dysphagia Severity Scale Ratings were analyzed. The results of Study A (retrospective) revealed that age and duration of intubation were independently associated with post-extubation dysphagia severity. The odds of a participant presenting with a more severe dysphagia was increased by 7.5% for each additional year of age (p= 0.009). The odds of a participant presenting with a more severe dysphagia severity rating was increased by 48.2% for each additional day of intubation (p=0.032). Age and duration of intubation were also independently associated with aspiration. The odds of a participant exhibiting aspiration was increased by 4.1% for each additional year of age (p=0.018). The odds of a participant exhibiting aspiration was increased by 25% for each additional day of intubation (p=0.004). Reintubation (0=0.008) was significantly associated with dysphagia severity. Pneumonia (p=0.034) was also significantly associated with increased aspiration risk. The Results of Study B (prospective) demonstrated that age was independently associated with post-extubation aspiration risk. The odds of a participant exhibiting aspiration was increased by 4.5% for each additional year of age (p=0.027). Admission diagnosis, particularly infectious, was significantly associated with aspiration (p=0.046). Excellent inter-rater reliability was demonstrated for 20% of patient's overall dysphagia severity ratings (r=0.918). In conclusion, age was independently significantly associated with increased post-extubation dysphagia severity and aspiration. Further investigation is warranted to examine the risk factors that were only found to be significant in one of the two studies, i.e. duration of intubation, presence of PNA, reintubation and admission diagnosis.

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# DEDICATION

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# I. INTRODUCTION

Preliminary research substantiates that traumatic causes of laryngeal dysfunction, such as orotracheal intubation, may cause significant harm to laryngeal structures and function, thus, potentially impeding efficient swallowing function (Bhattacharrya, Kotz, & Shapiro, 2005; Heitmiller, Tseng, & Jones, 2000; Leder & Ross, 2005; Ollivere, Duce, Rowlands, Harrison & O'Reilly, 2005; Skoretz, Flowers, & Martino, 2011). Consequently, various degrees and duration of deglutitive deficits have been reported to result from orotracheal intubation. The impact of orotracheal intubation on the occurrence of dysphagia in critically-ill patients is unclear (Macht, Wimbish, Clark, Benson, Burnham, Williams & Moss, 2011). A thorough understanding of the relationship between swallowing dysfunction after orotracheal intubation is important because the presence of dysphagia increases the risk of morbidity and mortality after prolonged intubation (Bordon, Bokhari, Speery, Testa, Feinstein, & Ghaemmaghami, 2011; Macht et al., 2011; Rabinowitz & Caplan, 1999; Skoretz et al., 2011). Identification of specific risk factors that may predict swallowing dysfunction is essential to identify critically-ill patients that are at high aspiration risk. By prophylactically identifying specific indicators of post-extubation dysphagia, more stringent criteria for referral for swallowing assessment can be obtained. A better understanding of the risk factors related to post-extubation dysphagia is important for accurate and prompt diagnostic and therapeutic intervention. This research study would help clinicians and other health care providers identify patients that exhibit specific medical issues that are significantly related to the increased likelihood of exhibiting post-extubation dysphagia. This would facilitate identification of aspiration

risk and minimize the potential for poor patient outcomes. The purpose of this study was to test the hypothesis that specific risk factors are reliable indicators of post-extubation dysphagia in critically-ill patients.

Before discussing the literature specific to this study, it is appropriate to provide brief background information about normal swallow function and definition of dysphagia.

## II. NORMAL SWALLOWING PHYSIOLOGY

Swallowing, also known as deglutition, involves the safe and efficient transport of a bolus from the oral cavity to the gastrointestinal tract (Van Der Bilt, Engelen, Pereira, Van Der Glas, & Abbink, 2006). Deglutition is divided into three phases: oral (preparatory and transit) pharyngeal and esophageal. Overall coordination and efficiency of each phase of swallowing is dependent on the texture and volume of the ingested bolus (Dantas et al., 1990b; Dodds, 1989; Engelen et al., 2005; Ruark et al., 2002; Steele & Van Lieshout, 2004).

### i. Oral Preparatory Phase

The purpose of the oral preparatory stage is to manipulate food or liquid in the oral cavity, for preparation of a safe and productive swallow (Dantas & Dodds, 1990; Dantas, Kern, Massey, Dodds, Kahrilas, Brasseur, Cook & Lang, 1990; Engelen, Fontijn-Tekamp, & Van Der Bilt, 2005; Logemann, 1998; Mishellany, Woda, Labas, & Peyron, 2006; Soboleva, Laurina, & Slaidina, 2005; Van Der Bilt et al., 2006). The chewing cycles of a bolus are dependent upon the texture, size, hunger, and particular

preferences of the individual (Dantas & Dodds, 1990; Dantas et al., 1990; Engelen et al., 2005; Hamlet, 1996; Kahrilas, 1993; Mishellany et al., 2006; Soboleva et al., 2005; Steele & Van Lieshout, 2004; Van Der Bilt et al., 2006). The viscosity of a bolus determines the movement patterns of the oral preparatory phase. This has been demonstrated in studies where high viscosity boluses resulted in longer swallow durations than low viscosity boluses (Dantas & Dodds, 1990; Dantas et al., 1990; Engelen et al., 2005; Pedersen, Bardow, Jensen & Nauntofte, 2002; Steele & Van Lieshout, 2004; Van Der Bilt et al., 2006).

Regardless of the consistency, a seal is maintained by the lips to prevent the loss of food, liquid or saliva from the oral cavity (Van Der Bilt et al., 2006). The tongue plays a crucial role in the oral preparatory stage. Adequate lingual strength and coordination are vital for manipulation of the bolus for a safe swallow (Dodds, 1989; Miller, 1982; Soboleva et al., 2005; Van Der Bilt et al., 2006; Youmans & Stierwalt, 2006). Finely tuned and organized lingual control facilitates formation of a cohesive bolus and prevents the bolus from prematurely entering the oropharynx (Miller, 1982; Mishellany et al., 2006; Van Der Bilt et al., 2006).

Cyclic and lateral motion of the mandible and tongue are necessary for mastication (Soboleva et al., 2005; Van Der Bilt et al., 2006). This is achieved by crushing food via contact of upper and lower dentition within the oral cavity (Logemann, 1998; Mishellany et al., 2006; Soboleva et al., 2005; Van Der Bilt et al., 2006). The material on the medial tongue is then pushed back to the upper and lower teeth in a repeated manner until a semi-cohesive bolus is formed. The number and duration cycle is highly individualized (Engelen et al., 2005; Mishellany et al., 2006;

Soboleva et al., 2005). Throughout this cyclic sequence, saliva is mixed with the material to lubricate and form a bolus (Dodds, 1989; Engelen et al., 2005; Miller, 1982; Mishellany et al., 2006; Pedersen et al., 2002; Soboleva et al., 2005; Van Der Bilt et al., 2006). Musculature of the cheeks prevents residual material from pooling between the mandible, lips and cheeks in the lateral or anterior sulci of the oral cavity during mastication. Once mastication has ceased, a cohesive ball is formed and placed on the medial furrow of the tongue against the hard palate (Engelen et al., 2005; Kahrilas, 1993; Pedersen et al., 2002; Van Der Bilt, et al., 2006). The oral preparation for a liquid bolus is less intricate than a solid bolus. The tongue surrounds the liquid bolus and holds this material in place until the oral transit phase is initiated. The oral preparatory phase does not have a designated duration of time due to great variability.

### ii. Oral Transit

The purpose of the oral (transit) phase is to propel the bolus from the oral cavity into the pharynx for a pharyngeal swallow (Miller, 1982; Martin-Harris, 2006; Van Der Bilt et al., 2006). This is achieved by sequential anterior to posterior peristaltic tongue movements that compress the bolus against the medial groove of the tongue and the hard and soft palate (Hori, Ono, Iwata, Nokubi & Kumakura, 2005; Kahrilas, Lin, Logemann, Ergun, & Facchini, 1993; Van Der Bilt et al., 2006). This results in a central furrow, which serves as an incline for the bolus to be propelled posteriorly into the pharynx. The tongue also serves a protective function in which this structure prevents the bolus from entering the pharynx or larynx until the appropriate volume, and texture

is achieved to ensure a safe swallow (Dodds, 1989; Martin-Harris, 2006; Soboleva et al., 2005; Van Der Bilt et al., 2006).

The base of tongue is the primary pressure generator to propel the bolus from the oral cavity into the pharynx (Hori et al., 2005; Martin-Harris, 2006). As bolus texture thickens, greater lingual musculature is needed for adequate propulsion of the bolus into the oropharynx (Engelen et al., 2005; Hori et al., 2005; Soboleva et al., 2005; Van Der Bilt et al., 2006; Youmans & Stierwalt, 2006). The oral phase is completed when the oral cavity is cleared of all bolus material and a swallow is triggered (Kahrilas et al., 1993). The bolus is contained at the glossopalatal junction (Kahrilas et al., 1993). The duration and size of the opening of the glossopalatal juncture is dependent on the volume and consistency of the bolus (Kahrilas et al., 1993). This phase takes approximately 0.9 to 1.5 seconds to finalize (Sonies, Parent, Morrish & Baum, 1988; Tracy, Logemann, Kahrilas, Jacob, Kobara & Kruger, 1989).

### iii. Pharyngeal Phase

The most intricate phase of swallowing is the pharyngeal stage. In order for this phase to occur, a swallow must be initiated by a series of physiological events within the larynx (Dodds, 1989; Engelen et al., 2005). The exact nature of the triggering of the pharyngeal swallow is highly variable among swallowing specialists (Kendall, 2002). Many researchers consider the initiation of the pharyngeal swallow to be the point where the bolus head traverses any location bordering the anterior faucial arches and the point where the tongue base passes the inferior perimeter of the mandible (Palmer, Rudin, Lara, & Crompton, 1992; Stephen, Taves, Smith & Martin, 2005).

Although great variation exists, a swallow should be triggered no later than at the point where the bolus head arrives at the tongue base for all age groups. If a pharyngeal swallow is not initiated at this juncture, this stage is deemed delayed (Linden, Tippett, Johnston, Siebens, & French, 1989; Stephens et al., 2005).

There are numerous well-coordinated physiological events that occur after a pharyngeal trigger (Engelen et al., 2005; Kendall, 2002; Kahrilas et al., 1993; Martin-Harris, Brodsky, Michel, Ford, Walters, & Heffner, 2005a; Martin-Harris, Michel, & Castell, 2005b; Miller, 1982; Shaker & Hogan, 2003). Retraction and elevation of the velum seals the velopharyngeal port to prevent material from entering the nasopharynx and enables pressure to generate within the pharynx (Kahrilas, 1993; Shaker, 1993; Shaker & Hogan, 2003). Complete velopharyngeal closure is achieved via the levator veli palatini, the tensor veli palatini, and the palato pharyngeus muscles (Kahrilas et al., 1993). Another physiological occurrence is the superior and anterior movement of the hyoid bone and larynx via contraction of the suprahyoid musculature (the anterior belly of the digastric, mylohyoid, geniohyoid, and stylohyoid, and infrahyoid musculature i.e. the thyrohyoid (Ishida et al., 2002; Kahrilas, 1993; Shaker & Hogan, 2003). This displacement is highly variable and may result in either small or large amplitude movements (Ishida et al., 2002; Palmer, 1997). A significant correlation was found for the volume of a bolus and hyoid bone displacement, movement was greatest for larger volumes of boluses than smaller bolus volumes (Ishida, Palmer, & Hiiemae, 2002). The third physiological event is laryngeal closure of three laryngeal sphincters to prevent foreign materials from entering the airway (Shaker & Hogan, 2003). The first two tiers of laryngeal sphincters are medialization and anterior tilt of the arytenoids towards the

base of the epiglottis. This is followed by adduction of the true vocal folds, which results in closure of the trachea from airway invasion (Shaker & Hogan, 2003). The last tier of laryngeal closure is retroversion of the epiglottis, which closes off the laryngeal vestibule (Langmore, 2001; Shaker & Hogan, 2003). These airway protective mechanisms result in the elevation and anterior displacement of the larynx beneath the base of tongue. This provides further protection of the airway and constructs a clear path for the bolus to pass through the gastrointestinal tract (Shaker & Hogan, 2003). Secondary to laryngeal elevation, the cricopharyngeal muscle/upper esophageal sphincter (UES) is opened via interruption of muscular tension and anterior and superior movement of this region via the supra and infra hyoid musculature (Cook, 1993; Kahrilas et al., 1993; Leonard, Kendall, & McKenzie, 2004; Shaker & Hogan, 2003). The Upper Esophageal Sphincter (UES) is located at the juncture between the pharynx and the esophagus. It serves numerous vital protective functions. The cricopharyngeal sphincter is the most proximal barrier for gastrointestinal reflux and therefore, protects the pharynx and airway from gastric contents (Cook, 1993; Leonard et al., 2004; Singh & Hamdy, 2005). Additionally, the UES's principal function is to regulate the flow of substances from the pharynx and esophagus (Cooke, 1993; Leonard et al., 2004; Singh & Hamdy, 2005). Synchronization of UES opening with pharyngeal driving forces is imperative for complete transfer of the ingested bolus into the esophagus (Cook, 1993; Imam, Shay, Ali, & Baker, 2005; Kendall, 2002; Leonard et al., 2004; Shaker & Hogan, 2003; Singh & Hamdy, 2005). The diameter and duration of cricopharyngeal sphincter opening is dependent on the volume and viscosity of the ingested bolus, where larger volumes increase diameter and extent of UES opening

(Kendall, 2002; Kahrilas, et al., 1993; Leonard et al., 2004; Shaker & Hogan, 2003; Singh & Hamdy, 2005). Increases in pressure also influence the diameter of the cricopharyngeal juncture (Leonard et al., 2004). The UES returns to its resting position upon completion of bolus transfer from the pharynx to the esophagus. The final physiological activity involves pharyngeal wall contraction and longitudinal shortening (Imam et al., 2005; Kahrilas et al.,, 1993). Pharyngeal shortening occurs at the commencement of the swallow, while contractions are initiated at the conclusion of the swallow (Kahrilas et al., 1993). This facilitates pharyngeal pressure to drive the bolus through the pharynx and into the esophagus. Pressure is generated when the tongue base and pharyngeal wall make total contact, which creates a peristaltic wave to help bolus propulsion (Hiss, Strauss, Treole, Stuart & Boutilier, 2003; Imam et al., 2005; Kendall, 2002; Kahrilas et al., 1993; Martin-Harris et al., 2005b). Pressure generated by the tongue base and pharyngeal contractions intensifies as bolus viscosity and volume increase (Kendall, 2002; Kahrilas et al., 1993; Shaker & Hogan, 2003). This phase of deglutition lasts approximately .6 (Dodds, 1989) to 1.0 second to finish (Martin-Harris, 2006; Sonies et al., 1988).

### iv. Swallowing Apnea Period

Swallowing and respiration are highly intricate processes. A reciprocal relationship exists, known as swallowing apnea. Respiration must cease and airway closure must transpire in order to permit safe and efficient transport from the oral cavity to the pharynx (Hiss et al., 2003; Hirst, Ford, Gibson, & Wilson, 2002; Kendall, 2002; Klahn & Perlman, 1999; Miller, 1982; Martin-Harris et al., 2005; Perlman et al., 2000;

Shaker & Hogan, 2003). This airway protective mechanism occurs during the pharyngeal stage of deglutition (Martin-Harris et al., 2005a; Martin-Harris et al., 2005b; Miller, 1982; Palmer & Hiiemae, 2003). The average duration of a pharyngeal apnea period is .75 seconds (Klahn & Perlman, 1999; Perlman, Ettema, & Barkmeier, 2000). The time interval during which the apnea period occurs has been found to increase with larger bolus volumes, ranging from 1.06 to 1.24 seconds (Hirst et al., 2002).

### v. Esophageal Phase

The esophageal phase is the final stage of swallowing. The purpose of this phase is to carry the bolus from the upper esophageal sphincter through the lower esophageal sphincter (LES) and into the stomach. This is achieved via peristaltic waves that are originated in the pharynx (Cook, 1993; Imam et al., 2005; Shaker & Hogan, 2003). The peristaltic waves propel the bolus through the esophagus in a consecutive manner. Adequate bolus transfer into the esophagus depends on the coordination of sphincter relaxation with pharyngeal bolus transport (Cook, 1993; Imam et al., 2005; Kendall, 2002; Leonard et al., 2004; Singh & Hamdy, 2005). Once the bolus reaches the stomach deglutition is complete. The esophageal phase takes between 8 to 20 seconds to complete (Dodds et al., 1973).

### vi. Dysphagia

Aberrant sensorimotor patterns may occur in one or more of the phases of deglutition. Swallowing dysfunction may result from behavioral, sensory and/or motor impairments (Morton, Minford, Ellis, & Pinnington, 2002; Murray, 1999; Prosiegel, Heintze, Wagner-Sonntag, Schenk, & Yassouridis, 2000; Ramsey, Smithard, & Kalra,

2005; Sellars, Campbell, Stott, Stewart & Wilson, 1999). Difficulty transporting a bolus or saliva from the oral cavity into the stomach is referred to as dysphagia. Dysphagia is a consequence of a preexisting disease or condition, and rarely occurs in isolation (Kendall, McKenzie, Leonard, Goncalves & Walker., 2000; Kuhlemeier, 1994). Prolonged orotracheal intubation has been reported frequently as a potential cause of dysphagia in adult and geriatric patients.

## III. LITERATURE REVIEW

### i. Orotracheal Intubation

Orotracheal intubation provides airway patency, protection, and artificial respiration via mechanical ventilation for patients undergoing elective and urgent surgical procedures, and/or in patients with respiratory compromise secondary to medical decline. Orotracheal intubation involves the forceful insertion of a tube connected to a mechanical ventilator into the oropharynx, which is passed through the larynx and directly below the vocal folds into the trachea.

Approximately 790,000 patients endure orotracheal intubation due to acute respiratory failure within the United States annually (Behrendt, 2000; Wunsch, Lunde-Zwirble, Angus, Hartman, Miltbrandt & Kahn, 2005). Amongst these patients, current literature reports a survival rate from 62%-69% after orotracheal intubation (Dasta, McLaughlin, Mody & Tak Piech, 2005; Esteban, Anzueto, Frutos, Alia, Brochard, Stewart, Bento, Epstein, Apezteguia, Nightingale, Arroliga, 2002; Garland, Dawson, Altman, Thomas, Phillips, Tsevat, Desbiens, Bellamy, Knaus & Connors, 2004; Macht, King, Wimbish, Clark, Benson, Burnham, Williams & Moss 2012; Wesley, Wheeler,

Thompson, Ancukiewicz, Steinberg & Bernard, 2002; Wunsch et al., 2010). Survival rate and duration of life after extubation is decreased for patients with increased age, male gender, multiple medical co-morbidities and discharge to other medical care facilities (Dasta et al., 2005; Ely, Wheeler, Thompson, Ancukiewicz, Steinberg & Bernard, 2002; Garland et al., 2004). Older patients have been found to require increased length of intubation and increased length of stay (LOS) in intensive care units (ICU) (Behrendt, 2000; Ely et al., 2002; Garland et al., 2004). Average length of stay (LOS) for ICU patients with orotracheal intubation has been found to range from 10 to 18.5 days Ely et al., 2002; Esteban et al., 2002; Garland et al., 2004). Patients that survive extubation, often present with long term medical, emotional and physical ramifications (Dasta et al., 2005; Garland et al., 2004; Macht et al., 2011; Macht, King, Wimbish, Clark, Benson, Burnham, Williams & Moss, 2013; Wunsch et al., 2005). Longitudinal and retrospective studies have shown that approximately 48% of patients who survive extubation will require ongoing assistance with daily activities several months after hospital discharge (Garland et al., 2004; Wunsch et al., 2005).

Approximately 12% ($270 Billion) of all US hospital costs are attributed to mechanical ventilation (Wunsch et al., 2010). ICU patients who endured mechanical ventilation cost almost three times as much as ICU patients who do not require mechanical ventilation (Dasta et al., 2005). The median cost for an ICU patient on a ventilator is $31,574 per day, whereas a non-ventilated ICU patient would cost on average $12,931 (Dasta et al., 2005). Mechanical ventilation creates a substantial fiscal burden on medical institutions. Improvements in inpatient care techniques and cost

effective measures may prevent the need for potential intubation and/or reintubation as medically appropriate.

### ii. Orotracheal Intubation and Dysphagia

Acute ephemeral changes in swallowing function, secondary to orotracheal intubation have been examined (Skoretz et al., 2011). A review of the literature has suggested, at minimum, temporary detrimental ramifications to one or more of the laryngeal subsystems (Ajemian, Nirmul, Anderson, Zirlen, & Kwasnik, 2001; Bordon et al., 2011; DeVita & Spierer-Rundback, 1990; El Solh, Okada, Bhat, & Pietrantoni, 2003; Leder, Sasaki, & Burrell, 1998; Macht et al., 2011; Skortez et al., 2011; Tolep, Leonard-Getch, & Criner, 1996). Prolonged orotracheal intubation may result in post-extubation consequences, and mechanical dysfunction of the laryngeal subsystems, particularly swallowing. This is attributed to the fact that the presence of an endotracheal tube may result in potential post-extubation damage or injury to laryngeal mucosa, alteration in upper airway sensation via injury to the chemo- and/or mechanoreceptors of the larynx, atrophy of laryngeal musculature, and modification of the biomechanics of the laryngeal subsystems (de Larminat, Montravers, Dureuil, & Desmonts 1995; DeVita & Spierer-Rundback, 1990; El Solh et al., 2003; Kikura, Suzuki, Itagaki, Takada, & Sato, 2007; Leder et al., 1998; Tolep et al., 1996). Extended immobility of the laryngeal muscles may also play a crucial role in deviation of efficient laryngeal functioning. In particular, post-extubation dysphagia may occur from disuse and muscular atrophy. This results in oropharyngeal weakness and discoordination (DeVita & Spierer-Rundback, 1990). Also, hypoxemia, or reduced

oxygen saturation levels, can further impair swallowing motoric mechanisms (de Larminat et al., 1995). Pharmacological sedative may also alter and cause latency in the physiological sequencing of the laryngeal subsystems (de Larminat et al., 1995; Tolep et al., 1996).

The prevalence of the consequences of prolonged intubation on swallowing function varies within the literature (Macht et al., 2011; Skoretz et al., 2011). The incidence of post extubation dysphagia has been reported to range from 20% to 83% (Ajemian et al., 2001; Barquist, Brown, Cohn, Lundy, & Jackowski, 2001; Bordon et al., 2011; El Solh et al., 2003; Leder et al., 1998; Macht et al., 2011; Macht et al., 2013; Skoretz et al., 2011). The preliminary research validates that potential traumatic causes of laryngeal dysfunction, such as, orotracheal intubation may cause substantial harm and disuse atrophy to laryngeal structures and function, therefore, significantly hindering functional deglutition (Bhattacharrya et al., 2005; Heitmiller et al., 2000; Leder & Ross, 2005; Ollivere et al., 2005; Skoretz et al., 2011).

Accordingly, divergent extent and persistence of deglutitive deficits have been yielded from orotracheal intubation, where abnormal pathways of the bolus (liquid and solid textures) from the oral cavity to the esophagus have been illustrated after prolonged orotracheal intubation. The alteration of swallowing physiology significantly increases an individual's risk of penetration into the laryngeal vestibule and airway invasion, known as aspiration. Aspiration results from the passing of foreign material below the subglottic surface of the vocal folds and into the trachea. Aspiration significantly increases one's risk of morbidity and mortality (Kikura et al., 2007; Tolep et al., 1996).

### iii. Risk Factors of Dysphagia After Prolonged Intubation

Although several research studies have demonstrated a high correlation between prolonged orotracheal intubation and alteration in swallowing function and safety, the effect of orotracheal intubation on the occurrence of deviant swallowing in critically-ill patients is largely inconsistent (Macht et al., 2011). A more thorough understanding of the relationship between swallowing dysfunction occurring as a result of orotracheal intubation is important. This is of significance because dysfunction of the swallowing mechanism increases the risk of dysfunctional swallowing and consequent airway compromise, thereby increasing the potential for aspiration pneumonia and related medical consequences (Ajemain et al., 2001; DeVita & Spierer-Rundback, 1990; Leder et al., 1998; Macht et al., 2011; Skoretz et al., 2011). These consequences in turn increase the risk of morbidity and mortality after prolonged intubation and thereby increasing length of stay (LOS) in intensive care units (ICU) (Bordon et al., 2011; Macht et al., 2011; Rabinowitz & Caplan, 1999; Skoretz et al., 2011; Tolep et al., 1996). The presence of post-extubation dysphagia has been associated with the number of hospital days admitted, discharge status, and feeding status (Macht et al., 2011). Furthermore, persistent severe post-extubation dysphagia is associated with an increased risk of re-intubation, development of pneumonia, longer hospital stay, reduced dietary intake, placement of feeding tubes, discharge to a nursing home and increased risk of death (Macht et al., 2011). Increased LOS due to medical complications is of concern because it generates an unnecessary and enhanced financial and resource burden on health care institutions. Therefore, identification of specific

risk factors that are reliable indicators of swallowing dysfunction is important for identifying critically-ill patients that are at high aspiration risk. By preemptively identifying specific indicators of potential swallowing disorder after prolonged intubation, more stringent criteria for referral for swallowing assessment can be determined. In particular, a greater understanding of the relationship between prolonged orotracheal intubation and dysphagia is necessary to facilitate accurate diagnosis and intervention techniques within this population. Further research is needed to examine the relationship of laryngeal subsystem deviation after prolonged intubation and dysphagia in efforts to enhance identification of aspiration risk and minimize the potential for patient morbidity.

Despite the fact that several research studies have demonstrated a high correlation between prolonged orotracheal intubation and alteration in swallowing function, identification of specific risk factors for identification of post-extubation dysphagia is highly variable within the literature. Numerous studies have demonstrated that increased duration of orotracheal intubation result in significantly larger incidence and duration of oropharyngeal dysphagia (Ajemian et al., 2001; Bordon et al., 2011; DeVita & Spierer-Rundback, 1990; Leder et al., 1998; Macht et al., 2011; Tolep et al., 1996). Macht and colleagues (2011& 2012) and Partik and colleagues (2000) demonstrated that over 84% of post-extubation patients presented with swallowing dysfunction. Particularly in two of Macht's studies (2011 & 2012), increased duration of intubation, the occurrence of reintubation and male gender were significantly associated with increased the severity of swallowing dysfunction in these patients (Macht et al., 2011; Macht et al., 2013). It should be noted that these studies did not

utilize a formalized diagnostic standard for dysphagia, such as Modified Barium Swallow Studies (MBS) or Fiberoptic Endoscopic Evaluation of Swallowing (FEES). Over two-thirds of patients in the initial cohort did not have an evaluation for dysphagia. Hence, deviant swallowing patterns were not objectively attained. As a result, the actual incidence of dysphagia among patients in these experiments is difficult to ascertain.

Several other studies have demonstrated a higher prevalence of aspiration in patients with intubation times and increased age (Barquist et al., 2001; Bordon et al., 2011; de Larminat et al., 1995; El Solh et al., 2003; Kikura et al., 2007; Leder et al., 1998; Macht et al., 2011; Tolep et al., 1996). These studies demonstrated that emergent orotracheal intubation results in significantly greater independent post-extubation adverse consequences. The findings were pronounced in older patients with greater duration of orotracheal intubation (Barquist et al., 2001; Bordon et al., 2011; El Solh et al., 2003; Kikura et al., 2007; Macht et al., 2011; Skoretz et al., 2011; Tolep et al., 1996).

Bordon and colleagues (2011) illustrated that elder trauma patients presented with a 2.5 higher susceptibility to dysphagia than younger participants. In this study, the only two independent risk factors for post-extubation dysphagia were age greater than 55 years, and the number of days on a ventilator. This risk exponentially increased by 14% with each additional day on a ventilator (Bordon et al., 2011). As in Macht (2011 and 2013), this rate of susceptibility may be even higher than demonstrated by Bordon and researchers (2011). This is attributed to the fact that the incidence of silent aspiration was not taken into account and formalized instrumentation techniques to

evaluate dysphagia such as MBS or FEES were not utilized. Additionally, since many of these patients may have presented with head trauma, the potential for a neurogenic-related dysphagia was not taken into account for the research outcomes.

Barquist and colleagues (2001) illustrated that 27 % of older patients (>55 years) were significantly more likely to present with severe swallowing dysfunction post extubation. Thus, increased age and greater duration of ventilator support was found to be indicative of increased incidence of swallowing dysfunction and latency in recovery of deglutition. As duration of intubation increases, spontaneous recovery of swallowing function has been found to occur at later time intervals. Increased intubation time and age were found to be strongly associated with increased patient morbidity and mortality, length of stay in the hospital and the need for alternative means of nutrition and hydration (Barquist et al., 2001; Macht et al., 2011; Macht et al., 2013).

Although numerous studies demonstrated a significant relationship between increased age and increased duration of intubation on swallow dysfunction, other studies have failed to illustrate statistical significance of age or duration of intubation as risk factors for dysphagia. In particular, El Solh and colleagues (2003) found that 52% of subjects in the over 65 years of age group aspirated, compared with 36% of subjects in the under 65 years old age group. They further showed that this disparity was evident at two weeks post initial assessment. Dysphagia completely absolved in the younger cohort, while 13% of the geriatric patients presented with persistent dysphagia (Bordon et al., 2011; El Solh et al., 2003; Macht et al., 2011). Despite these outcomes, age was not found to be a statistically significant predictor of swallowing dysfunction

after correction for level of independence scores and medical comorbidities. Therefore, the authors indicated that that age was not correlated with an increase in swallowing dysfunction. The researchers experimental design choice to divide patients into age groups at greater than or equal to 65 rather than greater than or equal to 55 years of age may be a factor as to why age was not indicated as a statistically significant predictor of aspiration. Hence, this is a potential contributing factor as to why the research outcomes did not corroborate with the findings of other studies in which age was identified as a significant predictor of dysphagia after prolonged intubation.

In addition, de Larminat et al., (1995) disparately illustrated transient deviant swallowing function after prolonged orotracheal intubation. Contrastingly to other studies, where only a brief initial dysphagia was noted, age and duration of intubation were found to have no correlation with alteration in swallowing (de Larminat et al., 1995). This study demonstrated that immediately after extubation, patients exhibited a significantly increased latency in swallow trigger, as compared to patients who had not been intubated. Unlike other studies, temporal latency in the swallow trigger and persistence of swallowing dysfunction were not apparent after two days post-extubation. This is likely attributed to the fact that de Larminat and colleagues (1995) defined prolonged intubation as greater than 24 hours on a ventilator. Other studies did not constitute an intubation as prolonged unless the patient endured mechanical ventilation for at least 48-72 hours. Moreover, de Larminat and colleagues (1995) utilized small saline boluses (less than 1 milliliter). This type of bolus was used to mimic the chemical properties of secretions. This method makes it difficult to generalize the results of this study to swallowing with larger and more viscous boluses.

Therefore, due to the inconsistencies in the influence of age and duration of intubation, further examination of the significance of these two factors in relation to dysfunction after prolonged intubation with an extended classification period of duration for intubation to be considered 'prolonged' is warranted.

In efforts to further clarify the incidence and potential risk factors of dysphagia after prolonged intubation, Skoretz, Flowers, and Martino (2011) conducted a systematic review of 14 prolonged intubation studies. They investigated the association between dysphagia and intubation duration, and patient characteristics associated with dysphagia. Each study was assessed for risk of bias and poor quality using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach. It was concluded that dysphagia incidence following intubation was variable and ranged widely across studies. The highest frequencies of dysphagia included patients experiencing prolonged intubation periods. In addition, no single medical diagnosis appeared to be associated with a greater risk of dysphagia. Overall, very few studies revealed specific outcomes focusing on dysphagia following intubation. The limitations of these reviewed studies included variations in study design, different descriptions of swallowing impairment, experimental design issues, and bias leading to the under-reporting and over-reporting of dysphagia.

Research also supports a high prevalence of swallowing impairment post-extubation in patients with neurological diagnoses and/or traumatic brain injury (TBI). In fact, a higher prevalence of post-extubation dysphagia has been illustrated in neurogenic patients (93%) in comparison to non-neurogenic patients (Macht et al., 2012; Tolep et al., 1996). In regard to TBI patients, severity of dysphagia has been

deemed more severe than non-TBI patients with prolonged orotracheal intubation (Padovani, Moraes, de Medeiros, de Almeida, & de Andrade, 2008). Despite these findings, previous research has firmly established a high prevalence of dysphagia in neurogenic populations and TBI patients without enduring orotracheal intubation (Padovani et al., 2008; Tolep et al, 1996). Many factors require additional examination. It is unclear whether dysphagia severity is exacerbated by the presence of a neurological impairment after prolonged intubation, if the mechanical ventilator is an independent factor of swallowing dysfunction, or if the neurological condition is the sole contributing factor for dysphagia. In addition, certain neurogenic disorders exhibit an increased propensity for the occurrence of dysphagia regardless of the presence of orotracheal intubation. Also, many patients with neurogenic diagnoses present with cognitive and behavioral challenges, which may also contribute to swallowing dysfunction. Therefore, the presence of a neurological impairment and/or TBI has been consistently identified as a risk factor for swallowing dysfunction after prolonged intubation. However, the research fails to solely recognize prolonged intubation as the sole precipitating factor of dysphagia in neurogenic populations.

### iv. Formal Instrumentation Assessment of Swallowing

Research has consistently demonstrated the imperative role of objective formal instrumentation for accurate and valid diagnosis, assessment, and treatment planning for swallowing impairments. The implementation of a Clinical Dysphagia Evaluation (CDE) is not sufficient for determination of dysphagia, due to its subjective nature, inconsistency of interpretation of clinical parameters, and inability to visualize the

pharyngeal and laryngeal components of deglutition (Aviv, Kaplan, Thompson, Spitzer, Diamond & Close, 2000; Aviv, Kim, Sacco, Kaplan, Goodhart, Diamond, B. & Close, 1998b; Aviv, Kim, Thompson, Sunshine, Kaplan, & Close, 1998b; Daniels et al., 1997; Leder et al., 1998; Lim et al., 2001; McCullough et al., 2000; Murray, 1999). A CDE fails to detect approximately 40% to 60% of individuals who experience aspiration of a bolus (Aviv et al., 1998a; Aviv et al., 1998b; Daniels et al., 1997; Leder et al., 1998; Lim, Lieu, Phua, Seshadri, Ventetasubramanian, Lee & Choo, 2001). Thus, formal instrumentation is important to be used in conjunction with a CDE for swallowing assessment when necessary. Two standard measures are typically employed for formal assessment of dysphagia, Videofluoroscopy (VFSS/ MBS) and Fiberoptic Endoscopic Evaluation of Swallowing (FEES).

### v. Formal Instrumentation of Swallowing After Prolonged Intubation

Several studies have examined the reliability of formal instrumentation techniques for identification of swallowing dysfunction and detection of aspiration after prolonged orotracheal intubation. Modified Barium Swallow Studies (MBS) and Fiberoptic Endoscopic Evaluation of Swallowing (FEES) have been demonstrated as reliable for identification of swallowing dysfunction and aspiration in individuals that have endured prolonged orotracheal intubation (Ajemian et al., 2001; Leder et al., 1998; Partik, Pokieser, Schima, Schober, Stadler, Eisenhuber, Denk & Lechner, 2000). Precise swallowing dysfunction and the pathophysiological etiology for aspiration have been accurately illustrated with these diagnostic techniques (Leder et al., 1998; Partik et al., 2000). However, great variability in swallowing-specific deficits, were found with

these techniques. Therefore, post-extubation patients may show a wide array of swallowing abnormalities. The precise incidence of aspiration after prolonged intubation in these objective instrumentation studies varies greatly from 50 to 86% (Ajemian et al., 2001; Leder et al., 1998; Partik et al., 2000). Variability in reliability may be attributed to patient variability, inter and intra rater inconsistency, and differences between FEES and MBS.

Modified Barium Swallow (MBS)/Videofluroscopy (VFSS):

This widely used formal instrumentation technique, employs the use of barium mixed with various bolus consistencies upon numerous trials to visualize the bony and cartilaginous structures of the head and neck and all three phases (oral preparatory, oral, pharyngeal and esophageal) via the utilization of recorded x-ray images (Broniatowski, 1998; Murray, 1999; Ramsey et al., 2005; Stoeckli et al., 2003; Youmans & Stierwalt, 2006). Since MBS has been recognized as the most reliable identifier of aspiration, this measure is commonly referred to as the "gold standard" for evaluation of swallowing adequacy (Broniatowski, 1998; Daniels, McAdam, Brailey, & Foundas, 1997; Murray, 1999; Ramsey et al., 2005; Sellars et al., 1999; Stoeckli, Huisman, Burkhardt, Seigert, & Martin-Harris, 2003).

Fiberoptic Endoscopic Evaluation of Swallowing (FEES®):

FEES® permits objective, direct transnasal or transoral cross-sectional visualization of the nasopharynx, oropharynx, pharynx, larynx, airway protection forces, vocal fold adduction, and oropharyngeal secretions via the utilization of a

flexible or rigid endoscope (Broniatowski, 1998; Langmore, 1999; Leder et al., 1998; Leder, Acton, Lisitano, & Murray, 2005). FEES® has been found to be the most reliable for identification of penetration and enables greater visualization of the bolus than all other formal instrumentation techniques (Broniatowski, 1998; Colodny, 2002). Also, FEES® is more sensitive to pharyngeal residue than other instrumentation techniques (Langmore, 1991).

### vi. Research Questions and Hypothesis

There is great variability on the risk factors for post-extubation dysphagia. Identification and management of dysphagia secondary to prolonged orotracheal intubation is of great importance due to the risk of medical complications for critically-ill patients. Thus, identification of variables that predict the inter-relationship between extubation and deglutition is important. Identification and implementation of the appropriate measures to be used for accurate assessment and clinical management of disordered swallowing is necessary. Accordingly, dysphagia after prolonged orotracheal intubation was investigated in this research.

Two studies were designed to address this question, one retrospective and one prospective. The retrospective study was needed to examine and identify potential risk factors of post-extubation dysphagia that were identified in previous studies. Retrospective research helps to extraoplate relationships between data that already may exist in archival files. A retrospective study examines exposures to suspected risk factors in relation to an outcome that is established at the start of the study. Additionally, the prospective study was also necessary to further expand on the

outcomes of Study A and to attempt to account for potential experimental design issues that were exhibited in Study A and other previous research studies. Specifically, prospective investigation is required to make precise estimates of either the incidence of an outcome or the relative risk of an outcome based on exposure. Both studies examine risk factors identified from the research literature, specifically, age, days intubated, gender, admission diagnosis and reintubation. Additional risk factors of cause of intubation and Pneumonia (PNA) were also selected to be examined based on the researcher's clinical experience with this particular population. The aim of Study A was to examine retrospectively the hypothesis that the specific risk factors identified through the literature reliably predict post-extubation dysphagia in critically-ill patients. The specific risk factors studied were duration of intubation, increased age, admitting diagnosis, precipitating cause of intubation, the presence of PNA (aspiration) and the need for multiple intubations were significantly associated with increased risk of dysphagia in patients who received prolonged intubation for >= 72 hours. The aim of Study B was to prospectively examine the same risk factors as in Study A and to compare the significance of all post-extubation risk factors in both studies. It was hypothesized that the selected risk factors that were identified as significant in Study A will also be significant indicators of post-extubation dysphagia in individuals who endured prolonged orotracheal intubation in Study B.

## IV. METHODS

### i. Study A: Methods

**1.** ***Subjects:*** A retrospective cohort analysis was conducted of 70 adult and geriatric (>/= 18 years of age) medical and surgical ICU patients from an urban Level I Trauma Hospital that underwent prolonged orotracheal intubation (>/= 3 days) and underwent either a MBS or FEES® study(s). These participants were pooled from 123 consecutive alphabetical patient charts that were intubated for >/= 72 hours. Patients who expired during mechanical ventilation or were terminally-extubated were not included for participation in this study.

#### 1. Demographics:

This study cohort (N=70) had 40 male (57.1%) and 30 female (42.9%) participants (See Table 1) with a mean age of 70.04 with a SD of 17.596 (See Table 1). Thirty-one (44.3%) participants underwent a FEES study and 39 (55.7%) had an MBS examination. The average length of days intubated for all patients was 7.64 with a SD of 3.849 (See Table 2).

**Table 1:** ***Gender***

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 male | 40 | 57.1 | 57.1 | 57.1 |
| | 2 female | 30 | 42.9 | 42.9 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Table 2:** ***Descriptive Statistics Age and Days Intubated***

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Age | 70 | 20 | 95 | 70.04 | 17.596 |
| Days Intubated | 70 | 3 | 18 | 7.64 | 3.849 |
| Valid N (listwise) | 70 | | | | |

## 2. Clusters by Admission Group:

All participants were clustered into one of 7 admission groups for analysis: Group 1: Cardiac 14 (20%), Group 2: Pulmonary 30 (42.9%). Group 3: Infection 4 (5.7%), Group 4: Gastrointestinal 8 (11.4%), Group 5: Hematology/Metabolic 7 (10%), Group 6: Traumatic 4 (5.7%) and Group 7: Alcohol/Narcotics 3 (4.3%) (See Table 3).

**Table 3:** ***Admission Group Clusters***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| Admission Group | 1 cardiac | Count | 9 | 5 | 14 |
| | | % within Gender | 22.5% | 16.7% | 20.0% |
| | 2 pulmonary | Count | 14 | 16 | 30 |
| | | % within Gender | 35.0% | 53.3% | 42.9% |
| | 3 infectious | Count | 3 | 1 | 4 |
| | | % within Gender | 7.5% | 3.3% | 5.7% |
| | 4 gastrointestinal | Count | 4 | 4 | 8 |
| | | % within Gender | 10.0% | 13.3% | 11.4% |
| | 5 hemodynamic/metabolic | Count | 5 | 2 | 7 |
| | | % within Gender | 12.5% | 6.7% | 10.0% |
| | 6 traumatic | Count | 2 | 2 | 4 |
| | | % within Gender | 5.0% | 6.7% | 5.7% |
| | 7 alcohol/narcotics | Count | 3 | 0 | 3 |
| | | % within Gender | 7.5% | .0% | 4.3% |
| Total | | Count | 40 | 30 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

## 3. Clusters by Reason for Intubation:

All patients were also stratified into one of 5 reasons for intubation groups for analysis: Group 1: Cardiac 5 (7.1%), Group 2: Pulmonary 43 (61.4%), Group 3: Infectious 10 (14.3%), Group 4: Airway Protection 8 (11.4%), and Group 5: Hemodynamic 4 (5.7%) (See Table 4). Pulmonary distress (61.4%) was the most common cause of intubation, while hemodynamic instability (5.7%) was the least common cause. The second most prevalent cause of intubation was infectious etiology

(14.3%), followed by airway protection (11.4%) and cardiac complications (7.1%) (See Table 4).

**Table 4:** ***Reason for Intubation Clusters***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| Reason for Int. Group | 1 cardiac | Count | 3 | 2 | 5 |
| | | % within Gender | 7.5% | 6.7% | 7.1% |
| | 2 pulmonary | Count | 25 | 18 | 43 |
| | | % within Gender | 62.5% | 60.0% | 61.4% |
| | 3 infectious | Count | 3 | 7 | 10 |
| | | % within Gender | 7.5% | 23.3% | 14.3% |
| | 4 airway protection | Count | 6 | 2 | 8 |
| | | % within Gender | 15.0% | 6.7% | 11.4% |
| | 5 hemodynamic | Count | 3 | 1 | 4 |
| | | % within Gender | 7.5% | 3.3% | 5.7% |
| Total | | Count | 40 | 30 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

*Inclusion Criteria*: All participants underwent prolonged emergent orotracheal intubation >/= 3 days). All participants were admitted either to the medical or surgical ICU. They exhibited the absence of a neurological diagnosis, head and neck cancer and/or cervical spinal surgery. All participants had a physician order for swallowing assessment after extubation. The participants were >/=18 years of age and all underwent either a MBS or FEES® study.

*Exclusion Criteria*: Patients were excluded if they did not endure orotracheal intubation and or less than 3 days of orotracheal intubation. They were excluded if they had a history of and/or currently a tracheostomy tube. Patients less than 18 years of age were not included in this study. Patients were also not included if they demonstrated the presence of a neurological diagnosis or stroke; history of traumatic brain injury; history

of head and neck cancer; history of cervical spinal surgery; and/or the inability to follow simple one-step commands. Patients with terminal extubation, and/or expiration of a patient were not included in this study. Lastly patients that did not undergo a MBS or FEES® study were excluded from participation.

## 2. *Power Analysis:*

An a priori power analysis indicated that a sample size of at least 68 subjects in each study was necessary to have 80% power for detecting a medium sized effect when employing the traditional .05 criterion of statistical significance (See Table 5). Thus, 70 participants were selected as sufficient based on the power analysis presented below.

**Table 5:** *Power Analysis*

| Outcome Variable | Power | N | P0* | P1** | Odds Ratio | R Squared | Alpha | Beta |
|---|---|---|---|---|---|---|---|---|
| Dysphagia (P0 = .41) | 0.80 | 201 | 0.41 | 0.51 | 1.5 | 0.02 | 0.05 | 0.20 |
| | 0.79 | 68 | 0.41 | 0.58 | 2.0 | 0.02 | 0.05 | 0.21 |
| | 0.79 | 39 | 0.41 | 0.64 | 2.5 | 0.02 | 0.05 | 0.21 |
| | 0.79 | 27 | 0.41 | 0.68 | 3.0 | 0.02 | 0.05 | 0.21 |
| Mild Dysphagia (P0 = .17 * .41) | 0.80 | 751 | 0.07 | 0.10 | 1.5 | 0.02 | 0.05 | 0.20 |
| | 0.80 | 257 | 0.07 | 0.13 | 2.0 | 0.02 | 0.05 | 0.20 |
| | 0.80 | 147 | 0.07 | 0.16 | 2.5 | 0.02 | 0.05 | 0.20 |
| | 0.79 | 102 | 0.07 | 0.18 | 3.0 | 0.02 | 0.05 | 0.21 |
| Moderate Dysphagia (P0= .44*.41) | 0.80 | 329 | 0.18 | 0.25 | 1.5 | 0.02 | 0.05 | 0.20 |
| | 0.79 | 112 | 0.18 | 0.31 | 2.0 | 0.02 | 0.05 | 0.21 |
| | 0.79 | 64 | 0.18 | 0.36 | 2.5 | 0.02 | 0.05 | 0.21 |
| | 0.79 | 44 | 0.18 | 0.40 | 3.0 | 0.02 | 0.05 | 0.21 |
| Severe Dysphagia (P0= .16*.41) | 0.80 | 794 | 0.07 | 0.10 | 1.5 | 0.02 | 0.05 | 0.20 |
| | 0.80 | 271 | 0.07 | 0.12 | 2.0 | 0.02 | 0.05 | 0.20 |
| | 0.80 | 155 | 0.07 | 0.15 | 2.5 | 0.02 | 0.05 | 0.20 |
| | 0.80 | 108 | 0.07 | 0.17 | 3.0 | 0.02 | 0.05 | 0.20 |

**3. *Instrumentation:***

*Perceptual and Objective Swallowing Assessment*:

Dysphagia was quantified using the following procedures and scales:

The Penetration-Aspiration Scale (PAS):

The Penetration Aspiration Scale (PAS) was developed by Rosenbek and colleagues (1996) in efforts to offer accurate and consistent values of the presence and severity of penetration and aspiration occurrences during MBS and FEES studies. The PAS is an ordinal 8 point scale (1 through 8), where severity of the swallowing impairment is dependent on the depth and response to airway invasion (Rosenbek et al., 1996). Scores ranging from 2 through 5 are reflective of penetration, where scores ranging from 6 to 8 are indicative of aspiration (Rosenbek, Robbins, Roecker, Coyle, & Wood 1996). Swallowing severity worsens as the numbers increase. Colodny (2002) replicated Rosenbeck et al., (1996) PAS study using FEES, which revealed that numeric ratings were considered reliable for both inter and intra judge assessments.

Four Point Dysphagia Severity Scale:

A 4 point Dysphagia Severity Scale was developed by Malandraki and colleagues (2011) to examine swallowing severity outcomes after objective swallowing assessment techniques. Swallowing severity outcomes are based on degree of dietary restriction and the amount of feeding modifications and/or techniques needed to maintain oral intake. Good agreement has been demonstrated between the use of the PAS scale and the dysphagia severity scale ($\kappa$=0.52-0.71) in previous research studies

examining inter and intrajudge reliability of MBS outcomes (Malandraki et al., 2011; Malandraki et al., 2013).

Proper training in the use of both of these scales enables several clinical advantages, such as increased precision of penetration and aspiration events, efficacy of different swallowing techniques, training of students and new clinicians, changes in functionality of patients, and future research (Malandraki, Maraki, Georgopoulos, Bauer, Kalogeropoulos, & Nanas, 2011; Malandraki, Maraki, Georgopoulos, Bauer, Kalogeropoulos, & Nanas, 2013; Rosenbek et al., 1996).

**4.** ***Design:*** A retrospective observational research design was implemented to evaluate the relationship of various risk factors with post-extubation dysphagia in medical and surgical ICU patients.

**5.** ***Data Collection:*** 70 consecutive alphabetical charts were reviewed of patients that received a formalized swallowing assessment after 72 hours of intubation from a Speech Pathology Swallowing database during a 6 month period. Patients were cohorted according to whether they had undergone either a MBS and/or FEES study(s). Additional pertinent medical data were obtained from the patient's electronic medical records, including admission notes, evaluations, diagnostic imaging, laboratory values, progress notes and ICU flow sheets. All extrapolated data were populated on the post-extubation data collection tool (see Appendix 1). Data that were collected included, but was not limited to, the patient's admission diagnosis, age, gender, cause of intubation, duration of mechanical ventilation, presence of PNA, method of dysphagia assessment,

and dysphagia severity. The main researcher selected participant charts for data analysis by two independent reviewers. The main chart reviewer was blinded to the study aims. A second blinded reviewer checked all data extracted for accuracy. One hundred percent agreement was yielded between the two reviewers.

**6.** ***Analysis***: An analysis to determine the potential risk factors for post-extubation dysphagia was conducted. The following Independent Variables were appraised: duration of mechanical ventilation; medical cause of intubation (i.e. sepsis, cardiogenic shock etc); admitting diagnosis; age; gender; reintubation; incidence of aspiration PNA. Admitting diagnoses and precipitating reasons for intubation were further clustered into classification groups for further analysis. All food and liquid consistencies that were utilized were consistent with the American Dietetic Association (ADA) National Dysphagia Diet guidelines for dietary textures.

**1. Dysphagia and Aspiration Severity Ratings:**

Abnormal swallowing was defined as laryngeal penetration, and/or aspiration observed during a MBS/FEES procedure. Each texture trial (two trials per texture) was assigned a PAS rating for further analysis. An average score was calculated per texture to determine degree of dysphagia severity. Normal swallowing was defined as the absence of supraglottic laryngeal penetration and/or aspiration, as evidenced by a PAS score of 1 or 2 for all food trials during a MBS/FEES procedure. PAS scores of 3 to 5 reflected laryngeal penetration and scores 6 to 8 indicated aspiration. Dysphagia severity outcomes were compared for statistical significance to the various independent

variables. Additionally, aspiration was examined for all texture trials that exhibited a score of 6 through 8. In particular, participants were divided into one of two groups after PAS scores were assigned: Aspiration or No Aspiration for further statistical analysis. A second 4 point (ratings 1 to 4) dysphagia severity scale was also used to determine dysphagia severity outcomes. As in Malandraki and colleagues (2011 and 2013), dysphagia severity increases with increasing numeric value. A score of 1 reflected typical swallowing function, without the need for any type of swallowing management techniques; a score of 2 indicated a mild swallowing disorder with the need for dietary modification and/or compensatory swallowing techniques; a score of 3 indicated a moderate dysphagia, as evidenced by a more restrictive diet and the need for multiple management techniques to permit continuation of oral feeding and a score of 4 represented a severe dysphagia with the recommendation of non-oral means of nutrition and hydration (Malandraki et al., 2011; Malandraki et al., 2013). Four Point Dysphagia Severity Ratings were determined after identifying the following content in the participant charts: dietary recommendation, recommendations for compensatory strategies, number of remediation techniques and the need for non-oral means of nutrition and hydration.

**2. Dysphagia and Aspiration Risk Factor Analysis:**

A logistic regression model was used to evaluate the relationship between independent variables with the primary outcome variable of interest, post-extubation swallowing dysfunction or determined by the PAS and the 4 Point Dysphagia Severity Rating Scale. This type of analysis was used to determine if any of the study variables, gender,

admission group, reason for intubation group, participant category, age, or days intubated was associated with aspiration or dysphagia severity. As in Bordon and colleagues (2011), two methods of logistic regression modeling were employed: the "forward stepwise" method and the 'backward stepwise" approach. When stepping is used, one item is added or removed at a time. With forward stepwise regression the item with the strongest significant relation to the dependent variable is entered first. In the next step, the variable most significantly related among the remaining items is entered. All covariants are entered on a one-by-one basis to determine the statistical significant of each variable with post-extubation swallowing function. Each variable was added or 'stepped' and tested for statistical significance until no items are significantly associated with the dependent variable. Backward stepwise regression is the inverse principle in that all of the items are entered first, and one by one, items are removed, beginning with the one that is least associated with the dependent variable. This process was repeated until no further improvements in the regression model have been demonstrated. The 'backward stepwise' method permits greater identification of the variables that are identified as the most robust independent risk factors for post extubation dysphagia. Multinomial Logistic Regression Analyses were conducted to examine if any of the study variables, gender, admission group, reason for intubation group, participant category, age, or days intubated was associated with dysphagia severity. In addition, all Odds Ratio outcomes, exp (β), were stringently examined to quantify the magnitude of prolonged intubation and its relationship to swallowing dysfunction. All of the variables mentioned above were entered into the model.

Additionally, all independent variables were appraised using the univariate model to determine significance (P<.05).

**3. Risk Factor Variables Relationship Analysis:**

T-tests were used to compare the means of statistically significant variables where the categorical variable had only two levels, i.e., gender, participant category, and aspiration. Unequal variance t-tests were used to determine if average age and average days intubated were significantly different for reintubated patients and participants with PNA. Unequal variance t-tests were selected after significant results were obtained from a Levene test of homogeneity of variance. ANOVA's were also performed to examine the relationship between the most statistically significant Independent Variables and their relationship to swallowing severity on the 4 point dysphagia scale. Post Hoc analyses were also conducted to examine potential research patterns that were not specified a priori and to account for any Type I errors. Correlation coefficients were evaluated to measure the strength of the linear relationships between two variables of interest. Correlations between age, days intubated and dietary textures averages (thin, puree, solids) on the PAS scale were examined. Chi-square tests were used to evaluate whether there were any significant associations between the categorical variables in the study.

**i. Study B: Methods**

**1.** ***Subjects***: A sample of 70 (N=70) adult and geriatric (>/= 18 years of age) medical and surgical ICU patients from an urban Level I Trauma Hospital, in New

York were included in the study during a three month period January 2014 to March 2014 . Participants were selected from a pool of 138 admitted ICU patients (MICU N=78; SICU N=60) that consecutively met the inclusion criteria for participation in this study. All participants automatically underwent a FEES examination despite the presence or absence of signs and symptoms of aspiration on a clinical beside examination. However, only 57 (81.43%) of the 70 participants would have been referred for FEES examination based on clinical presentation during a clinical beside examination. All patients were able to follow simple commands and will exhibit absence of neurological deficits on a cranial nerve examination.

## 1. Demographics:

This study cohort (N=70) had 41 male (58.6%) and 29 female (41.4%) participants (See Table 6) with a mean age of 64.53 with a SD of 16.668 (See Table 6). The average length of days intubated for all patients was 6.84 with a SD of 4.035 (See Table 7). Fifteen (21.4%) of the participants exhibited PNA (See Table 8).

**Table 6: *Gender***

| | Gender | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Age | 1 male | 41 | 60.24 | 16.112 | 2.516 |
| | 2 female | 29 | 70.59 | 15.776 | 2.930 |
| Days Intubated | 1 male | 41 | 6.32 | 3.297 | .515 |
| | 2 female | 29 | 7.59 | 4.859 | .902 |

**Table 7: *Descriptive Statistics***

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Age | 70 | 21 | 92 | 64.53 | 16.668 |
| Days Intubated | 70 | 3 | 25 | 6.84 | 4.035 |
| Valid N (listwise) | 70 | | | | |

**Table 8: *PNA***

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 0 other | 55 | 78.6 | 78.6 | 78.6 |
| | 1 PNA | 15 | 21.4 | 21.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## 2. Clusters by Admission Group:

All participants were clustered into one of 7 admission groups for analysis: Group 1: Cardiac 6 (8.6%), Group 2: Pulmonary 25 (35.7%). Group 3: Infection 5 (7.1%), Group 4: Gastrointestinal 11 (15.7%), Group 5: Hematology/Metabolic 7 (10%), Group 6: Traumatic 7 (10%) and Group 7: Alcohol/Narcotics 9 (12.9%) (See Table 9).

**Table 9:** ***Admission Group Clusters***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| Admission Group | 1 Cardiac | Count | $3_a$ | $3_a$ | 6 |
| | | % within Gender | 7.3% | 10.3% | 8.6% |
| | 2 Pulmonary | Count | $12_a$ | $13_a$ | 25 |
| | | % within Gender | 29.3% | 44.8% | 35.7% |
| | 3 Infectious | Count | $2_a$ | $3_a$ | 5 |
| | | % within Gender | 4.9% | 10.3% | 7.1% |
| | 4 Gastrointestinal | Count | $7_a$ | $4_a$ | 11 |
| | | % within Gender | 17.1% | 13.8% | 15.7% |
| | 5 Hemotology/Metabolic | Count | $5_a$ | $2_a$ | 7 |
| | | % within Gender | 12.2% | 6.9% | 10.0% |
| | 6 Traumatic | Count | $5_a$ | $2_a$ | 7 |
| | | % within Gender | 12.2% | 6.9% | 10.0% |
| | 7 Alcohol/Narcotics | Count | $7_a$ | $2_a$ | 9 |
| | | % within Gender | 17.1% | 6.9% | 12.9% |
| Total | | Count | 41 | 29 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0 % |

## 3. Clusters by Reason for Intubation:

All patients were also stratified into one of 5 reasons for intubation groups for analysis: Group 1: Cardiac 6 (8.6%), Group 2: Pulmonary 24 (34.3%), Group 3: Infectious 12 (17.1%), Group 4: Airway Protection 13 (18.6%), and Group 5: Hemodynamic 13 (18.6%) (See Table10).

**Table 10:** ***Reason For Intubation Clusters***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| Reason for Intubation Group | Airway Protection | Count | $10_a$ | $3_a$ | 13 |
| | | % within Gender | 24.4% | 10.3% | 18.6% |
| | Cardiac | Count | $2_a$ | $4_a$ | 6 |
| | | % within Gender | 4.9% | 13.8% | 8.6% |
| | Endocrine/Infectious | Count | $0_a$ | $2_a$ | 2 |
| | | % within Gender | .0% | 6.9% | 2.9% |
| | Hemodynamic | Count | $10_a$ | $3_a$ | 13 |
| | | % within Gender | 24.4% | 10.3% | 18.6% |
| | Infectious | Count | $7_a$ | $5_a$ | 12 |
| | | % within Gender | 17.1% | 17.2% | 17.1% |
| | Pulmonary | Count | $12_a$ | $12_a$ | 24 |
| | | % within Gender | 29.3% | 41.4% | 34.3% |
| Total | | Count | 41 | 29 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

*Inclusion Criteria*: All participants underwent prolonged emergent orotracheal intubation >/= 3 days). All participants were admitted either to the medical or surgical ICU. They exhibited the absence of a neurological diagnosis, head and neck cancer and/or cervical spinal surgery. All participants had a physician order for swallowing assessment after extubation. They were >/=18 years of age and all underwent either a MBS or FEES® study.

*Exclusion Criteria*: Patients were excluded if they did not endure orotracheal intubation and or less than 3 days of orotracheal intubation. They were excluded if they had a history of and/or currently a tracheostomy tube. Patients less than 18 years of age were not included in this study. Patients were also not included if they demonstrated the presence of a neurological diagnosis or stroke; history of traumatic brain injury; history of head and neck cancer; history of cervical spinal surgery; and/or the inability to follow simple one-step commands. Patients with terminal extubation, and/or expiration of a patient were not included in this study. Patients that did not undergo a FEES® study were excluded from participation. Patients were also not permitted to participate

in a FEES examination if they were not able to maintain alertness for the duration of a meal and/or were unable to maintain an oxygen saturation level of at least 90%.

***2. Instrumentation:***

*Perceptual and Objective Swallowing Assessment*:

- Fiberoptic Endoscopic Evaluation of Swallowing (FEES®)
- Penetration Aspiration Scale (PAS) (Rosenbeck et al., 1996)
- 4 point Dysphagia Severity Scale (Malandraki et al., 2011; Malandraki et al., 2013).

**3. *Design*:** A prospective observational study research design was implemented to evaluate the effect of prolonged orotracheal intubation on swallowing function in medical and surgical ICU patients. Identification of potential risk factors for post-extubation swallowing was examined.

**4. *Procedure*:** Appraisal of each patient's medical history, precipitating cause(s) of orotracheal intubation, admitting medical diagnosis, and length and quality of orotracheal intubation were documented for careful review and further analysis. All participants underwent an operationalized preliminary FEES® examination to objectively assess swallowing function pending, medical stability. The main researcher scheduled all participant FEES examinations and entered all pertinent case history information prior to commencement of the FEES examinations in efforts to prevent the purpose of study blinded to the raters. Two American Speech Language and Hearing

Association (ASHA) certified SLPs were blinded to the diagnoses and purpose of study. These SLPs have 10 and 12 years of clinical experience and expertise in assessment and treatment of swallowing disorders, respectively. These two SLPs had been trained in FEES® at the Columbia University Otolaryngology 12 week FEES training program and had been independently performing FEES studies for 7 years. The SLPs confirmed the presence of aspiration and/or penetration after the FEES studies were recorded. The SLP reviewers rated these objective measures collaboratively for critical review to ensure satisfactory inter- and intra-judge reliability. Twenty percent of randomly selected swallows from the FEES examinations were re-analyzed by a third ASHA certified SLP with 9 years of clinical experience in swallowing, to further enhance interjudge reliability. At least two trials of various 5-10 ml bolus viscosities (thin, puree, and solids) were administered in a random fashion to the patients in order to reduce experimenter bias. All consistencies that were utilized were consistent with ADA National Dysphagia Diet guidelines for dietary textures. The PAS Scale (Rosenbeck et al., 1996) was used in conjunction with the FEES® studies to standardize oropharyngeal secretions and the incidence of penetration and aspiration. Abnormal swallowing was defined as laryngeal penetration, and/or aspiration during a MBS/FEES procedure. Study parameters for swallowing assessments included the presence of penetration and/or aspiration and severity of dysphagia. All FEES® studies were digitally recorded for diagnostic purposes and data analysis.

**5.** ***Analysis***: The same risk factors for potentially influencing post-extubation dysphagia in the retrospective study were analyzed in the prospective participant group. As in study A, all admitting diagnoses and precipitating causes of intubation were clustered for further analysis. Analogous to study A, each texture trial (two trials per texture) were assigned a PAS rating for further analysis. Swallowing severity was determined by highest PAS score assigned per texture and the 4 Point Dysphagia Severity Rating Scale.

**1. Dysphagia and Aspiration Severity Ratings:**

Normal swallowing was defined as the absence of supraglottic laryngeal penetration and/or aspiration, as illustrated by a PAS score of 1 or 2 for all food trials during a MBS/FEES procedure. Scores 3 through 5 reflected laryngeal penetration and score 6 through 8 demonstrated aspiration. Texture averages were calculated for each trial for all participants. Additionally, aspiration risk was calculated for all texture trials that exhibited a score of 6 through 8. As in Study A, participants were divided into one of two groups after PAS scores were assigned: Aspiration or No Aspiration for further statistical analysis. A second 4 point (ratings 1 to 4) dysphagia severity scale was also used to determine dysphagia severity outcomes. As in Malandraki and colleagues (2011 and 2013), as numeric value increases, dysphagia severity increases. A score of 1 reflected typical swallowing function, without the need for any type of swallowing management techniques; a score of 2 indicated a mild swallowing disorder with the need for dietary modification and/or compensatory swallowing techniques; a score of 3 indicated a moderate dysphagia, as evidenced by a more restrictive diet and the need for

multiple management techniques to permit continuation of oral feeding and a score of 4 represented a severe dysphagia with the recommendation of non-oral means of nutrition and hydration (Malandraki et al., 2011; Malandraki et al., 2013).

**2. Dysphagia and Aspiration Risk Factor Analysis:**

The logistic regression model was used to determine if any of the study variables, gender, admission group, reason for intubation group, participant category, age, or days intubated was associated with aspiration. As in Bordon and colleagues (2011), two methods of logistic regression modeling were employed: the "forward stepwise" method and the 'backward stepwise" approach. When stepping is used, one item is added or removed at a time. With forward stepwise regression the item with the strongest significant relation to the dependent variable is entered first. In the next step, the variable most significantly related among the remaining items is entered. All covariants are entered on a one-by-one basis to determine the statistical significant of each variable with post-extubation swallowing function. Each variable was added and tested for statistical significance until no items are significantly associated with the dependent variable. Backward stepwise regression is the inverse principle in that all variables are entered simultaneously and tested for the statistical significance of deleting of each independent variable. This process was repeated until no further statistically significant relationship to the dependent variable have been demonstrated. The 'backward stepwise' method permits greater identification of the variables that are identified as the most robust independent risk factors for post extubation dysphagia. Multinomial Logistic Regression Analyses were conducted to examine if any of the

study variables, gender, admission group, reason for intubation group, participant category, age, or days intubated was associated with dysphagia severity. In addition, all Odds Ratio outcomes, exp (β), were examined to quantify the magnitude of prolonged intubation and its relationship to swallowing dysfunction. All of the variables mentioned above were entered into the model. Additionally, all independent variables were appraised using the univariate model to determine significance ($P<.05$).

**3. Risk Factor Variables Relationship Analysis:**

Analogous to Study A, a Levene test of homogeneity of variance revealed statistically significant outcomes. As a result unequal variance t-tests were used to compare the means of statistically significant variables where the categorical variable had only two levels, i.e., gender and aspiration. Unequal variance t-tests were also used to determine if average age and average days intubated were significantly different for reintubated patients and participants with PNA. ANOVAs were also performed to appraise the relationship between the most statistically insignificant Independent Variables identified and their relationship to dysphagia on the 4 point dysphagia scale. Post Hoc analyses were also conducted to examine potential research patterns that were not specified a priori and to account for any Type I errors. Correlation coefficients were evaluated to measure the strength of the linear relationships between two variables of interest. Correlations between age, days intubated and dietary textures averages (thin, puree, solids) on the PAS scale were examined. Chi-square tests were also used to evaluate whether there were any significant associations between the categorical variables in the study.

**4. Interjudge Reliability:**

The intraclass correlation coefficient was used to determine the reproducibility of an assessment made by different observers for 20% (N=14) of the swallows rated (thin and puree textures) with the PAS and the 4 Point Dysphagia Severity Scale. The intraclass correlation determines the inter-rater reliability of two or more different raters. An intraclass coefficient of 1.00 indicates perfect concordance between the raters.

5. **Comparison of Study A and Study B Participant Demographics:**

Study A participants exhibited a mean age of 70.04 (SD 17.596). Study B participants represented a younger cohort with a mean age of 64.53 (SD 16.668). With respect to days intubated, Study A demonstrated a slighter higher mean of 7.643 (SD 3.849), where Study B yielded a mean of 6.84 (SD 4.035).

In Study A, the most common admission diagnosis was a pulmonary etiology for 42.9% (N=30) of patients. The second most frequent was a cardiac etiology for 20% (N=14) of patients. In Study B, the most common diagnosis was also a pulmonary etiology for 37.5% (N=14) of all patients. The second most common diagnosis was a gastrointestinal for 15.7% (N=11) of patients.

In Study A, the most common reason for intubation cluster was a pulmonary etiology for 61.4% (N=43) of all participants. This was also found to be the most common reason for intubation cluster in Study B, but with a much smaller incidence. Only 34.3% (N=24) of patients were intubated because of a pulmonary incidence, which suggests other reasons for intubation as more prevalent in study B than in Study A.

## V. **RESULTS**:

### i. Study A: Results

#### *1. Four Point Dysphagia Severity Scale Outcomes:*

Four Point Dysphagia Severity Scale outcomes were analyzed to determine dysphagia severity frequencies, trends in data, and relationships among risk factors of post-extubation dysphagia. Amongst the 70 participants in Study A, dysphagia severity on Malandraki and colleagues (2011 and 2013) 4 point scale was normal in 7.1% (N=5), mild in 31.4% (N=22), moderate in 20% (N=14) and severe in 41.4% (N=29) (See Table 11).

**Table 11:** ***4 Point Dysphagia Severity Scale Outcomes***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| 4pt Dysphagia | 1 | Count | 1 | 4 | 5 |
| | | % within Gender | 2.5% | 13.3% | 7.1% |
| | 2 | Count | 15 | 7 | 22 |
| | | % within Gender | 37.5% | 23.3% | 31.4% |
| | 3 | Count | 9 | 5 | 14 |
| | | % within Gender | 22.5% | 16.7% | 20.0% |
| | 4 | Count | 15 | 14 | 29 |
| | | % within Gender | 37.5% | 46.7% | 41.4% |
| Total | | Count | 40 | 30 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

In regards to the relationship between the reason for intubation and the 4 Point Dysphagia Severity Scale outcomes, the Pulmonary (Group 2) group exhibited the most severe outcome ratings, where 46.5% (N=20) received a rating of 4. This group also exhibited the greatest prevalence for a mild dysphagia rating, where 30.2% (N=13) of participants received a score of 2. It should be noted that although the Pulmonary

(Group 2) group demonstrated the highest prevalence for extreme scores, likely due to this group representing 61.4% of the entire sample size. The Infectious (Group 3) demonstrated the second highest prevalence for the most severe dysphagia severity ratings, where 13.8% (N=4) of patients received a rating of 4 (See Table 12).

**Table 12:** ***Reason For Intubation-4 Point Dysphagia Severity Crosstabulation***

| | | | 4pt Dysphagia | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| Reason for Int. Group | 1 cardiac | Count | 0 | 2 | 1 | 2 | 5 |
| | | % within 4pt Dysphagia | .0% | 9.1% | 7.1% | 6.9% | 7.1% |
| | 2 pulmonary | Count | 2 | 13 | 8 | 20 | 43 |
| | | % within 4pt Dysphagia | 40.0% | 59.1% | 57.1% | 69.0% | 61.4% |
| | 3 infectious | Count | 1 | 4 | 1 | 4 | 10 |
| | | % within 4pt Dysphagia | 20.0% | 18.2% | 7.1% | 13.8% | 14.3% |
| | 4 airway protection | Count | 1 | 3 | 3 | 1 | 8 |
| | | % within 4pt Dysphagia | 20.0% | 13.6% | 21.4% | 3.4% | 11.4% |
| | 5 hemodynamic | Count | 1 | 0 | 1 | 2 | 4 |
| | | % within 4pt Dysphagia | 20.0% | .0% | 7.1% | 6.9% | 5.7% |
| Total | | Count | 5 | 22 | 14 | 29 | 70 |
| | | % within 4pt Dysphagia | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

### *2. PAS Outcomes*:

PAS scale outcomes were examined to determine the presence or absence of aspiration, trends in the data and relationships with risk factors of post-extubation dysphagia. In regards to aspiration rate using PAS scale outcomes, 47.1% (N=33) exhibited PAS scores of 6 through 8, where 52.9% (N= 37) of participants illustrated PAS scores of 1 through 5. The most prevalent PAS score for thin liquids was an 8 (silent aspiration), for 28.6% (N=20) of all participants. The second most frequent score was a 1, for 20% (N=14) of patients. PAS scores of 5 and 7 each represented 15.7% of participants (N=11 each group) (See Table 13). The most prevalent PAS score for puree was a 1 (Normal) for 51.4% (N=36) of patients. The two second most

frequent PAS scores with puree were 3 and 8 for 12.9% of participants (N=9 each group) (See Table 14).

**Table 13:** ***Penetration Aspiration Scale Thin Liquid Averages***

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1.00 | 14 | 20.0 | 20.0 | 20.0 |
| | 1.50 | 4 | 5.7 | 5.7 | 25.7 |
| | 2.00 | 2 | 2.9 | 2.9 | 28.6 |
| | 2.50 | 2 | 2.9 | 2.9 | 31.4 |
| | 3.00 | 2 | 2.9 | 2.9 | 34.3 |
| | 4.50 | 2 | 2.9 | 2.9 | 37.1 |
| | 5.00 | 11 | 15.7 | 15.7 | 52.9 |
| | 6.50 | 2 | 2.9 | 2.9 | 55.7 |
| | 7.00 | 11 | 15.7 | 15.7 | 71.4 |
| | 8.00 | 20 | 28.6 | 28.6 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Table 14:** ***Penetration Aspiration Scale Puree Averages***

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1.00 | 36 | 51.4 | 51.4 | 51.4 |
| | 1.50 | 4 | 5.7 | 5.7 | 57.1 |
| | 2.00 | 4 | 5.7 | 5.7 | 62.9 |
| | 3.00 | 9 | 12.9 | 12.9 | 75.7 |
| | 4.50 | 1 | 1.4 | 1.4 | 77.1 |
| | 5.00 | 1 | 1.4 | 1.4 | 78.6 |
| | 6.00 | 1 | 1.4 | 1.4 | 80.0 |
| | 7.00 | 4 | 5.7 | 5.7 | 85.7 |
| | 7.50 | 1 | 1.4 | 1.4 | 87.1 |
| | 8.00 | 9 | 12.9 | 12.9 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

In regards to Admission Group PAS outcomes, 33 patients exhibited aspiration. Admission Group 2 (Pulmonary) exhibited the highest prevalence of aspiration 45.5% (N=15). Disparately, Admission Groups 3 (Infectious), 6 (Trauma), and 7 (Alcohol/Narcotics) (N=2 for each group) exhibited the lowest incidence of aspiration on the PAS scale. However, upon examining each group's aspiration rate

independently, Group 7 (Alcohol/Narcotics) demonstrated the greatest aspiration risk. This was likely due to small group clustering sample sizes, where only 3 participants were included in Group 7 (See Table 15).

**Table 15:** ***Admission Group- Penetration Aspiration Scale Scores***

| | | | PAS Scores | | |
|---|---|---|---|---|---|
| | | | .00 1-5 | 1.00 6-8 | Total |
| Admission Group | 1 cardiac | Count | $10_a$ | $4_a$ | 14 |
| | | % within Admission Group | 71.4% | 28.6% | 100.0% |
| | 2 pulmonary | Count | $15_a$ | $15_a$ | 30 |
| | | % within Admission Group | 50.0% | 50.0% | 100.0% |
| | 3 infectious | Count | $2_a$ | $2_a$ | 4 |
| | | % within Admission Group | 50.0% | 50.0% | 100.0% |
| | 4 gastrointestinal | Count | $4_a$ | $4_a$ | 8 |
| | | % within Admission Group | 50.0% | 50.0% | 100.0% |
| | 5 hemodynamic/ metabolic | Count | $3_a$ | $4_a$ | 7 |
| | | % within Admission Group | 42.9% | 57.1% | 100.0% |
| | 6 traumatic | Count | $2_a$ | $2_a$ | 4 |
| | | % within Admission Group | 50.0% | 50.0% | 100.0% |
| | 7 alcohol/ narcotics | Count | $1_a$ | $2_a$ | 3 |
| | | % within Admission Group | 33.3% | 66.7% | 100.0% |
| Total | | Count | 37 | 33 | 70 |
| | | % within Admission Group | 52.9% | 47.1% | 100.0% |

### *3. Logistic Regression Analyses:*

In order to determine what risk factors were significant for dysphagia and aspiration risk, regression analyses were conducted. Logistic regression analysis was used to determine if gender, admission group, reason for intubation group, participant category, age, reintubation or days intubated were significantly associated with aspiration.

The only two factors that were significantly associated with aspiration (6 or greater on any texture trial) risk were: days intubated ($p = 0.004$), and age ($p = 0.018$) (See Table 16). For each increase of one day of intubation, the odds of a subject being in the aspiration group was increased by a factor of 1.25. For each increase of one year of

age, the odds of a subject exhibiting aspiration was increased by a factor of 1.041 (See Table 16).

**Table 16:** ***Logistic Regression: Aspiration-Reintubation***

| | | B | S.E. | Wald | df | Sig. | Exp(B) | 95% C.I.for EXP(B) Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|
| Step 1[a] | Days Intubated | .187 | .072 | 6.842 | 1 | .009 | 1.206 | 1.048 | 1.388 |
| | Constant | -1.542 | .595 | 6.713 | 1 | .010 | .214 | | |
| Step 2[b] | Days Intubated | .223 | .078 | 8.151 | 1 | .004 | 1.250 | 1.072 | 1.457 |
| | Age | .040 | .017 | 5.608 | 1 | .018 | 1.041 | 1.007 | 1.076 |
| | Constant | -4.633 | 1.494 | 9.615 | 1 | .002 | .010 | | |

The model correctly predicted aspiration incidence for 68.6% of the patients. 78.4% of the subjects without aspiration were correctly identified, while 57.6% of the subjects with aspiration were correctly predicted (See Table 17).

**Table 17:** ***Classification Table: Aspiration***

| | | | Predicted | | |
|---|---|---|---|---|---|
| | | | Aspiration | | |
| | Observed | | .00 1-5 | 1.00 6-8 | Percentage Correct |
| Step 1 | Aspiration | .00 1-5 | 29 | 8 | 78.4 |
| | | 1.00 6-8 | 14 | 19 | 57.6 |
| | Overall Percentage | | | | 68.6 |

### *4. Multinomial Logistic Regression Analyses:*

A Multinomial logistic regression analysis was conducted to appraise predictability of the 4 point dysphagia severity scale outcome. Factors that were found to be significantly associated with dysphagia are days intubated (p = 0.032), and age (p=0.009). For each increase of one day of intubation, the odds of a participant being in

the highest dysphagia severity rating group compared to the lowest one was found to increase by a factor of 1.482, holding the other values in the model constant. For each increase of one year of age, the odds of a participant exhibiting a more severe dysphagia rating compared to a less severe dysphagia rating one was found to increase by a factor of 1.075, holding the other values in the model constant (See Table 18).

**Table 18:** ***Multinomial Logistic Regression: Dysphagia Severity Level***

| 4ptDysphagia[a] | | B | Std. Error | Wald | df | Sig. | Exp(B) | 95% Confidence Interval for Exp(B) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Lower Bound | Upper Bound |
| 2 | Intercept | -.310 | 2.176 | .020 | 1 | .887 | | | |
| | Age | .016 | .024 | .461 | 1 | .497 | 1.017 | .969 | 1.066 |
| | Days Intubated | .125 | .181 | .478 | 1 | .490 | 1.133 | .795 | 1.616 |
| 3 | Intercept | -2.789 | 2.407 | 1.342 | 1 | .247 | | | |
| | Age | .040 | .027 | 2.174 | 1 | .140 | 1.040 | .987 | 1.097 |
| | Days Intubated | .195 | .186 | 1.094 | 1 | .296 | 1.215 | .843 | 1.751 |
| 4 | Intercept | -6.012 | 2.475 | 5.900 | 1 | .015 | | | |
| | Age | .072 | .027 | 6.943 | 1 | .008 | 1.075 | 1.019 | 1.134 |
| | Days Intubated | .394 | .182 | 4.679 | 1 | .031 | 1.482 | 1.038 | 2.118 |

The regression model correctly predicted 72.4% of participants that received a score of 2 on the 4 point dysphagia severity scale. Eight percent of the patients that received a score of 3 on the 4 point dysphagia severity scale were correctly predicted by the regression model (See Table 19).

**Table 19: Classification Table: Dysphagia Severity**

| Observed | Predicted | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Percent Correct |
| 1 | 0 | 4 | 0 | 1 | .0% |
| 2 | 0 | 16 | 0 | 6 | 72.7% |
| 3 | 0 | 5 | 0 | 9 | .0% |
| 4 | 0 | 6 | 0 | 23 | 79.3% |
| Overall Percentage | .0% | 44.3% | .0% | 55.7% | 55.7% |

### *5. Unequal Variance T-Tests:*

T Tests were used to compare the means of age and number of days intubated where the categorical variable had only two levels, i.e., gender, participant category, reintubation and aspiration. The average age of subjects with aspiration was significantly higher, 74.7, than those who did not exhibit aspiration, 65.9 ($p = 0.033$) using the unequal variance t test. The average days intubated was significantly higher for patients with aspiration, 8.97 days, as opposed to those who did not exhibit aspiration, 6.46 days ($p = 0.006$) (See Table 20).

**Table 20:** ***T-Test Age/Intubation and Aspiration***

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Age | Equal variances assumed | 5.466 | .022 | -2.129 | 68 | .037 | -8.748 | 4.109 | -16.948 | -.548 |
| | Equal variances not assumed | | | -2.173 | 64.055 | .033 | -8.748 | 4.025 | -16.788 | -.707 |
| Days Intubated | Equal variances assumed | 1.958 | .166 | -2.862 | 68 | .006 | -2.510 | .877 | -4.260 | -.760 |
| | Equal variances not assumed | | | -2.829 | 61.782 | .006 | -2.510 | .887 | -4.284 | -.736 |

In regards to patients with reintubation, the average age and average days of intubation were not statistically different than in the participants who only underwent one intubation (See Table 21).

**Table 21 : *T-Test Age/Intubation and Reintubation***

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Age | Equal variances assumed | .128 | .721 | -.114 | 68 | .909 | -.865 | 7.567 | -15.964 | 14.235 |
| | Equal variances not assumed | | | -.099 | 5.688 | .924 | -.865 | 8.725 | -22.501 | 20.772 |
| Days Intubated | Equal variances assumed | 3.356 | .071 | -.902 | 68 | .370 | -1.484 | 1.645 | -4.768 | 1.799 |
| | Equal variances not assumed | | | -1.614 | 9.810 | .138 | -1.484 | .920 | -3.539 | .570 |

T tests were also used to determine if average age and average days intubated are significantly different for the group diagnosed with pneumonia compared to the group that was not diagnosed with pneumonia. The averages were not found to be significantly different (See Table 22).

**Table 22: *T-Test Age/Intubation and Pneumonia***

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Age | Equal variances assumed | .012 | .912 | -.173 | 68 | .864 | -.778 | 4.509 | -9.776 | 8.220 |
| | Equal variances not assumed | | | -.175 | 45.279 | .862 | -.778 | 4.452 | -9.743 | 8.187 |
| Days Intubated | Equal variances assumed | 3.564 | .063 | -1.344 | 68 | .183 | -1.309 | .974 | -3.252 | .634 |
| | Equal variances not assumed | | | -1.225 | 34.926 | .229 | -1.309 | 1.068 | -3.478 | .860 |

### *6. Analysis of Variance (ANOVA):*

An ANOVA was performed on the 4 point dysphagia scale for the two most significant independent variables identified during previous analyses: age and days intubated. The results demonstrate that the average age of the patients marginally differed by dysphagia level. Although statistical significance was not demonstrated by comparing mean averages for age, a consistent linear trend in average age increase as severity group increased was demonstrated. Moreover, the average number of days intubated differed significantly by dysphagia level (p= 0.024) (See Table 23).

**Table 23:** ***ANOVA 4 Point Dysphagia Scale- Age/Days Intubated***

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Age | Between Groups | 2139.332 | 3 | 713.111 | 2.448 | .071 |
| | Within Groups | 19223.539 | 66 | 291.266 | | |
| | Total | 21362.871 | 69 | | | |
| Days Intubated | Between Groups | 135.667 | 3 | 45.222 | 3.367 | .024 |
| | Within Groups | 886.405 | 66 | 13.430 | | |
| | Total | 1022.071 | 69 | | | |

This was also found true for reintubated patients, where the number of days reintubated patients were intubated differed significantly by the 4 point dysphagia severity rating (p=0.008) (See Table 24).

**Table 24:** ***ANOVA Reintubation Patients***

Dependent Variable: Days Intubated

| | Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Contrast | 168.817 | 3 | 56.272 | 4.332 | .008 | .169 |
| Error | 831.434 | 64 | 12.991 | | | |

## 1. Post Hoc Tests:

Post hoc comparisons demonstrated that the average days intubated for participants with a dysphagia severity rating of 2 was significantly lower than that of participants that received a dysphagia rating of 4 (p = 0.040) (See Table 25).

**Table 25:** ***Post Hoc Tests: Multiple Comparisons For Age and Days Intubated***

| Dependent Variable | | (I)4pt Dysphagia | (J)4pt Dysphagia | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Lower Bound | Upper Bound |
| Age | Tukey HSD | 1 | 2 | -3.718 | 8.455 | .971 | -26.00 | 18.57 |
| | | | 3 | -9.829 | 8.891 | .688 | -33.26 | 13.61 |
| | | | 4 | -15.228 | 8.264 | .263 | -37.01 | 6.55 |
| | | 2 | 1 | 3.718 | 8.455 | .971 | -18.57 | 26.00 |
| | | | 3 | -6.110 | 5.835 | .722 | -21.49 | 9.27 |
| | | | 4 | -11.509 | 4.825 | .090 | -24.23 | 1.21 |
| | | 3 | 1 | 9.829 | 8.891 | .688 | -13.61 | 33.26 |
| | | | 2 | 6.110 | 5.835 | .722 | -9.27 | 21.49 |
| | | | 4 | -5.399 | 5.554 | .766 | -20.04 | 9.24 |
| | | 4 | 1 | 15.228 | 8.264 | .263 | -6.55 | 37.01 |
| | | | 2 | 11.509 | 4.825 | .090 | -1.21 | 24.23 |
| | | | 3 | 5.399 | 5.554 | .766 | -9.24 | 20.04 |
| | Tamhane | 1 | 2 | -3.718 | 8.449 | .999 | -32.80 | 25.36 |
| | | | 3 | -9.829 | 8.124 | .843 | -39.22 | 19.57 |
| | | | 4 | -15.228 | 7.406 | .450 | -46.28 | 15.82 |
| | | 2 | 1 | 3.718 | 8.449 | .999 | -25.36 | 32.80 |
| | | | 3 | -6.110 | 6.282 | .916 | -23.67 | 11.45 |
| | | | 4 | -11.509 | 5.321 | .208 | -26.43 | 3.42 |
| | | 3 | 1 | 9.829 | 8.124 | .843 | -19.57 | 39.22 |
| | | | 2 | 6.110 | 6.282 | .916 | -11.45 | 23.67 |
| | | | 4 | -5.399 | 4.789 | .851 | -19.22 | 8.42 |
| | | 4 | 1 | 15.228 | 7.406 | .450 | -15.82 | 46.28 |
| | | | 2 | 11.509 | 5.321 | .208 | -3.42 | 26.43 |
| | | | 3 | 5.399 | 4.789 | .851 | -8.42 | 19.22 |
| Days Intubated | Tukey HSD | 1 | 2 | -.655 | 1.816 | .984 | -5.44 | 4.13 |
| | | | 3 | -.986 | 1.909 | .955 | -6.02 | 4.05 |
| | | | 4 | -3.476 | 1.775 | .214 | -8.15 | 1.20 |
| | | 2 | 1 | .655 | 1.816 | .984 | -4.13 | 5.44 |
| | | | 3 | -.331 | 1.253 | .993 | -3.63 | 2.97 |
| | | | 4 | -2.821 | 1.036 | .040 | -5.55 | -.09 |
| | | 3 | 1 | .986 | 1.909 | .955 | -4.05 | 6.02 |
| | | | 2 | .331 | 1.253 | .993 | -2.97 | 3.63 |
| | | | 4 | -2.490 | 1.193 | .168 | -5.63 | .65 |
| | | 4 | 1 | 3.476 | 1.775 | .214 | -1.20 | 8.15 |
| | | | 2 | 2.821 | 1.036 | .040 | .09 | 5.55 |
| | | | 3 | 2.490 | 1.193 | .168 | -.65 | 5.63 |
| | Tamhane | 1 | 2 | -.655 | 1.960 | 1.000 | -8.90 | 7.59 |
| | | | 3 | -.986 | 2.105 | .998 | -8.83 | 6.86 |
| | | | 4 | -3.476 | 1.999 | .591 | -11.56 | 4.61 |
| | | 2 | 1 | .655 | 1.960 | 1.000 | -7.59 | 8.90 |
| | | | 3 | -.331 | 1.180 | 1.000 | -3.72 | 3.06 |
| | | | 4 | -2.821 | .979 | .035 | -5.50 | -.14 |
| | | 3 | 1 | .986 | 2.105 | .998 | -6.86 | 8.83 |
| | | | 2 | .331 | 1.180 | 1.000 | -3.06 | 3.72 |
| | | | 4 | -2.490 | 1.244 | .289 | -6.01 | 1.03 |
| | | 4 | 1 | 3.476 | 1.999 | .591 | -4.61 | 11.56 |
| | | | 2 | 2.821 | .979 | .035 | .14 | 5.50 |
| | | | 3 | 2.490 | 1.244 | .289 | -1.03 | 6.01 |

## 2. Pairwise Comparisons:

Average days intubated was found to be significant for reintubated patients, where pairwise comparisons revealed that patients with a 2 point dysphagia severity rating differed significantly from a level 4 dysphagia severity rating (p=0.014) (See Table 26). Thus, demonstrating that the greater the number of days a patient was intubated the more severe the dysphagia rating.

**Table 26:** ***Pairwise Comparisons For Reintubated Patients***

Dependent Variable: Days Intubated

| (I) 4ptDysphagia | (J) @4ptDysphagia | Mean Difference (I-J) | Std. Error | Sig.[a] | 95% Confidence Interval for Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | -.732 | 1.794 | 1.000 | -5.616 | 4.152 |
| | 3 | -1.389 | 1.898 | 1.000 | -6.558 | 3.780 |
| | 4 | -4.109 | 1.797 | .153 | -9.002 | .784 |
| 2 | 1 | .732 | 1.794 | 1.000 | -4.152 | 5.616 |
| | 3 | -.657 | 1.243 | 1.000 | -4.041 | 2.727 |
| | 4 | -3.377* | 1.062 | .014 | -6.269 | -.485 |
| 3 | 1 | 1.389 | 1.898 | 1.000 | -3.780 | 6.558 |
| | 2 | .657 | 1.243 | 1.000 | -2.727 | 4.041 |
| | 4 | -2.720 | 1.182 | .148 | -5.940 | .499 |
| 4 | 1 | 4.109 | 1.797 | .153 | -.784 | 9.002 |
| | 2 | 3.377* | 1.062 | .014 | .485 | 6.269 |
| | 3 | 2.720 | 1.182 | .148 | -.499 | 5.940 |

## 3. Test of Between-Subjects Effects:

An additional ANOVA, where days intubated was the dependent variable and Dysphagia severity level and reintubation as the Independent Variables revealed that days intubated differed significantly by dysphagia severity level (p=0.008). None of the other independent variables were found to be significant (See Table 27).

**Table 27:** ***ANOVA Tests of Between-Subjects Effects: 4 Point Dysphagia Severity Scale***

Dependent Variable: Days Intubated

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 190.638[a] | 5 | 38.128 | 2.935 | .019 | .187 |
| Intercept | 406.841 | 1 | 406.841 | 31.317 | .000 | .329 |
| 4ptDysphagia | 168.817 | 3 | 56.272 | 4.332 | .008 | .169 |
| reintubation | 7.536 | 1 | 7.536 | .580 | .449 | .009 |
| Age | 47.253 | 1 | 47.253 | 3.637 | .061 | .054 |
| Error | 831.434 | 64 | 12.991 | | | |
| Total | 5111.000 | 70 | | | | |
| Corrected Total | 1022.071 | 69 | | | | |

Another ANOVA, where days intubated was the Dependent Variable and Aspiration and Reintubation were the Independent Variables, days intubated differed significantly from aspiration (p=0.003) (See Table 28). Specifically, increased days of intubation demonstrated an increased aspiration risk for intubated and reintubated patients.

**Table 28:** ***ANOVA Tests of Between-Subjects Effects: Aspiration***

Dependent Variable: Days Intubated

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 149.048[a] | 3 | 49.683 | 3.756 | .015 | .146 |
| Intercept | 417.497 | 1 | 417.497 | 31.562 | .000 | .324 |
| Aspiration | 127.227 | 1 | 127.227 | 9.618 | .003 | .127 |
| reintubation | 4.576 | 1 | 4.576 | .346 | .558 | .005 |
| Age | 34.130 | 1 | 34.130 | 2.580 | .113 | .038 |
| Error | 873.024 | 66 | 13.228 | | | |
| Total | 5111.000 | 70 | | | | |
| Corrected Total | 1022.071 | 69 | | | | |

The means of the PNA participants were used to compare the average of days intubated and age. The results obtained were not statistically significant, thus, failing to demonstrate a relationship between PNA and group averages of days of intubation and patient age (See Table 29).

**Table 29:** ***ANOVA Pneumonia***

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Days Intubated | Between Groups | 26.460 | 1 | 26.460 | 1.807 | .183 |
| | Within Groups | 995.611 | 68 | 14.641 | | |
| | Total | 1022.071 | 69 | | | |
| Age | Between Groups | 9.347 | 1 | 9.347 | .030 | .864 |
| | Within Groups | 21353.525 | 68 | 314.022 | | |
| | Total | 21362.871 | 69 | | | |

### 7. *Correlation Coefficients:*

Correlations between age, days intubated, and the puree, liquid, and solids averages were evaluated. There were significant correlations between age and puree average ($r = 0.339$, $p = 0.004$) and age and liquids average ($r = 0.348$, $p = 0.003$) (See Table 30). As age increased, the average PAS scores increased. There were significant correlations between days intubated and puree average ($r = 0.349$, $p = 0.003$) and days intubated and liquids average ($r = 0.329$, $p = 0.005$) (See Table 30). As intubation days increased, the average PAS scores increased. This demonstrates that dysphagia severity outcomes significantly increased with increased age and intubation days.

**Table 30:** ***Correlation Coefficients***

| | | Age | Days Intubated | Puree_avg | liquids_avg | solids_avg |
|---|---|---|---|---|---|---|
| Age | Pearson Correlation | 1 | -.096 | .339** | .348** | .317 |
| | Sig. (2-tailed) | | .429 | .004 | .003 | .100 |
| | N | 70 | 70 | 70 | 70 | 28 |
| Days Intubated | Pearson Correlation | -.096 | 1 | .349** | .329** | -.217 |
| | Sig. (2-tailed) | .429 | | .003 | .005 | .267 |
| | N | 70 | 70 | 70 | 70 | 28 |
| Puree_avg | Pearson Correlation | .339** | .349** | 1 | .617** | .733** |
| | Sig. (2-tailed) | .004 | .003 | | .000 | .000 |
| | N | 70 | 70 | 70 | 70 | 28 |
| liquids_avg | Pearson Correlation | .348** | .329** | .617** | 1 | .286 |
| | Sig. (2-tailed) | .003 | .005 | .000 | | .140 |
| | N | 70 | 70 | 70 | 70 | 28 |
| solids_avg | Pearson Correlation | .317 | -.217 | .733** | .286 | 1 |
| | Sig. (2-tailed) | .100 | .267 | .000 | .140 | |
| | N | 28 | 28 | 28 | 28 | 28 |

## 8. *Chi-Square Analyses:*

Chi-square tests were used to evaluate whether there were any significant associations between the categorical variables in the study. The statistical significance of admitting diagnosis group, reintubation, cause of intubation group, PNA, and aspiration risk were examined.

Pneumonia was found to be significantly associated with aspiration (p=0.034) (See Table 31). Forty-six percent of participants with aspiration scores on the PAS scale exhibited PNA, while only 21.6% of participants that did not exhibit aspiration on the PAS scale had PNA. In particular, out of all participant admission diagnoses, 65.2% of all participants that exhibited PNA, also presented with aspiration, while only 38.3% of patients with other diagnoses demonstrated aspiration (See Table 32). This demonstrated a statistically significant association between the presence of PNA and aspiration.

**Table 31:** ***Chi-Square Tests Pneumonia- Aspiration***

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | 4.491[a] | 1 | .034 | | |
| Continuity Correction[b] | 3.476 | 1 | .062 | | |
| Likelihood Ratio | 4.534 | 1 | .033 | | |
| Fisher's Exact Test | | | | .043 | .031 |
| Linear-by-Linear Association | 4.427 | 1 | .035 | | |
| N of Valid Cases | 70 | | | | |

**Table 32:** ***PNA - Aspiration Crosstabulation***

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | No | Yes | Total |
| PNA | 0 | Count | 29 | 18 | 47 |
| | | % within Aspiration | 78.4% | 54.5% | 67.1% |
| | 1 | Count | 8 | 15 | 23 |
| | | % within Aspiration | 21.6% | 45.5% | 32.9% |
| Total | | Count | 37 | 33 | 70 |
| | | % within Aspiration | 100.0% | 100.0% | 100.0% |

Gender was not significantly associated with admission group or reason for intubation (See Table 33 and Table 34).

**Table 33:** ***Chi-Square Tests Admission Group-Gender***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 5.240[a] | 6 | .513 |
| Likelihood Ratio | 6.393 | 6 | .381 |
| Linear-by-Linear Association | .928 | 1 | .335 |
| N of Valid Cases | 70 | | |

**Table 34:** ***Gender- Admission Group Crosstabulation***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| Admission Group | 1 cardiac | Count | 9 | 5 | 14 |
| | | % within Gender | 22.5% | 16.7% | 20.0% |
| | 2 pulmonary | Count | 14 | 16 | 30 |
| | | % within Gender | 35.0% | 53.3% | 42.9% |
| | 3 infectious | Count | 3 | 1 | 4 |
| | | % within Gender | 7.5% | 3.3% | 5.7% |
| | 4 gastrointestinal | Count | 4 | 4 | 8 |
| | | % within Gender | 10.0% | 13.3% | 11.4% |
| | 5 hemodynamic/metabolic | Count | 5 | 2 | 7 |
| | | % within Gender | 12.5% | 6.7% | 10.0% |
| | 6 traumatic | Count | 2 | 2 | 4 |
| | | % within Gender | 5.0% | 6.7% | 5.7% |
| | 7 alcohol/narcotics | Count | 3 | 0 | 3 |
| | | % within Gender | 7.5% | .0% | 4.3% |
| Total | | Count | 40 | 30 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

The associations between gender and aspiration (where aspiration is defined as 6 or greater on any texture trial) (See Table 35 and 36), 4 point dysphagia scale outcomes and gender (See Table 37 and Table 38), and participant category (FEES vs. MBS) (See Table 39 and 40) and aspiration rate (See Table 41 and 42) were all not statistically significant.

Four point dysphagia severity rating outcomes were comparable to PAS aspiration ratings. Patients that exhibited aspiration (scores of 6 through 8) on the PAS scale only received 4 point dysphagia scale ratings of 3 or 4. Specifically, 42.9% of patients that presented with aspiration received a 4 point scale rating of 3 and 93.1% of aspirating patients received a 4 point scale rating of 4 (See Table 43).

**Table 35:** ***Chi-Square Tests Gender-Aspiration***

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | .172[a] | 1 | .678 | | |
| Continuity Correction[b] | .030 | 1 | .863 | | |
| Likelihood Ratio | .172 | 1 | .678 | | |
| Fisher's Exact Test | | | | .810 | .431 |
| Linear-by-Linear Association | .170 | 1 | .681 | | |
| N of Valid Cases | 70 | | | | |

**Table 36:** ***Gender-Aspiration Crosstabulation***

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | .00 low | 1.00 high | Total |
| Gender | 1 male | Count | $22_a$ | $18_a$ | 40 |
| | | % within Gender | 55.0% | 45.0% | 100.0 % |
| | 2 female | Count | $15_a$ | $15_a$ | 30 |
| | | % within Gender | 50.0% | 50.0% | 100.0 % |
| Total | | Count | 37 | 33 | 70 |
| | | % within Gender | 52.9% | 47.1% | 100.0 % |

**Table 37:** ***Chi-Square Tests 4 pt Dysphagia Scale-Gender***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 4.551[a] | 3 | .208 |
| Likelihood Ratio | 4.664 | 3 | .198 |
| Linear-by-Linear Association | .005 | 1 | .946 |
| N of Valid Cases | 70 | | |

**Table 38:** ***4 Point Dysphagia Scale- Gender Crosstabulation***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| 4 pt Dysphagia | 1 | Count | 1 | 4 | 5 |
| | | % within Gender | 2.5% | 13.3% | 7.1% |
| | 2 | Count | 15 | 7 | 22 |
| | | % within Gender | 37.5% | 23.3% | 31.4% |
| | 3 | Count | 9 | 5 | 14 |
| | | % within Gender | 22.5% | 16.7% | 20.0% |
| | 4 | Count | 15 | 14 | 29 |
| | | % within Gender | 37.5% | 46.7% | 41.4% |
| Total | | Count | 40 | 30 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

**Table 39:** ***Chi-Square Tests 4 Point Dyphagia Scale- MBS/FEES***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 1.249[a] | 3 | .741 |
| Likelihood Ratio | 1.253 | 3 | .740 |
| N of Valid Cases | 70 | | |

**Table 40:** ***4 Point Dysphagia- MBS/FEES Crosstabulation***

| | | | Participant Category | | |
|---|---|---|---|---|---|
| | | | FEES | MBS | Total |
| 4 pt Dysphagia | 1 | Count | 3 | 2 | 5 |
| | | % within Participant Category | 9.7% | 5.1% | 7.1% |
| | 2 | Count | 8 | 14 | 22 |
| | | % within Participant Category | 25.8% | 35.9% | 31.4% |
| | 3 | Count | 7 | 7 | 14 |
| | | % within Participant Category | 22.6% | 17.9% | 20.0% |
| | 4 | Count | 13 | 16 | 29 |
| | | % within Participant Category | 41.9% | 41.0% | 41.4% |
| Total | | Count | 31 | 39 | 70 |
| | | % within Participant Category | 100.0% | 100.0% | 100.0% |

**Table 41:** ***Chi-Square Tests 4 Point Dysphagia Scale-Aspiration***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 48.768[a] | 3 | .000 |
| Likelihood Ratio | 63.135 | 3 | .000 |
| Linear-by-Linear Association | 45.064 | 1 | .000 |

**Table 42:** ***4 Point Dysphagia Scale-Aspiration Crosstabulation***

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | .00 low | 1.00 high | Total |
| 4pt Dysphagia | 1 | Count | $5_a$ | $0_b$ | 5 |
| | | % within 4pt Dysphagia | 100.0% | .0% | 100.0% |
| | 2 | Count | $22_a$ | $0_b$ | 22 |
| | | % within 4pt Dysphagia | 100.0% | .0% | 100.0% |
| | 3 | Count | $8_a$ | $6_a$ | 14 |
| | | % within 4pt Dysphagia | 57.1% | 42.9% | 100.0% |
| | 4 | Count | $2_a$ | $27_b$ | 29 |
| | | % within 4pt Dysphagia | 6.9% | 93.1% | 100.0% |
| Total | | Count | 37 | 33 | 70 |
| | | % within 4pt Dysphagia | 52.9% | 47.1% | 100.0% |

**Table 43:** ***Chi-Square Tests Admission Group- 4 Point Dysphagia Scale***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 13.673[a] | 18 | .750 |
| Likelihood Ratio | 15.214 | 18 | .647 |
| Linear-by-Linear Association | .001 | 1 | .972 |
| N of Valid Cases | 70 | | |

The associations between admissions group and 4 point dysphagia outcomes were not statistically significant; thus, failing to demonstrate a relationship between admission diagnosis and dysphagia severity (See Table 44).

**Table 44:** ***Admission Group- 4 Point Dysphagia Scale Crosstabulation***

| | | | 4 pt Dysphagia | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| Admission Group | 1 cardiac | Count | 1 | 5 | 4 | 4 | 14 |
| | | % within 4pt Dysphagia | 20.0% | 22.7% | 28.6% | 13.8% | 20.0% |
| | 2 pulmonary | Count | 2 | 9 | 4 | 15 | 30 |
| | | % within 4pt Dysphagia | 40.0% | 40.9% | 28.6% | 51.7% | 42.9% |
| | 3 infectious | Count | 0 | 2 | 1 | 1 | 4 |
| | | % within 4pt Dysphagia | .0% | 9.1% | 7.1% | 3.4% | 5.7% |
| | 4 gastrointestinal | Count | 1 | 2 | 1 | 4 | 8 |
| | | % within 4pt Dysphagia | 20.0% | 9.1% | 7.1% | 13.8% | 11.4% |
| | 5 hemodynamic/ metabolic | Count | 1 | 2 | 0 | 4 | 7 |
| | | % within 4pt Dysphagia | 20.0% | 9.1% | .0% | 13.8% | 10.0% |
| | 6 traumatic | Count | 0 | 1 | 2 | 1 | 4 |
| | | % within 4pt Dysphagia | .0% | 4.5% | 14.3% | 3.4% | 5.7% |
| | 7 alcohol/narcotics | Count | 0 | 1 | 2 | 0 | 3 |
| | | % within 4pt Dysphagia | .0% | 4.5% | 14.3% | .0% | 4.3% |
| Total | | Count | 5 | 22 | 14 | 29 | 70 |
| | | % within 4pt Dysphagia | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

The reason for intubation and 4 point dysphagia outcomes were also found to be not significant (See Tables 45 and 46). These outcomes may be attributed to the percentage of expected values below 5 exceeded 80% in both cases.

**Table 45:** ***Chi-Square Tests Reason for Intubation- 4 Point Dysphagia Severity Scale***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 8.453[a] | 12 | .749 |
| Likelihood Ratio | 9.765 | 12 | .637 |
| Linear-by-Linear Association | 1.064 | 1 | .302 |
| N of Valid Cases | 70 | | |

**Table 46:** ***Reason for Intubation- 4 Point Dysphagia Severity Scale Crosstabulation***

| | | | 4pt Dysphagia | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| Reason for Int. Group | 1 cardiac | Count | 0 | 2 | 1 | 2 | 5 |
| | | % within 4pt Dysphagia | .0% | 9.1% | 7.1% | 6.9% | 7.1% |
| | 2 pulmonary | Count | 2 | 13 | 8 | 20 | 43 |
| | | % within 4pt Dysphagia | 40.0% | 59.1% | 57.1% | 69.0% | 61.4% |
| | 3 infectious | Count | 1 | 4 | 1 | 4 | 10 |
| | | % within 4pt Dysphagia | 20.0% | 18.2% | 7.1% | 13.8% | 14.3% |
| | 4 airway protection | Count | 1 | 3 | 3 | 1 | 8 |
| | | % within 4pt Dysphagia | 20.0% | 13.6% | 21.4% | 3.4% | 11.4% |
| | 5 hemodynamic | Count | 1 | 0 | 1 | 2 | 4 |
| | | % within 4pt Dysphagia | 20.0% | .0% | 7.1% | 6.9% | 5.7% |
| Total | | Count | 5 | 22 | 14 | 29 | 70 |
| | | % within 4pt Dysphagia | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

The associations between reason for intubation group and aspiration were not statistically significant (See Table 47 and 48).

**Table 47:** ***Chi-Square Tests Reason for Intubation- Aspiration***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | .181[a] | 4 | .996 |
| Likelihood Ratio | .182 | 4 | .996 |
| Linear-by-Linear Association | .122 | 1 | .727 |
| N of Valid Cases | 70 | | |

**Table 48:** ***Reason for Intubation-Aspiration Crosstabulation***

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | .00 1-5 | 1.00 6-8 | Total |
| Reason for Int .Group | 1 cardiac | Count | $3_a$ | $2_a$ | 5 |
| | | % within Reason for Int. Group | 60.0% | 40.0% | 100.0% |
| | 2 pulmonary | Count | $23_a$ | $20_a$ | 43 |
| | | % within Reason for Int. Group | 53.5% | 46.5% | 100.0% |
| | 3 infectious | Count | $5_a$ | $5_a$ | 10 |
| | | % within Reason for Int. Group | 50.0% | 50.0% | 100.0% |
| | 4 airway protection | Count | $4_a$ | $4_a$ | 8 |
| | | % within Reason for Int. Group | 50.0% | 50.0% | 100.0% |
| | 5 hemodynamic | Count | $2_a$ | $2_a$ | 4 |
| | | % within Reason for Int. Group | 50.0% | 50.0% | 100.0% |
| Total | | Count | 37 | 33 | 70 |
| | | % within Reason for Int. Group | 52.9% | 47.1% | 100.0% |

Admission group and aspiration were also found to not be statistically significant (See Tables 49 and 50). These outcomes are likely attributed to the fact that in both cases the percentage of expected values below 5 exceeded 70%.

**Table 49:** ***Chi-Square Tests Admission Group-Admission Risk***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | $2.828^a$ | 6 | .830 |
| Likelihood Ratio | 2.911 | 6 | .820 |
| Linear-by-Linear Association | 1.454 | 1 | .228 |
| N of Valid Cases | 70 | | |

**Table 50:** ***Admission Group-Aspiration Risk Crosstabulation***

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | No | Yes | Total |
| Admission Group | 1 cardiac | Count | $10_a$ | $4_a$ | 14 |
| | | % within Admission Group | 71.4% | 28.6% | 100.0% |
| | 2 pulmonary | Count | $15_a$ | $15_a$ | 30 |
| | | % within Admission Group | 50.0% | 50.0% | 100.0% |
| | 3 infectious | Count | $2_a$ | $2_a$ | 4 |
| | | % within Admission Group | 50.0% | 50.0% | 100.0% |
| | 4 gastrointestinal | Count | $4_a$ | $4_a$ | 8 |
| | | % within Admission Group | 50.0% | 50.0% | 100.0% |
| | 5 hemodynamic/ metabolic | Count | $3_a$ | $4_a$ | 7 |
| | | % within Admission Group | 42.9% | 57.1% | 100.0% |
| | 6 traumatic | Count | $2_a$ | $2_a$ | 4 |
| | | % within Admission Group | 50.0% | 50.0% | 100.0% |
| | 7 alcohol/narcotics | Count | $1_a$ | $2_a$ | 3 |
| | | % within Admission Group | 33.3% | 66.7% | 100.0% |
| Total | | Count | 37 | 33 | 70 |
| | | % within Admission Group | 52.9% | 47.1% | 100.0% |

**9. *Study A Results Summary:***

- Age was independently associated with post-extubation dysphagia severity.
- Duration of intubation was independently associated with post-extubation dysphagia severity.
- The odds of a participant presenting with a more severe dysphagia was increased by 7.5% for each additional year of age (p= 0.009).
- The odds of a participant presenting with a more severe dysphagia severity rating was increased by 48.2% for each additional day of intubation (p=0.032).
- Age was also independently associated with aspiration.
- Duration of intubation was also independently associated with aspiration.
- The odds of a participant exhibiting aspiration was increased by 4.1% for each additional year of age (p=0.018).
- The odds of a participant exhibiting aspiration was increased by 25% for each additional day of intubation (p=0.004).
- Reintubation (0=0.008) was significantly associated with dysphagia severity.
- Pneumonia (p=0.034) was significantly associated with aspiration.

## i. Study B Results

### *1. Four Point Dysphagia Severity Scale Outcomes:*

Amongst the 70 participants in Study B, dysphagia severity on Malandraki and colleagues (2011 and 2013) 4 point scale was normal in 15.7% (N=11), mild in 38.6% (N=27), moderate in 21.4% (N=15) and severe in 24.3% (N=17) (See Table 51).

**Table 51:** ***Four Point Dysphagia Severity Scale Outcomes***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| 4pt Dysphagia Severity | 1 | Count | $5_a$ | $6_a$ | 11 |
| | | % within Gender | 12.2% | 20.7% | 15.7% |
| | 2 | Count | $17_a$ | $10_a$ | 27 |
| | | % within Gender | 41.5% | 34.5% | 38.6% |
| | 3 | Count | $6_a$ | $9_a$ | 15 |
| | | % within Gender | 14.6% | 31.0% | 21.4% |
| | 4 | Count | $13_a$ | $4_a$ | 17 |
| | | % within Gender | 31.7% | 13.8% | 24.3% |
| Total | | Count | 41 | 29 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

In regards to the relationship between the reason for intubation and the 4 Point Dysphagia Severity Scale outcomes, the Pulmonary (Group 2) and Airway Protection (Group 4) groups exhibited the most severe outcome ratings, where 20.84% (N=5) and 30.8% (N=4) received a rating of 4, respectively. These groups also exhibited the greatest prevalence for a mild dysphagia rating, where 45.84% (N=11) and 38.5% (N=5) of participants received a score of 2, respectively. Thus, these two groups demonstrated the highest prevalence for extreme scores (See Table 52).

**Table 52:** ***Reason For Intubation- 4 Point Dysphagia Severity Crosstabulation***

| | | | 4pt Dysphagia Severity | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| Reason for Intubation Group | Airway Protection | Count | $2_a$ | $5_a$ | $2_a$ | $4_a$ | 13 |
| | | % within 4pt Dysphagia Severity | 18.2% | 18.5% | 13.3% | 23.5% | 18.6% |
| | Cardiac | Count | $1_a$ | $2_a$ | $1_a$ | $2_a$ | 6 |
| | | % within 4pt Dysphagia Severity | 9.1% | 7.4% | 6.7% | 11.8% | 8.6% |
| | Hemodynamic | Count | $3_a$ | $5_a$ | $2_a$ | $3_a$ | 13 |
| | | % within 4pt Dysphagia Severity | 27.3% | 18.5% | 13.3% | 17.6% | 18.6% |
| | Infectious | Count | $1_a$ | $4_a$ | $6_a$ | $3_a$ | 14 |
| | | % within 4pt Dysphagia Severity | 9.1% | 14.8% | 26.7% | 17.6% | 17.1% |
| | Pulmonary | Count | $4_a$ | $11_a$ | $4_a$ | $5_a$ | 24 |
| | | % within 4pt Dysphagia Severity | 36.4% | 40.7% | 26.7% | 29.4% | 34.3% |
| Total | | Count | 11 | 27 | 15 | 17 | 70 |
| | | % within 4pt Dysphagia Severity | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

### 2. *PAS Outcomes:*

With respect to aspiration rate using PAS scale outcomes, 25.7% (N=18) exhibited PAS scores of 6 through 8, where 74.3% (N= 52) of participants illustrated PAS scores of 1 through 5. The most prevalent PAS score for thin liquids was an average score of 5.5 (deep penetration without clearance, for 24.3% (N=17) of all participants. The second most frequent score was a 1, for 22.9% (N=6) of patients. A PAS score of 8 represented 11.4% of participants (N=8) (See Table 53). The most prevalent PAS score for puree was a 3 (Upper vestibule penetration without clearance) for 34.3% (N=24) of patients. The second most frequent PAS score with puree was a 1 (Normal) for 32.9% of participants (N=23). The third most commonly occurring score was a 5 (deep penetration without clearance) for 5.7% (N=4) (See Table 54).

**Table 53:** ***Penetration Aspiration Scale Thin Liquid Averages***

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 16 | 22.9 | 22.9 | 22.9 |
| | 2 | 5 | 7.1 | 7.1 | 30.0 |
| | 2.5 | 7 | 10.0 | 10.0 | 40.0 |
| | 3 | 6 | 8.6 | 8.6 | 48.6 |
| | 5 | 1 | 1.4 | 1.4 | 50.0 |
| | 5.5 | 17 | 24.3 | 24.3 | 74.3 |
| | 6 | 1 | 1.4 | 1.4 | 75.7 |
| | 7 | 2 | 2.9 | 2.9 | 78.6 |
| | 7.5 | 7 | 10.0 | 10.0 | 88.6 |
| | 8 | 8 | 11.4 | 11.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Table 54:** ***Penetration Aspiration Scale Puree Averages***

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 23 | 32.9 | 32.9 | 32.9 |
| | 2 | 2 | 2.9 | 2.9 | 35.7 |
| | 2.5 | 10 | 14.3 | 14.3 | 50.0 |
| | 3 | 24 | 34.3 | 34.3 | 84.3 |
| | 4 | 1 | 1.4 | 1.4 | 85.7 |
| | 5 | 4 | 5.7 | 5.7 | 91.4 |
| | 6 | 1 | 1.4 | 1.4 | 92.9 |
| | 6.5 | 1 | 1.4 | 1.4 | 94.3 |
| | 7 | 2 | 2.9 | 2.9 | 97.1 |
| | 8 | 2 | 2.9 | 2.9 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

In regards to Admission Group PAS outcomes, 18 participants exhibited aspiration. Admission Group 2 (Pulmonary) exhibited the highest prevalence of aspiration 27.8% (N=5). Disparately, Admission Group 5 (Hematology/Metabolic) exhibited the lowest incidence of aspiration 0% (N=0) on the PAS scale. However, upon examining each group's aspiration rate independently, Admission Group 3 (Infectious) demonstrated the greatest aspiration risk. This was likely due to small group clustering sample sizes, where only 5 participants were included in Admission Group 3 (See Table 55).

**Table 55:** ***Admission Group-Penetration Aspiration Scale Scores***

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | 0 no | 1 yes | Total |
| AdmissionGroup1 | 1 Cardiac | Count | $5_a$ | $1_a$ | 6 |
| | | % within Aspiration | 9.6% | 5.6% | 8.6% |
| | 2 Pulmonary | Count | $20_a$ | $5_a$ | 25 |
| | | % within Aspiration | 38.5% | 27.8% | 35.7% |
| | 3 Infectious | Count | $1_a$ | $4_b$ | 5 |
| | | % within Aspiration | 1.9% | 22.2% | 7.1% |
| | 4 Gastrointestinal | Count | $9_a$ | $2_a$ | 11 |
| | | % within Aspiration | 17.3% | 11.1% | 15.7% |
| | 5 Hemotology/Metabolic | Count | $7_a$ | $0_a$ | 7 |
| | | % within Aspiration | 13.5% | .0% | 10.0% |
| | 6 Traumatic | Count | $5_a$ | $2_a$ | 7 |
| | | % within Aspiration | 9.6% | 11.1% | 10.0% |
| | 7 Alcohol/Narcotics | Count | $5_a$ | $4_a$ | 9 |
| | | % within Aspiration | 9.6% | 22.2% | 12.9% |
| Total | | Count | 52 | 18 | 70 |
| | | % within Aspiration | 100.0% | 100.0% | 100.0% |

### 3. *Logistic Regression Analyses:*

Logistic Regression Analysis was used to determine if any of the study variables, gender, PNA, reason for intubation, reintubation, age or days intubated were associated with aspiration risk. The result of a forward and backward stepping approach determined that age was significantly associated with a higher risk of aspiration (p=0.027) (See Table 56). For each one year of age, the odds of a participant being in the aspiration group were increased by a factor of 1.045 (See Table 56).

**Table 56:** ***Logistic Regression: Aspiration- Age***

| | | | | | | | | 95% C.I.for EXP(B) | |
|---|---|---|---|---|---|---|---|---|---|
| | | B | S.E. | Wald | df | Sig. | Exp(B) | Lower | Upper |
| Step 1[a] | Age | .044 | .020 | 4.867 | 1 | .027 | 1.045 | 1.005 | 1.087 |
| | Constant | -4.045 | 1.433 | 7.966 | 1 | .005 | .018 | | |

The classification table indicates that the model predicted incidence of aspiration for 75.7% of participants. 100% of the subjects with no aspiration were correctly predicted, while only 5.6% of the participants with aspiration were correctly predicted (see Table 57). Thus, indicating that this regression model was not a good fit.

**Table 57:** ***Classification Table: Aspiration***

| | | | Predicted | | |
|---|---|---|---|---|---|
| | | | Aspiration | | |
| | Observed | | 0 no | 1 yes | Percentage Correct |
| Step 1 | Aspiration | 0 no | 52 | 0 | 100.0 |
| | | 1 yes | 17 | 1 | 5.6 |
| | Overall Percentage | | | | 75.7 |

### 4. *Multinomial Logistic Regression Analyses:*

Multinomial Logistic Regression was used to determine if any of the study variables, gender, PNA, reason for intubation, age, reintubation, or days intubated was associated with dysphagia severity rating. There were no significant associations demonstrated (See Table 58 and 59).

**Table 58:** ***Multinomial Logistic Regression: Dysphagia Severity Level***

| 4pt Dysphagia Severity | | B | Std. Error | Wald | df | Sig. |
|---|---|---|---|---|---|---|
| 1 | Intercept | -.435 | .387 | 1.266 | 1 | .261 |
| 2 | Intercept | .463 | .310 | 2.233 | 1 | .135 |
| 3 | Intercept | -.125 | .354 | .125 | 1 | .724 |

**Table 59:** ***Multinomial Logistic Regression Age and Gender***

| 4pt Dysphagia Severity[a] | | B | Std. Error | Wald | df | Sig. | Exp(B) | 95% Confidence Interval for Exp(B) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Lower Bound | Upper Bound |
| 1 | Intercept | 11.253 | 2.944 | 14.610 | 1 | .000 | | | |
| | Age | -.155 | .040 | 15.073 | 1 | .000 | .857 | .792 | .926 |
| | [Gender=1] | -3.328 | 1.138 | 8.547 | 1 | .003 | .036 | .004 | .334 |
| | [Gender=2] | 0[b] | . | . | 0 | . | . | . | . |
| 2 | Intercept | 7.616 | 2.501 | 9.273 | 1 | .002 | | | |
| | Age | -.088 | .031 | 8.158 | 1 | .004 | .916 | .862 | .973 |
| | [Gender=1] | -1.755 | .856 | 4.207 | 1 | .040 | .173 | .032 | .925 |
| | [Gender=2] | 0[b] | . | . | 0 | . | . | . | . |
| 3 | Intercept | 3.491 | 2.749 | 1.613 | 1 | .204 | | | |
| | Age | -.034 | .034 | 1.008 | 1 | .315 | .967 | .905 | 1.033 |
| | [Gender=1] | -1.973 | .887 | 4.946 | 1 | .026 | .139 | .024 | .791 |
| | [Gender=2] | 0[b] | . | . | 0 | . | . | . | . |

### *5. Unequal Variance T-Tests:*

T-Tests were used to compare the means of age and number of days intubated, where the categorical variable has only two levels. Using the unequal variance t-test, the average age participants was significantly higher, 70.6, for female participants than for male participants, 60.2 (p=.010) (See Table 60 and 61). The average days intubated was not significantly higher for male or female participants.

**Table 60:** ***T Test Age Statistics***

| | Gender | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Age | 1 male | 41 | 60.24 | 16.112 | 2.516 |
| | 2 female | 29 | 70.59 | 15.776 | 2.930 |
| Days Intubated | 1 male | 41 | 6.32 | 3.297 | .515 |
| | 2 female | 29 | 7.59 | 4.859 | .902 |

**Table 61:** ***T Test Age and Days Intubated: Independent Samples Test***

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Age | Equal variances assumed | .023 | .879 | -2.668 | 68 | .010 | -10.342 | 3.876 | -18.077 | -2.608 |
| | Equal variances not assumed | | | -2.678 | 61.226 | .009 | -10.342 | 3.862 | -18.064 | -2.621 |
| Days Intubated | Equal variances assumed | 1.363 | .247 | -1.303 | 68 | .197 | -1.269 | .974 | -3.213 | .675 |
| | Equal variances not assumed | | | -1.222 | 45.809 | .228 | -1.269 | 1.039 | -3.361 | .822 |

Using the unequal variance t-test, the average age of participants in the reintubation group was significantly higher, 76.5, than the non-reintubated participants, 63.0 (p=0.030) (See Table 62 and 63). Average days intubated was not found to be significantly associated with reintubation.

**Table 62:** ***Reintubation Group Statistics***

| | **reintubation** | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Age | 0 not reintubated | 62 | 62.98 | 16.739 | 2.126 |
| | 1 reintubated | 8 | 76.50 | 10.583 | 3.742 |
| Days Intubated | 0 not reintubated | 62 | 6.55 | 4.128 | .524 |
| | 1 reintubated | 8 | 9.13 | 2.295 | .811 |

**Table 63:** ***Reintubation Independent Samples T Test***

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Age | Equal variances assumed | 2.139 | .148 | -2.219 | 68 | .030 | -13.516 | 6.091 | -25.670 | -1.362 |
| | Equal variances not assumed | | | -3.141 | 12.104 | .008 | -13.516 | 4.303 | -22.883 | -4.149 |
| Days Intubated | Equal variances assumed | 1.807 | .183 | -1.724 | 68 | .089 | -2.577 | 1.495 | -5.559 | .406 |
| | Equal variances not assumed | | | -2.667 | 13.787 | .019 | -2.577 | .966 | -4.652 | -.502 |

The average age of patients that exhibited aspiration was significantly higher 72.2, than patients that did not exhibit aspiration, 61.9 (p=0.022) (See Table 64 and 65). Average days of intubation was not significantly associated with aspiration.

**Table 64:** ***Aspiration Group Statistics***

| | Aspiration | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| Age | 0 no | 52 | 61.87 | 17.420 | 2.416 |
| | 1 yes | 18 | 72.22 | 11.528 | 2.717 |
| Days Intubated | 0 no | 52 | 6.44 | 3.369 | .467 |
| | 1 yes | 18 | 8.00 | 5.488 | 1.294 |

**Table 65:** ***T Test Aspiration***

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| Age | Equal variances assumed | 4.286 | .042 | -2.345 | 68 | .022 | -10.357 | 4.416 | -19.170 | -1.544 |
| | Equal variances not assumed | | | -2.849 | 45.103 | .007 | -10.357 | 3.636 | -17.679 | -3.035 |
| Days Intubated | Equal variances assumed | 3.564 | .063 | -1.422 | 68 | .160 | -1.558 | 1.095 | -3.743 | .628 |
| | Equal variances not assumed | | | -1.133 | 21.602 | .270 | -1.558 | 1.375 | -4.413 | 1.298 |

### 6. *Analysis of Variance (ANOVA):*

An ANOVA was performed on the 4 Point Dysphagia scale for both age and days intubated. The results demonstrated that the average age of the participants differed by dysphagia severity level (p< 0.0005) (See Table 66). However, the average days intubated did not significantly differ by dysphagia severity level (See Table 67).

**Table 66:** ***ANOVA- 4 Point Dysphagia Scale- Age***

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 5153.663 | 3 | 1717.888 | 8.089 | .000 |
| Within Groups | 14015.780 | 66 | 212.360 | | |
| Total | 19169.443 | 69 | | | |

**Table 67:** ***ANOVA- 4 Point Dysphagia Scale- Days Intubated***

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 61.671 | 3 | 20.557 | 1.278 | .289 |
| Within Groups | 1061.600 | 66 | 16.085 | | |
| Total | 1123.271 | 69 | | | |

## 1. Post Hoc Tests:

Post Hoc comparisons demonstrate that the average age of participants that received a dysphagia severity rating of 3, 72.8, was significantly higher than that of participants that received a severity rating of 1, 49.1 ($p=0.001$). The average age of participants that received a rating of 4, 72.82, was significantly higher than participants who received a rating of 1, 49.1 ($p< 0.0005$) (See Table 68).

**Table 68*: Post Hoc Tests: Multiple Comparisons For Age***

Dependent Variable: Age

| | (I) 4pt Dysphagia Severity | (J) 4pt Dysphagia Severity | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Tukey HSD | 1 | 2 | -11.909 | 5.213 | .112 | -25.65 | 1.83 |
| | | 3 | -23.709 | 5.785 | .001 | -38.96 | -8.46 |
| | | 4 | -23.733 | 5.639 | .000 | -38.60 | -8.87 |
| | 2 | 1 | 11.909 | 5.213 | .112 | -1.83 | 25.65 |
| | | 3 | -11.800 | 4.693 | .067 | -24.17 | .57 |
| | | 4 | -11.824 | 4.512 | .052 | -23.72 | .07 |
| | 3 | 1 | 23.709 | 5.785 | .001 | 8.46 | 38.96 |
| | | 2 | 11.800 | 4.693 | .067 | -.57 | 24.17 |
| | | 4 | -.024 | 5.162 | 1.000 | -13.63 | 13.58 |
| | 4 | 1 | 23.733 | 5.639 | .000 | 8.87 | 38.60 |
| | | 2 | 11.824 | 4.512 | .052 | -.07 | 23.72 |
| | | 3 | .024 | 5.162 | 1.000 | -13.58 | 13.63 |
| Tamhane | 1 | 2 | -11.909 | 6.176 | .353 | -30.18 | 6.36 |
| | | 3 | -23.709 | 5.936 | .007 | -41.64 | -5.78 |
| | | 4 | -23.733 | 6.003 | .007 | -41.75 | -5.71 |
| | 2 | 1 | 11.909 | 6.176 | .353 | -6.36 | 30.18 |
| | | 3 | -11.800 | 4.193 | .045 | -23.42 | -.18 |
| | | 4 | -11.824 | 4.287 | .051 | -23.67 | .02 |
| | 3 | 1 | 23.709 | 5.936 | .007 | 5.78 | 41.64 |
| | | 2 | 11.800 | 4.193 | .045 | .18 | 23.42 |
| | | 4 | -.024 | 3.933 | 1.000 | -11.10 | 11.05 |
| | 4 | 1 | 23.733 | 6.003 | .007 | 5.71 | 41.75 |
| | | 2 | 11.824 | 4.287 | .051 | -.02 | 23.67 |
| | | 3 | .024 | 3.933 | 1.000 | -11.05 | 11.10 |

Post Hoc Comparisons did not demonstrate a statistically significant relationship between days intubated and dysphagia severity (See Table 69).

**Table 69:** ***Post Hoc Tests: Multiple Comparisons For Days Intubated***

Dependent Variable: Days Intubated

| | (I) 4ptDysphagiaSeverity | (J) 4ptDysphagiaSeverity | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound |
| Tukey HSD | 1 | 2 | -2.000 | 1.435 | .507 | -5.78 | 1.78 |
| | | 3 | -1.600 | 1.592 | .747 | -5.80 | 2.60 |
| | | 4 | -3.000 | 1.552 | .224 | -7.09 | 1.09 |
| | 2 | 1 | 2.000 | 1.435 | .507 | -1.78 | 5.78 |
| | | 3 | .400 | 1.292 | .990 | -3.00 | 3.80 |
| | | 4 | -1.000 | 1.242 | .852 | -4.27 | 2.27 |
| | 3 | 1 | 1.600 | 1.592 | .747 | -2.60 | 5.80 |
| | | 2 | -.400 | 1.292 | .990 | -3.80 | 3.00 |
| | | 4 | -1.400 | 1.421 | .758 | -5.14 | 2.34 |
| | 4 | 1 | 3.000 | 1.552 | .224 | -1.09 | 7.09 |
| | | 2 | 1.000 | 1.242 | .852 | -2.27 | 4.27 |
| | | 3 | 1.400 | 1.421 | .758 | -2.34 | 5.14 |
| Tamhane | 1 | 2 | -2.000 | 1.006 | .291 | -4.83 | .83 |
| | | 3 | -1.600 | 1.144 | .684 | -4.88 | 1.68 |
| | | 4 | -3.000 | 1.466 | .275 | -7.21 | 1.21 |
| | 2 | 1 | 2.000 | 1.006 | .291 | -.83 | 4.83 |
| | | 3 | .400 | 1.172 | 1.000 | -2.89 | 3.69 |
| | | 4 | -1.000 | 1.488 | .986 | -5.23 | 3.23 |
| | 3 | 1 | 1.600 | 1.144 | .684 | -1.68 | 4.88 |
| | | 2 | -.400 | 1.172 | 1.000 | -3.69 | 2.89 |
| | | 4 | -1.400 | 1.585 | .946 | -5.89 | 3.09 |
| | 4 | 1 | 3.000 | 1.466 | .275 | -1.21 | 7.21 |
| | | 2 | 1.000 | 1.488 | .986 | -3.23 | 5.23 |
| | | 3 | 1.400 | 1.585 | .946 | -3.09 | 5.89 |

### 7. *Correlation Coefficients:*

Correlations between age, days intubated, and food trial average PAS scores were evaluated. There were significant correlations between age and puree average ($r=0.424$, $p<=0.0005$) and liquid averages ($r=0.349$, $p=0.003$). As age increased, the average PAS scores increased (See Table 70). These results demonstrated that dysphagia severity outcomes significantly increased with increased age. This was not demonstrated for days intubated.

**Table 70:** ***Correlation Coefficients***

| | | Age | Days Intubated | Puree AVG | Liquids AVG | Solids AVG |
|---|---|---|---|---|---|---|
| Age | Pearson Correlation | 1 | .087 | .424** | .349** | .121 |
| | Sig. (2-tailed) | | .476 | .000 | .003 | .412 |
| | N | 70 | 70 | 70 | 70 | 48 |
| Days Intubated | Pearson Correlation | .087 | 1 | .140 | .129 | -.081 |
| | Sig. (2-tailed) | .476 | | .249 | .287 | .583 |
| | N | 70 | 70 | 70 | 70 | 48 |
| Puree AVG | Pearson Correlation | .424** | .140 | 1 | .678** | .513** |
| | Sig. (2-tailed) | .000 | .249 | | .000 | .000 |
| | N | 70 | 70 | 70 | 70 | 48 |
| Liquids AVG | Pearson Correlation | .349** | .129 | .678** | 1 | .341* |
| | Sig. (2-tailed) | .003 | .287 | .000 | | .018 |
| | N | 70 | 70 | 70 | 70 | 48 |
| Solids AVG | Pearson Correlation | .121 | -.081 | .513** | .341* | 1 |
| | Sig. (2-tailed) | .412 | .583 | .000 | .018 | |
| | N | 48 | 48 | 48 | 48 | 48 |

## 8. *Chi-Square Analyses:*

Chi-square tests were used to evaluate whether there were any significant associations between the categorical variables in the study. The statistical significance of admitting diagnosis group, reintubation, cause of intubation group, PNA, gender, and aspiration were examined.

Admission group was significantly associated with aspiration (p=0.046) (See Table 71). Only 1.9% of the non-aspiration patients had an infectious admitting diagnosis, while 22.2% of the aspiration patients had an infectious admitting diagnosis (See Table 72). These results demonstrate a statistically significant association between admission diagnosis and aspiration.

**Table 71:** ***Chi-Square Tests Admission Group- Aspiration***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 12.831[a] | 6 | .046 |
| Likelihood Ratio | 13.204 | 6 | .040 |
| Linear-by-Linear Association | .572 | 1 | .450 |
| N of Valid Cases | 70 | | |

**Table 72:** ***Admission Group- Aspiration Crosstabulation***

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | 0 no | 1 yes | Total |
| Admission Group | 1 Cardiac | Count | $5_a$ | $1_a$ | 6 |
| | | % within Aspiration | 9.6% | 5.6% | 8.6% |
| | 2 Pulmonary | Count | $20_a$ | $5_a$ | 25 |
| | | % within Aspiration | 38.5% | 27.8% | 35.7% |
| | 3 Infectious | Count | $1_a$ | $4_b$ | 5 |
| | | % within Aspiration | 1.9% | 22.2% | 7.1% |
| | 4 Gastrointestinal | Count | $9_a$ | $2_a$ | 11 |
| | | % within Aspiration | 17.3% | 11.1% | 15.7% |
| | 5 Hemotology/Metabolic | Count | $7_a$ | $0_a$ | 7 |
| | | % within Aspiration | 13.5% | .0% | 10.0% |
| | 6 Traumatic | Count | $5_a$ | $2_a$ | 7 |
| | | % within Aspiration | 9.6% | 11.1% | 10.0% |
| | 7 Alcohol/Narcotics | Count | $5_a$ | $4_a$ | 9 |
| | | % within Aspiration | 9.6% | 22.2% | 12.9% |
| Total | | Count | 52 | 18 | 70 |
| | | % within Aspiration | 100.0% | 100.0% | 100.0% |

Gender was not significantly associated with admission group or reason for intubation (See Table 73 and Table 74).

**Table 73:** ***Chi-Square Admission Group-Gender***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 4.482[a] | 6 | .612 |
| Likelihood Ratio | 4.601 | 6 | .596 |
| Linear-by-Linear Association | 3.736 | 1 | .053 |
| N of Valid Cases | 70 | | |

**Table 74:** ***Gender- Admission Group Crosstabulation***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| Admission Group | 1 Cardiac | Count | $3_a$ | $3_a$ | 6 |
| | | % within Gender | 7.3% | 10.3% | 8.6% |
| | 2 Pulmonary | Count | $12_a$ | $13_a$ | 25 |
| | | % within Gender | 29.3% | 44.8% | 35.7% |
| | 3 Infectious | Count | $2_a$ | $3_a$ | 5 |
| | | % within Gender | 4.9% | 10.3% | 7.1% |
| | 4 Gastrointestinal | Count | $7_a$ | $4_a$ | 11 |
| | | % within Gender | 17.1% | 13.8% | 15.7% |
| | 5 Hemotology/Metabolic | Count | $5_a$ | $2_a$ | 7 |
| | | % within Gender | 12.2% | 6.9% | 10.0% |
| | 6 Traumatic | Count | $5_a$ | $2_a$ | 7 |
| | | % within Gender | 12.2% | 6.9% | 10.0% |
| | 7 Alcohol/Narcotics | Count | $7_a$ | $2_a$ | 9 |
| | | % within Gender | 17.1% | 6.9% | 12.9% |
| Total | | Count | 41 | 29 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

The associations between admission group and reintubation (See Table 75 and 76) , admission group and 4 point dysphagia scale outcomes (See Table 77 and 78), and 4 point dysphagia scale outcomes and gender (See Table 79 and Table 80), were all not statistically significant.

**Table 75***: Chi-Square Tests Admission Group and Reintubation*

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 2.987[a] | 6 | .811 |
| Likelihood Ratio | 4.581 | 6 | .599 |
| Linear-by-Linear Association | .362 | 1 | .548 |
| N of Valid Cases | 70 | | |

**Table 76:** ***Admission Group- Reintubation Crosstabulation***

| | | | reintubation | | |
|---|---|---|---|---|---|
| | | | 0 not reintubated | 1 reintubated | Total |
| Admission Group | 1 Cardiac | Count | $6_a$ | $0_a$ | 6 |
| | | % within reintubation | 9.7% | .0% | 8.6% |
| | 2 Pulmonary | Count | $21_a$ | $4_a$ | 25 |
| | | % within reintubation | 33.9% | 50.0% | 35.7% |
| | 3 Infectious | Count | $4_a$ | $1_a$ | 5 |
| | | % within reintubation | 6.5% | 12.5% | 7.1% |
| | 4 Gastrointestinal | Count | $10_a$ | $1_a$ | 11 |
| | | % within reintubation | 16.1% | 12.5% | 15.7% |
| | 5 Hemotology/Metabolic | Count | $6_a$ | $1_a$ | 7 |
| | | % within reintubation | 9.7% | 12.5% | 10.0% |
| | 6 Traumatic | Count | $6_a$ | $1_a$ | 7 |
| | | % within reintubation | 9.7% | 12.5% | 10.0% |
| | 7 Alcohol/Narcotics | Count | $9_a$ | $0_a$ | 9 |
| | | % within reintubation | 14.5% | .0% | 12.9% |
| Total | | Count | 62 | 8 | 70 |
| | | % within reintubation | 100.0% | 100.0% | 100.0% |

**Table 77:** ***Chi-Square Tests Admission Group- 4 Point Dysphagia Outcomes***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 21.082[a] | 18 | .275 |
| Likelihood Ratio | 26.512 | 18 | .089 |
| Linear-by-Linear Association | .009 | 1 | .926 |
| N of Valid Cases | 70 | | |

**Table 78:** ***Admission Group- 4 Point Dysphagia Severity Outcomes Crosstabulation***

| | | | 4pt Dysphagia Severity | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| Admission Group | 1 Cardiac | Count | $2_a$ | $1_a$ | $2_a$ | $1_a$ | 6 |
| | | % within 4ptDysphagia Severity | 18.2% | 3.7% | 13.3% | 5.9% | 8.6% |
| | 2 Pulmonary | Count | $3_a$ | $11_a$ | $6_a$ | $5_a$ | 25 |
| | | % within 4ptDysphagia Severity | 27.3% | 40.7% | 40.0% | 29.4% | 35.7% |
| | 3 Infectious | Count | $0_{a, b}$ | $0_b$ | $2_{a, b}$ | $3_a$ | 5 |
| | | % within 4ptDysphagia Severity | .0% | .0% | 13.3% | 17.6% | 7.1% |
| | 4 Gastrointestinal | Count | $2_a$ | $6_a$ | $1_a$ | $2_a$ | 11 |
| | | % within 4ptDysphagia Severity | 18.2% | 22.2% | 6.7% | 11.8% | 15.7% |
| | 5 Hemotology/Metabolic | Count | $0_a$ | $4_a$ | $3_a$ | $0_a$ | 7 |
| | | % within 4ptDysphagia Severity | .0% | 14.8% | 20.0% | .0% | 10.0% |
| | 6 Traumatic | Count | $2_a$ | $3_a$ | $0_a$ | $2_a$ | 7 |
| | | % within 4ptDysphagia Severity | 18.2% | 11.1% | .0% | 11.8% | 10.0% |
| | 7 Alcohol/Narcotics | Count | $2_a$ | $2_a$ | $1_a$ | $4_a$ | 9 |
| | | % within 44ptDysphagia Severity | 18.2% | 7.4% | 6.7% | 23.5% | 12.9% |
| Total | | Count | 11 | 27 | 15 | 17 | 70 |
| | | % within 4ptDysphagia Severity | 100.0% | 100.0% | 100.0% | 100.0 % | 100.0% |

**Table 79:** ***Chi-Square Tests 4 Point Dysphagia Severity Outcomes and Gender***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 5.371[a] | 3 | .147 |
| Likelihood Ratio | 5.480 | 3 | .140 |
| Linear-by-Linear Association | 1.245 | 1 | .264 |
| N of Valid Cases | 70 | | |

**Table 80:** ***4 Point Dysphagia Severity- Gender Crosstabulation***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| 4pt Dysphagia Severity | 1 | Count | $5_a$ | $6_a$ | 11 |
| | | % within Gender | 12.2% | 20.7% | 15.7% |
| | 2 | Count | $17_a$ | $10_a$ | 27 |
| | | % within Gender | 41.5% | 34.5% | 38.6% |
| | 3 | Count | $6_a$ | $9_a$ | 15 |
| | | % within Gender | 14.6% | 31.0% | 21.4% |
| | 4 | Count | $13_a$ | $4_a$ | 17 |
| | | % within Gender | 31.7% | 13.8% | 24.3% |
| Total | | Count | 41 | 29 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

Reason for intubation and aspiration risk (See Table 81 and 82), and reason for intubation and 4 point dysphagia severity outcomes (See Table 83 and 84) were not statistically significant.

**Table 81:** ***Chi-Square Tests Reason For Intubation- Aspiration Risk***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 3.723[a] | 5 | .590 |
| Likelihood Ratio | 4.147 | 5 | .528 |
| N of Valid Cases | 70 | | |

**Table 82***: Reason For Intubation- Aspiration Crosstabulation*

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | 0 no | 1 yes | Total |
| Reason for Intubation Group | Airway Protection | Count | $9_a$ | $4_a$ | 13 |
| | | % within Aspiration | 17.3% | 22.2% | 18.6% |
| | Cardiac | Count | $4_a$ | $2_a$ | 6 |
| | | % within Aspiration | 7.7% | 11.1% | 8.6% |
| | Endocrine/Infectious | Count | $2_a$ | $0_a$ | 2 |
| | | % within Aspiration | 3.8% | .0% | 2.9% |
| | Hemodynamic | Count | $10_a$ | $3_a$ | 13 |
| | | % within Aspiration | 19.2% | 16.7% | 18.6% |
| | Infectious | Count | $7_a$ | $5_a$ | 12 |
| | | % within Aspiration | 13.5% | 27.8% | 17.1% |
| | Pulmonary | Count | $20_a$ | $4_a$ | 24 |
| | | % within Aspiration | 38.5% | 22.2% | 34.3% |
| Total | | Count | 52 | 18 | 70 |

**Table 83:** ***Chi-Square Tests Reason For Intubation- 4 Point Dysphagia Severity Outcomes***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 10.782[a] | 15 | .768 |
| Likelihood Ratio | 9.553 | 15 | .847 |
| N of Valid Cases | 70 | | |

**Table 84:** ***Reason For Intubation- 4 Point Dysphagia Severity Scale Outcomes Crosstabulation***

| | | | 4pt Dysphagia Severity | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | Total |
| Reason for Intubation Group | Airway Protection | Count | $2_a$ | $5_a$ | $2_a$ | $4_a$ | 13 |
| | | % within 4pt DysphagiaSeverity | 18.2% | 18.5% | 13.3% | 23.5% | 18.6% |
| | Cardiac | Count | $1_a$ | $2_a$ | $1_a$ | $2_a$ | 6 |
| | | % within 4pt DysphagiaSeverity | 9.1% | 7.4% | 6.7% | 11.8% | 8.6% |
| | Endocrine/Infectious | Count | $0_a$ | $0_a$ | $2_a$ | $0_a$ | 2 |
| | | % within 4pt DysphagiaSeverity | .0% | .0% | 13.3% | .0% | 2.9% |
| | Hemodynamic | Count | $3_a$ | $5_a$ | $2_a$ | $3_a$ | 13 |
| | | % within 4pt DysphagiaSeverity | 27.3% | 18.5% | 13.3% | 17.6% | 18.6% |
| | Infectious | Count | $1_a$ | $4_a$ | $4_a$ | $3_a$ | 12 |
| | | % within 4pt DysphagiaSeverity | 9.1% | 14.8% | 26.7% | 17.6% | 17.1% |
| | Pulmonary | Count | $4_a$ | $11_a$ | $4_a$ | $5_a$ | 24 |
| | | % within 4pt DysphagiaSeverity | 36.4% | 40.7% | 26.7% | 29.4% | 34.3% |

The presence of PNA and 4 Point Dysphagia Scale outcomes were not statistically significant (See Tables 85 and 86).

**Table 85:** ***Chi-Square Tests 4 Point Dyphagia Scale- PNA***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 2.078[a] | 3 | .556 |
| Likelihood Ratio | 2.012 | 3 | .570 |
| Linear-by-Linear Association | .651 | 1 | .420 |
| N of Valid Cases | 70 | | |

**Table 86:** ***4 Point Dysphagia Scale- PNA Crosstabulation***

| | | | PNA | | |
|---|---|---|---|---|---|
| | | | 0 other | 1 PNA | Total |
| 4pt Dysphagia Severity | 1 | Count | $9_a$ | $2_a$ | 11 |
| | | % within PNA | 16.4% | 13.3% | 15.7% |
| | 2 | Count | $23_a$ | $4_a$ | 27 |
| | | % within PNA | 41.8% | 26.7% | 38.6% |
| | 3 | Count | $10_a$ | $5_a$ | 15 |
| | | % within PNA | 18.2% | 33.3% | 21.4% |
| | 4 | Count | $13_a$ | $4_a$ | 17 |
| | | % within PNA | 23.6% | 26.7% | 24.3% |
| Total | | Count | 55 | 15 | 70 |
| | | % within PNA | 100.0% | 100.0% | 100.0% |

Reason for intubation and gender (See Table 87 and 88), reason for intubation and PNA (See Table 89 and 90), reason for intubation and reintubation (See Table 91and 92) all were not statistically significant.

**Table 87:** ***Chi-Square Tests Reason For Intubation- Gender***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 8.738[a] | 5 | .120 |
| Likelihood Ratio | 9.673 | 5 | .085 |
| N of Valid Cases | 70 | | |

**Table 88:** ***Reason For Intubation- Gender Crosstabulation***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| Reason for Intubation Group | Airway Protection | Count | $10_a$ | $3_a$ | 13 |
| | | % within Gender | 24.4% | 10.3% | 18.6% |
| | Cardiac | Count | $2_a$ | $4_a$ | 6 |
| | | % within Gender | 4.9% | 13.8% | 8.6% |
| | Endocrine/Infectious | Count | $0_a$ | $2_a$ | 2 |
| | | % within Gender | .0% | 6.9% | 2.9% |
| | Hemodynamic | Count | $10_a$ | $3_a$ | 13 |
| | | % within Gender | 24.4% | 10.3% | 18.6% |
| | Infectious | Count | $7_a$ | $5_a$ | 12 |
| | | % within Gender | 17.1% | 17.2% | 17.1% |
| | Pulmonary | Count | $12_a$ | $12_a$ | 24 |
| | | % within Gender | 29.3% | 41.4% | 34.3% |
| Total | | Count | 41 | 29 | 70 |
| | | % within | 100.0% | 100.0% | 100.0% |

**Table 89:** ***Chi-Square Tests Reason For Intubation- PNA***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 7.484[a] | 5 | .187 |
| Likelihood Ratio | 10.343 | 5 | .066 |
| N of Valid Cases | 70 | | |

**Table 90:** ***Reason For Intubation- PNA Crosstabulation***

| | | | PNA | | |
|---|---|---|---|---|---|
| | | | 0 other | 1 PNA | Total |
| Reason for Intubation Group | Airway Protection | Count | $11_a$ | $2_a$ | 13 |
| | | % within PNA | 20.0% | 13.3% | 18.6% |
| | Cardiac | Count | $5_a$ | $1_a$ | 6 |
| | | % within PNA | 9.1% | 6.7% | 8.6% |
| | Endocrine/Infectious | Count | $2_a$ | $0_a$ | 2 |
| | | % within PNA | 3.6% | .0% | 2.9% |
| | Hemodynamic | Count | $13_a$ | $0_b$ | 13 |
| | | % within PNA | 23.6% | .0% | 18.6% |
| | Infectious | Count | $8_a$ | $4_a$ | 12 |
| | | % within PNA | 14.5% | 26.7% | 17.1% |
| | Pulmonary | Count | $16_a$ | $8_a$ | 24 |
| | | % within PNA | 29.1% | 53.3% | 34.3% |
| Total | | Count | 55 | 15 | 70 |
| | | % within PNA | 100.0% | 100.0% | 100.0% |

**Table *91: Chi-Square Tests Reason for Intubation and Reintubation***

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 4.013[a] | 5 | .548 |
| Likelihood Ratio | 3.432 | 5 | .634 |
| N of Valid Cases | 70 | | |

**Table 92: *Reason For Intubation and Reintubation Crosstabulation***

| | | | reintubation | | |
|---|---|---|---|---|---|
| | | | 0 not reintubated | 1 reintubated | Total |
| Reason for Intubation Group | Airway Protection | Count | $12_a$ | $1_a$ | 13 |
| | | % within reintubation | 19.4% | 12.5% | 18.6% |
| | Cardiac | Count | $4_a$ | $2_a$ | 6 |
| | | % within reintubation | 6.5% | 25.0% | 8.6% |
| | Endocrine/Infectious | Count | $2_a$ | $0_a$ | 2 |
| | | % within reintubation | 3.2% | .0% | 2.9% |
| | Hemodynamic | Count | $12_a$ | $1_a$ | 13 |
| | | % within reintubation | 19.4% | 12.5% | 18.6% |
| | Infectious | Count | $10_a$ | $2_a$ | 12 |
| | | % within reintubation | 16.1% | 25.0% | 17.1% |
| | Pulmonary | Count | $22_a$ | $2_a$ | 24 |
| | | % within reintubation | 35.5% | 25.0% | 34.3% |
| Total | | Count | 62 | 8 | 70 |
| | | % within reintubation | 100.0% | 100.0% | 100.0% |

Gender and PNA were not found to be statistically significant (See Table 93 and 94). Gender and reintubation were also not found to be statistically significant (See Table 95 and 96).

**Table 93:** ***Chi-Square Tests PNA- Gender***

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | .216[a] | 1 | .642 | | |
| Continuity Correction[b] | .029 | 1 | .866 | | |
| Likelihood Ratio | .214 | 1 | .643 | | |
| Fisher's Exact Test | | | | .769 | .429 |
| Linear-by-Linear Association | .213 | 1 | .645 | | |
| N of Valid Cases | 70 | | | | |

**Table 94:** ***PNA and Gender Crosstabulation***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| PNA | 0 other | Count | $33_a$ | $22_a$ | 55 |
| | | % within Gender | 80.5% | 75.9% | 78.6% |
| | 1 PNA | Count | $8_a$ | $7_a$ | 15 |
| | | % within Gender | 19.5% | 24.1% | 21.4% |
| Total | | Count | 41 | 29 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

**Table 95:** ***Chi-Square Tests Reintubation- Gender***

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | 1.653[a] | 1 | .199 | | |
| Continuity Correction[b] | .818 | 1 | .366 | | |
| Likelihood Ratio | 1.627 | 1 | .202 | | |
| Fisher's Exact Test | | | | .262 | .183 |
| Linear-by-Linear Association | 1.629 | 1 | .202 | | |
| N of Valid Cases | 70 | | | | |

**Table 96:** ***Reintubation and Gender Crosstabulation***

| | | | Gender | | |
|---|---|---|---|---|---|
| | | | 1 male | 2 female | Total |
| reintubation | 0 not reintubated | Count | $38_a$ | $24_a$ | 62 |
| | | % within Gender | 92.7% | 82.8% | 88.6% |
| | 1 reintubated | Count | $3_a$ | $5_a$ | 8 |
| | | % within Gender | 7.3% | 17.2% | 11.4% |
| Total | | Count | 41 | 29 | 70 |
| | | % within Gender | 100.0% | 100.0% | 100.0% |

Comparable to Study A, 4 point dysphagia severity rating outcomes were comparable to aspiration on the PAS scale. Patients that exhibited aspiration (scores of 6 through 8) on the PAS scale only received 4 point dysphagia scale ratings of 3 or 4. Specifically, 8.4% (N=3) of patients that presented with aspiration received a 4 point scale rating of 3 and 83.4% (N=15) of aspirating patients received a 4 point scale rating of 4 (See Table 97). However, less patients presented with aspiration in Study B (N=18) than Study A (N=33).

**Table 97:** ***4 Point Dysphagia Scale- Aspiration Crosstabulation***

| | | | Aspiration | | |
|---|---|---|---|---|---|
| | | | 0 no | 1 yes | Total |
| 4pt Dysphagia Severity | 1 | Count | 11 | 0 | 11 |
| | | % within Aspiration | .2 | .0 | .2 |
| | 2 | Count | 27 | 0 | 27 |
| | | % within Aspiration | .5 | .0 | .4 |
| | 3 | Count | 12 | 3 | 15 |
| | | % within Aspiration | .2 | .2 | .2 |
| | 4 | Count | 2 | 15 | 17 |
| | | % within Aspiration | .0 | .8 | .2 |
| Total | | Count | 52 | 18 | 70 |
| | | % within Aspiration | 1.0 | 1.0 | 1.0 |

### 9. *Interjudge Reliability:*

Five intraclass correlation coefficients were calculated for 20% (N=14) of swallows of thin and puree textures with the PAS and 4 Point Dysphagia Severity Rating Scale. Rater 3 from a pool of 280 grand total swallows rated a total of 56 swallows (Thin=28; Puree=28). Rater 1 and Rater 2 exhibited a mean 4 Point Dysphagia Severity Scale Rating of 2.93 with a SD of 1.141 (See Table 98). Rater 3 exhibited a mean 4 Point Dysphagia Severity Rating of 3.14 with a SD of .949 (See Table 98).

**Table 98:** ***Interjudge Reliability Descriptive Statistics***

| | Mean | Std. Deviation | N |
|---|---|---|---|
| 4ptDysphagiaSeverity 4 pt Dysphagia Severity | 2.93 | 1.141 | 14 |
| 4PtdysphagiaRater3 4 Pt dysphagia Rater 3 | 3.14 | .949 | 14 |

All intraclass correlations for both scales exhibited correlations over 0.9, which indicated an extremely high level of inter-rater reliability. For 4 Point Dysphagia Severity Ratings, an intraclass correlation coefficient of 0.918 was demonstrated (See Table 99).

a. Puree Trial1
    i. Intraclass correlation coefficient = 1.00
b. Puree Trial 2
    i. Intraclass correlation coefficient = 0.989
c. Thin Liquids Trial1
    i. Intraclass correlation coefficient = 0.994
d. Thin liquids Trial 2
    i. Intraclass correlation coefficient = 0.989
e. Dysphagia
    i. Intraclass correlation coefficient = 0.918

**Table 99:** ***Intraclass Correlation Coefficient***

| | Intraclass Correlation | 95% Confidence Interval | | F Test with True Value 0 | | | |
|---|---|---|---|---|---|---|---|
| | | Lower Bound | Upper Bound | Value | df1 | df2 | Sig |
| Single Measures | 0.918 | .764 | .973 | 23.303 | 13 | 13 | .000 |

**10.** ***Study B: Results Summary:***

- Age was independently associated with post-extubation aspiration.
- The odds of a participant exhibiting aspiration was increased by 4.5% for each additional year of age (p=0.027).
- Increased age was associated with an increased incidence of reintubation.
- Admission diagnosis, particularly of an infectious etiology was significantly associated with aspiration (p=0.046).
- Excellent agreement between preliminary swallow ratings by Rater 1 and 2 and 20% of swallows scored by Rater 3 were demonstrated (r=0.918).

## VI. DISCUSSION

Post-extubation dysphagia is often under-detected for critically-ill patients. This is of great importance since the presence of dysphagia increases the risk of aspiration, morbidity and mortality. Identification of specific risk factors for post-extubation dysphagia is variable in previous studies. The present two part retrospective and prospective study investigated various post-extubation risk factors that have been identified in prior research and novel potential risk factors. The specific risk factors of interest were: age, gender, days intubated, admission diagnosis, reason for intubation, reintubation and PNA. The aim of Study A, a retrospective observational design was to test the hypothesis that specific risk factors are reliable predictors of swallowing dysfunction after prolonged emergent orotracheal intubation in critically-ill patients. The aim of Study B was to examine the same risk factors as Study A using a prospective observational method. It was hypothesized that duration of intubation, increased age, admitting diagnosis, precipitating cause of intubation, the presence of PNA and the need for multiple intubations would be significantly associated with increased risk of dysphagia in patients who received prolonged intubation for >= 72 hours. This hypothesis was only partially supported in both Study A and Study B. In Study A, age, duration of intubation and reintubation were each independently associated with post-extubation dysphagia severity. Age, duration of intubation and pneumonia were also found to be independently associated with aspiration. In Study B, age was independently associated with post-extubation aspiration and admission diagnosis was significantly associated with aspiration.

### i. Dysphagia Frequency:

Variability has been reported in the incidence of post-extubation dysphagia and aspiration risk in the swallowing literature. This lack of consistency can likely be attributed to several experimental design factors such as variation in swallowing assessment techniques which is a potential cause of inconsistency in dysphagia frequency. Numerous studies have selected divergent assessment techniques to determine swallowing function. In particular, previous studies that used FEES examinations, such as Ajemian et al (2001) and El Solh et al (2003), reported the highest incidence of post-extubation dysphagia. This may be attributed to enhanced sensitivity with direct visualization of the oropharynx during a FEES examination, or bias towards patients with more severe dysphagia. Secondly, variation for timing of swallowing assessment after extubation in previous research may alter the incidence and severity of post-extubation dysphagia. Swallowing assessment timing intervals have been found to range from immediately after extubation, as in de Larminat et al., (1995), to up to 5 days post-extubation, as in Padovani et al., (2008). It might be expected that with more timely swallowing assessment, there would be a greater incidence of post-extubation dysphagia, given less time for spontaneous recovery. Also, demonstration of large standard deviations for independent variables of interest may confound accurate demonstration of post-extubation dysphagia frequency. Additionally, variation in how swallowing outcomes are demarcated may have altered post-extubation frequency. Many studies, including Ajemain et al., (2001), Barquist et al., (2001) and El Solh et al., (2003), selected aspiration as their swallowing outcome. Other studies, such as Partik and colleagues (2000), examined aberrant pharyngeal

phase issues of swallowing as the outcome of interest. Finally, use of subject samples with a well-established relationship with dysphagia prior to intubation potentially may artificially increase dysphagia incidence. Thus, demonstrating reduced accuracy of dysphagia frequency estimates. Consequently, this present two part study strove to ascertain post-extubation dysphagia frequency while controlling for these potential design limitations. The present two part study demonstrated a 92.9% post-extubation dysphagia incidence in Study A and an 84.3% post-extubation dysphagia incidence in Study B. With respect to aspiration frequency, 47.15% (N=33) of participants in Study A aspirated, while 25.7% (N=18) of participants in Study B exhibited aspiration. This finding demonstrates a greater severity of post-extubation dysphagia and aspiration for subjects in Study A. This is likely because all Study A participants were recommended to undergo either an MBS or FEES procedure and thus these participants represented a more severe post-extubation dysphagia group. Study B participants also had a younger median age than Study A. Given the significant relationship of age and post-extubation dysphagia severity, the younger sample cohort may account for the lower incidence in dysphagia severity in Study B.

### ii. Swallowing Assessment Techniques:

In Study A, no statistically significant differences in dysphagia severity outcomes were demonstrated between the two formal instrumentation techniques used to determine dysphagia severity and aspiration risk. Within the literature, several assessment and screening techniques have been employed in efforts to determine dysphagia severity. Bordon et al (2011), Macht and researchers (2011) (2013), and

Padovani and colleagues (2008) relied solely on swallowing screening techniques or a Clinical Dysphagia Evaluation (CDE) to determine dysphagia severity. Due to the subjective nature and inter and intra judge reliability concerns, the studies that used this technique may be a misrepresentation of dysphagia severity ratings. Partik and colleagues (2000) and Barker and researchers (2009) used MBS studies to determine dysphagia severity and aspiration after prolonged intubation. Barker and researchers (2009) demonstrated a significant relationship between intubation days and dysphagia. Conversely, the majority of research studies that evaluated post-extubation dysphagia utilized FEES examinations. Interestingly, these studies that used FEES did not demonstrate a relationship between intubation days and post-extubation dysphagia. Additional research is needed to compare the use of various assessment techniques to determine post-extubation swallowing severity.

### iii. Risk Factor: Age:

In both studies, age was independently significantly associated with an increased risk of dysphagia severity and aspiration. In Study A, the odds of aspiration were found to increase by 4.1% for each additional year of age. The odds of having severe dysphagia were increased by 7.5% for each additional year of age. In Study B, the odds of aspiration were found to increase by 4.5%. These studies substantiated the influence of age on post-extubation dysphagia demonstrated in previous research. Similarly, Barquist and colleagues (2001) and Bordon and researchers (2011) demonstrated that the older the participant, the more severe the dysphagia. Bordon and colleagues (2011) illustrated a 2.5 fold increased risk of post-extubation dysphagia for

trauma patients 55 and older. However, it should be noted that this finding may be attributed to age related changes and degenerative changes of the oropharynx and larynx, referred to as presbylarynx, which may have exacerbated a pre-existing dysphagia or falsely elevated the number of participants identified as presenting with a dysphagia. Also, other studies have not demonstrated a statistically significant association between increased age and post-extubation dysphagia. El Solh and colleagues (2003), de Larminat and colleagues (1995), and Macht and researchers (2011) did not demonstrate a significant independent relationship between age and post-extubation dysphagia. Due to great variability in research outcomes, additional exploration is needed to determine the influence of age as an independent risk factor for dysphagia severity and aspiration risk.

**iv. Risk Factor: Days Intubated:**

In Study A, days of intubation was also found to be independently significantly associated with an increased risk of dysphagia severity and aspiration. The odds of aspiration were found to increase by 25% for each additional day intubated. The odds of having severe dysphagia was increased by 48.2% for each additional day intubated. The longer a patient was intubated, the more severe the post-extubation dysphagia. In Study B, no significant increase in odds of exhibiting post-extubation dysphagia was noted for each additional day of intubation. The presence of an endotracheal tube during intubation may significantly alter motoric and sensory aspects of swallowing. Thus, suggesting that prolonged immobility of the larynx secondary to orotracheal intubation causes some degree of potential laryngeal trauma, disuse atrophy of

laryngeal musculature and deviant swallowing function. Study A's finding supports previous literature, which found increased dysphagia severity for prolonged ventilator use. In particular, Bordon and researchers (2011) and Macht and colleagues (2011) (2012) demonstrated increased dysphagia severity after prolonged intubation. Bordon and colleagues (2011) demonstrated a 14% increased risk of post-extubation dysphagia for each additional day intubated for trauma patients. It should be noted that these studies were based on neurological and head trauma patients. Specifically, Bordon et al.'s (2011) study included trauma patients with extensive head injury and Macht and colleagues (2012) study was based on neurogenic patients. Also, in Macht et al.'s (2011) study, the researchers were unable to exclude the presence of a prior neurological history or diagnosis due to limited case history information obtained during retrospective analysis. The inability to ascertain premorbid or subsequent dysphagia secondary to head trauma or neurological conditions may have inaccurately inflated the incidence of post-extubation dysphagia in these two experiments. Determining the true etiology of the post-extubation dysphagia would also be difficult in a neurogenic patient. Barquist and colleagues (2001) and El Solh and researchers (2003) did not demonstrate a statistically significant correlation between duration of intubation and post-extubation dysphagia or aspiration. Additionally, de Larminat and colleagues (1995) also did not find an association between these two variables. This is likely attributed to the fact that all patients who were intubated for at least 24 hours were included in de Larminat's study. Hence, decreasing the likelihood of more extensive laryngeal trauma and muscular atrophy secondary to prolonged orotracheal intubation. It should be noted that extensive laryngeal edema has been demonstrated in

animal studies for intubation of only 24 hours (Bishop, Hibbard, & Fink, 1985). Interestingly, previous studies conducted by Barquist and colleagues (2001) and Leder and researchers (1998) that reported the longest days of intubation duration did not demonstrate the highest dysphagia incidences. Hence, demonstrating great variability in the effect of days intubated on post-extubation dysphagia. This significant association demonstrated in Study A was however, not demonstrated in Study B. This discrepancy in results may be attributed to large standard deviations in length of intubation, and variation in sample size, and admission and extent of laryngeal trauma and/or disuse atrophy. Greater exploration of the relationship between duration of intubation and post-extubation dysphagia needs to be examined.

### v. Risk Factor: Reintubation:

Reintubation was found to be significantly associated with increased dysphagia severity or aspiration in Study A, but not Study B. Similarly to Study B, Barquist and researchers (2001) did not demonstrate a statistical association between reintubation and aspiration. The lack of significance for reintubation demonstrated in Study B may be attributed to limited incidence of reintubation in this study. This may be attributed to the fact that many reintubated patients that were screened for potential participation had an increased prevalence of tracheostomy conversion or expiration, both of which prevented participation in either study. Consequently, Study A's research finding is consistent with Macht and colleagues (2011) study that demonstrated a significant relationship between reintubation and dysphagia severity. Another study conducted by Barker and researchers (2009) also demonstrated a significant relationship between

reintubation and post-extubation dysphagia is cardiac surgical patients. However, it should be noted that potential damage to various cranial nerves involved in swallowing during cardiac surgery, particularly the Recurrent Laryngeal Nerve (RLN), may have caused an increased incidence of post-extubation dysphagia in this experiment. Damage to the RLN has been demonstrated to cause swallowing dysfunction in patients without prolonged intubation. Consequently, there is no way to accurately determine the true etiology of the dysphagia in this particular surgical population. This may have potentially inflated the incidence of post-operative dysphagia for reintubated patients in that study.

### vi. Risk Factor: PNA:

In Study A, PNA was significantly associated with aspiration risk. Forty-six percent of participants that exhibited aspiration also presented with PNA. Specifically, out of all admission diagnoses, PNA was significantly associated with aspiration. Sixty-five percent of patients that exhibited PNA also presented with aspiration on the PAS scale, while 38.3% of patients with other diagnoses exhibited aspiration. Barquist and researchers (2001) and Macht and colleagues (2011) both illustrated an independent relationship between PNA and dysphagia severity. Their findings however, were representative of the development of PNA as a poor medical outcome and not a precipitating diagnosis or cause of intubation. Nonetheless, this relationship is of great clinical significance since aspiration is one of the primary cause of infection within medical fragile patients, which increases a patient's risk of poor medical outcomes. A greater incidence of PNA was exhibited in Study A than Study B, hence

potentially accounting for this statistical relationship. Stratification of the type of PNA, rather than examining PNA as an umbrella diagnosis, may also be beneficial to determine if certain types of PNA (i.e. Asp PNA) have a greater propensity for post-extubation dysphagia.

### vii. Risk Factor: Admission Diagnosis:

In Study B, admission diagnosis was significantly associated with aspiration. In particular, the infectious diagnosis cluster was found to be significantly associated with aspiration risk. However, due to the limited amount of patients clustered into the infectious group (N=5), an association between an infectious diagnosis group and dysphagia severity is difficult to validate. Due to great variability in admitting diagnoses, it should be note that over two-thirds of the cells had expected values less than 5. The assumptions of the test require that 80% of the cells have expected values greater than 5. Conversely, Study A failed to demonstrate a significant relationship between admission diagnosis and dysphagia severity. This finding was in accordance with Bordon and researchers (2011), Macht and colleagues (2011) and Skortez and colleagues (2011) research studies that did not find a significant association between medical diagnosis and dysphagia severity. Additional research is needed for exploration of specific admission diagnosis clusters or diagnoses with a more robust sample size to examine this potential relationship.

This present two part study included patients with medical and surgical admission diagnoses. This patient sample was similar to the patients selected for Ajemian and researchers (2001) and Barquist and researchers (2001) studies. Other

previous studies however either exclusively examined medical or surgical patients. In particular de Larminat et al (1995), El Solh and colleagues (2003) and Padovani and researchers (2008) examined patients with various medical diagnoses only. By examining specific clusters of diagnoses may reveal important, disorder specific differences in swallowing. Further investigation on the type of patient diagnoses and specific diagnoses and their relationship to post-extubation dysphagia is needed.

### viii. Risk Factor: Reason for Intubation:

In both studies, reason for intubation was not found to be significantly associated with dysphagia severity or aspiration. Although this factor was not specifically examined in previous studies, the researcher strove to determine if a relationship potentially existed between these variables. Failure to demonstrate a statistically significant relationship may have been illustrated due to stratification of patients into smaller groups for analysis with limited statistical power. This risk factor has not been previously investigated in other studies. Further investigation is needed for reason for intubation clusters with a more robust sample size to examine this potential relationship.

### ix. Risk Factor: Gender:

In both studies, gender was not found to be statistically associated with dysphagia severity or aspiration. It should be noted however that the average age of female participants in Study B was significantly higher than Study A. Macht and colleagues (2011 and 2013) demonstrated that male gender was associated with

increased dysphagia severity after prolonged intubation in neurogenic patients. This relationship has not been illustrated in other previous publications to date.

### x. Relationship between 4 Point Dysphagia Severity Scale and PAS Scale Outcomes:

In both studies, consistency was demonstrated between the 4 Point Dysphagia Scale Severity Ratings and the PAS outcomes for patients that exhibited aspiration. All patients that exhibited aspiration (scores 6 through 8) on the PAS scale received a score of either 3 or 4 on the 4 Point Dysphagia Severity Scale, which reflects a moderate or severe dysphagia. Consistency was demonstrated between these scores for both MBS and FEES examinations. Good reliability between these two dysphagia scales was demonstrated in telepractice dysphagia studies conducted by Malandraki and researchers (2011 and 2013). These outcomes demonstrate that both dysphagia scales appear to be accurate for determination of dysphagia severity for post-extubation dysphagia. However, clinical expertise and extensive training of the SLPs implementing these scales in this study may have increased the accuracy of the cohesion between the scale outcomes.

### xi. Interjudge Reliability for Study B:

Excellent intrajudge reliability was demonstrated for 20% of all patients in Study B for both the PAS and 4 Point Dysphagia Severity Rating Scale. All intraclass correlations exhibited extremely high level of inter-rater reliability. Overall dysphagia severity yielded a correlation of 0.918. There was exact agreement for 11 out of 14 patients (78.6%) for thin liquid trials and exact agreement for 12 out of 14 patients

(85.7%) for puree trials. Disagreement was always within 1 point on the 4 Point Dysphagia Severity Scale. For all rating disagreements, Rater 3 consistently rated the patient as more severe than Raters 1 and 2 collaboratively. This suggests excellent agreement between raters using the PAS and 4 Point Dysphagia Severity Scale. Strong agreement may be attributed to a milder dysphagia severity incidence in Study B. More severe dysphagia outcomes are harder to attain consensus for during interpretation.

### xii. Limitations of Study A and Study B:

The results of this two study experiment should be interpreted with respect to several limitations:

A. A single site was used for data collection rather than a multisite collaboration to potentially enhance the sample size and further examine reliability concerns.
B. Only patients that received swallowing evaluations initiated by physician order.
C. Study A only examined participants that were referred for MBS/FEES studies after a clinical dysphagia evaluation. This lends bias to a more severe dysphagia sample than Study B, where all participants were automatically referred for a FEES examination.
D. The participants exhibited a variety of admission diagnoses and causes of intubation, which may account for low statistical significance of many variables.
E. Subgroup sample sizes after assignment to cluster groups for admission diagnosis and reason for intubation.

F. Study A was based on retrospective data, where potential rater biases could not be controlled for or determined.

G. Study B only examined FEES outcomes. As a result, no comparison could be made between swallowing assessment techniques as in Study A.

### xiii. Clinical Implications

The results of this two part study suggest that age is a strong prognostic indicator of post-extubation dysphagia. Older patients should be recommended to undergo objective swallowing assessment techniques due to the strong relationship demonstrated between age and increased dysphagia severity and aspiration. All other potential risk factor variables examined were not consistently demonstrated as statistically significant predictors of dysphagia secondary to prolonged orotracheal intubation. As a result, these variables should be taken into consideration after extubation but should not dictate patient care or clinical decision making. In regards to the dysphagia outcome measurement scales used in both the retrospective and prospective studies, both demonstrated strong inter-judge reliability and strong correlations in severity ratings and aspiration risk. Each scale can be used during clinical swallowing assessments to help determine the degree of dysphagia severity and aspiration.

## VII. CONCLUSION AND FUTURE RESEARCH

This present two study experiment sought to determine the significance of several risk factors for post-extubation dysphagia in critically-ill patients. A large

incidence of post-extubation dysphagia was revealed in both studies. However, some discrepancy in aspiration risk was demonstrated between Study A and Study B.

Increased age was found to be a significant risk factor for post-extubation dysphagia in both studies. In Study A only, days intubated was a significant risk factor for post-extubation dysphagia. Also in Study A, the presence of reintubation and PNA were also significantly associated with increased aspiration risk and post-extubation dysphagia severity. In Study B, admission diagnosis, particularly an infectious diagnosis, was found to be a significant predictor of post-extubation dysphagia severity. Reason for intubation and gender were not found to be strong prognostic indicators of post-extubation dysphagia or aspiration risk in either study. These results suggest that age is a strong risk factor for post-extubation dysphagia and aspiration risk. Further investigation is needed to determine the risk factors that showed an inconsistent significance between Study A and Study B. Additional inquiry of all variables with larger subsamples is warranted to determine the significance of these risk factors on post-extubation dysphagia and aspiration risk. Also, additional evaluation of retrospective and prospective outcomes for risk factors of post-extubation dysphagia is needed. It would also be interesting to examine longitudinal outcomes of post-extubation dysphagia in this population to determine the persistence of dysphagia and its impact on patient morbidity and mortality. Lastly, comparison of swallowing assessment techniques and further examination of the reliability of the dysphagia outcome measures are warranted.

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## APPENDIX A

**ICU PROLONGED INTUBATION DATA COLLECTION TOOL**

**Patient Initials: _____ MR # : _____**

Age: _____ Unit: 1. SICU 2. MICU 3. IICU Gender: 1. Female 2. Male

Date of Admission (Month/Date/Yr): _____

Admitting Dx: _____

Indication(s) for Intubation:

1. ARDS
2. Hypoxic Respiratory Failure
3. Midline Shift/ Cerebral Edema
4. Airway Protection
5. Cardiopulmonary Arrest
6. Airway Obstruction
7. Obtunded
8. Metabolic Acidosis
9. Metabolic Alkalosis
10. Hyperventilation
11. Other_____

Date of Intubation (Month/Date/Year) :
_____ Number of days Intubated (>/3): _____

Date of Extubation:
_____ Previous
Intubation(s): Y N Number:_____

PMHx: _____

Previous intubation(s): Y N Unk if yes, specify: _____

PNA Y N Unk if yes, specify: _____

PAS Outcomes:

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Thin | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | DNT | CNA |
| Nectar | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | DNT | CNA |
| Honey | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | DNT | CNA |
| Puree | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | DNT | CNA |
| Semi Solid | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | DNT | CNA |
| Regular | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | DNT | CNA |

MBS or FEES: 1. MBS 2. FEES
Dysphagia Dx: Y N

4 Point Severity Rating _____

PAS Rating:
Thin Liquids 1
Thin Liquids 2
Puree 1
Puree 2
Solids 1
Solids 2

## APPENDIX B

**Study A: Admission Diagnosis Frequencies**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | ACS | 3 | 4.3 | 4.3 | 4.3 |
| | ARF | 1 | 1.4 | 1.4 | 5.7 |
| | Aspiration PNA | 8 | 11.4 | 11.4 | 17.1 |
| | Bradycardia | 1 | 1.4 | 1.4 | 18.6 |
| | Bronchiectasis | 1 | 1.4 | 1.4 | 20.0 |
| | Cardiac Arrest | 3 | 4.3 | 4.3 | 24.3 |
| | Carotid cutaneous fistula | 1 | 1.4 | 1.4 | 25.7 |
| | CHF | 4 | 5.7 | 5.7 | 31.4 |
| | Cholangitis | 1 | 1.4 | 1.4 | 32.9 |
| | COPD Exacerbation | 9 | 12.9 | 12.9 | 45.7 |
| | Discectomy | 1 | 1.4 | 1.4 | 47.1 |
| | DKA | 1 | 1.4 | 1.4 | 48.6 |
| | Endovascularaortic repair | 1 | 1.4 | 1.4 | 50.0 |
| | ESRD | 1 | 1.4 | 1.4 | 51.4 |
| | ETOH withdrawal | 3 | 4.3 | 4.3 | 55.7 |
| | GIB | 4 | 5.7 | 5.7 | 61.4 |
| | Hemi-colectomy | 1 | 1.4 | 1.4 | 62.9 |
| | NSTEMI | 1 | 1.4 | 1.4 | 64.3 |
| | pancytopenia | 1 | 1.4 | 1.4 | 65.7 |
| | Pleural Effusion | 2 | 2.9 | 2.9 | 68.6 |
| | PNA | 10 | 14.3 | 14.3 | 82.9 |
| | s/p colostomy | 1 | 1.4 | 1.4 | 84.3 |
| | s/p fall | 1 | 1.4 | 1.4 | 85.7 |
| | SBO | 1 | 1.4 | 1.4 | 87.1 |
| | Seizure | 2 | 2.9 | 2.9 | 90.0 |
| | Sepsis | 4 | 5.7 | 5.7 | 95.7 |
| | status epilepticus | 1 | 1.4 | 1.4 | 97.1 |
| | Suicide Attempt | 2 | 2.9 | 2.9 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX C

**Study A: Age Frequencies**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 20 | 1 | 1.4 | 1.4 | 1.4 |
| | 28 | 1 | 1.4 | 1.4 | 2.9 |
| | 31 | 1 | 1.4 | 1.4 | 4.3 |
| | 36 | 1 | 1.4 | 1.4 | 5.7 |
| | 37 | 1 | 1.4 | 1.4 | 7.1 |
| | 42 | 1 | 1.4 | 1.4 | 8.6 |
| | 45 | 1 | 1.4 | 1.4 | 10.0 |
| | 46 | 1 | 1.4 | 1.4 | 11.4 |
| | 49 | 1 | 1.4 | 1.4 | 12.9 |
| | 50 | 1 | 1.4 | 1.4 | 14.3 |
| | 52 | 1 | 1.4 | 1.4 | 15.7 |
| | 53 | 1 | 1.4 | 1.4 | 17.1 |
| | 54 | 1 | 1.4 | 1.4 | 18.6 |
| | 56 | 3 | 4.3 | 4.3 | 22.9 |
| | 57 | 2 | 2.9 | 2.9 | 25.7 |
| | 58 | 1 | 1.4 | 1.4 | 27.1 |
| | 59 | 1 | 1.4 | 1.4 | 28.6 |
| | 60 | 2 | 2.9 | 2.9 | 31.4 |
| | 62 | 1 | 1.4 | 1.4 | 32.9 |
| | 63 | 1 | 1.4 | 1.4 | 34.3 |
| | 65 | 1 | 1.4 | 1.4 | 35.7 |
| | 66 | 2 | 2.9 | 2.9 | 38.6 |
| | 69 | 1 | 1.4 | 1.4 | 40.0 |
| | 70 | 2 | 2.9 | 2.9 | 42.9 |
| | 71 | 1 | 1.4 | 1.4 | 44.3 |
| | 72 | 2 | 2.9 | 2.9 | 47.1 |
| | 73 | 1 | 1.4 | 1.4 | 48.6 |
| | 74 | 1 | 1.4 | 1.4 | 50.0 |
| | 75 | 3 | 4.3 | 4.3 | 54.3 |
| | 76 | 1 | 1.4 | 1.4 | 55.7 |
| | 77 | 1 | 1.4 | 1.4 | 57.1 |
| | 78 | 1 | 1.4 | 1.4 | 58.6 |
| | 79 | 1 | 1.4 | 1.4 | 60.0 |
| | 80 | 2 | 2.9 | 2.9 | 62.9 |
| | 81 | 1 | 1.4 | 1.4 | 64.3 |
| | 82 | 3 | 4.3 | 4.3 | 68.6 |
| | 83 | 1 | 1.4 | 1.4 | 70.0 |
| | 84 | 2 | 2.9 | 2.9 | 72.9 |
| | 85 | 3 | 4.3 | 4.3 | 77.1 |
| | 86 | 2 | 2.9 | 2.9 | 80.0 |
| | 87 | 5 | 7.1 | 7.1 | 87.1 |
| | 88 | 4 | 5.7 | 5.7 | 92.9 |
| | 89 | 1 | 1.4 | 1.4 | 94.3 |
| | 90 | 1 | 1.4 | 1.4 | 95.7 |
| | 92 | 1 | 1.4 | 1.4 | 97.1 |
| | 95 | 2 | 2.9 | 2.9 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX D

**Study A: Days Intubated Frequencies**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 3 | 9 | 12.9 | 12.9 | 12.9 |
| | 4 | 10 | 14.3 | 14.3 | 27.1 |
| | 5 | 7 | 10.0 | 10.0 | 37.1 |
| | 6 | 6 | 8.6 | 8.6 | 45.7 |
| | 7 | 8 | 11.4 | 11.4 | 57.1 |
| | 8 | 5 | 7.1 | 7.1 | 64.3 |
| | 9 | 3 | 4.3 | 4.3 | 68.6 |
| | 10 | 4 | 5.7 | 5.7 | 74.3 |
| | 11 | 8 | 11.4 | 11.4 | 85.7 |
| | 12 | 1 | 1.4 | 1.4 | 87.1 |
| | 13 | 1 | 1.4 | 1.4 | 88.6 |
| | 14 | 3 | 4.3 | 4.3 | 92.9 |
| | 15 | 3 | 4.3 | 4.3 | 97.1 |
| | 16 | 1 | 1.4 | 1.4 | 98.6 |
| | 18 | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX E

**Study A: Reason For Intubation Frequencies**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Airway protection | 5 | 7.1 | 7.1 | 7.1 |
| | ARDS | 12 | 17.1 | 17.1 | 24.3 |
| | ARDS/ Asp PNA | 5 | 7.1 | 7.1 | 31.4 |
| | Cardiopulmonary Arrest | 5 | 7.1 | 7.1 | 38.6 |
| | COPD Exacerbation | 8 | 11.4 | 11.4 | 50.0 |
| | Drug Overdose | 1 | 1.4 | 1.4 | 51.4 |
| | ETOH Withdrawal | 1 | 1.4 | 1.4 | 52.9 |
| | GIB | 1 | 1.4 | 1.4 | 54.3 |
| | Hypercapneia Resp Failure | 3 | 4.3 | 4.3 | 58.6 |
| | Hypovolemic Shock | 2 | 2.9 | 2.9 | 61.4 |
| | Hypoxic Resp Failure | 15 | 21.4 | 21.4 | 82.9 |
| | Metabolic Acidosis | 1 | 1.4 | 1.4 | 84.3 |
| | Septic Shock | 10 | 14.3 | 14.3 | 98.6 |
| | Status Epileptics | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX F

**Study A: Thin Liquids Trial 1**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 15 | 21.4 | 21.4 | 21.4 |
| | 2 | 5 | 7.1 | 7.1 | 28.6 |
| | 3 | 4 | 5.7 | 5.7 | 34.3 |
| | 5 | 13 | 18.6 | 18.6 | 52.9 |
| | 6 | 1 | 1.4 | 1.4 | 54.3 |
| | 7 | 12 | 17.1 | 17.1 | 71.4 |
| | 8 | 20 | 28.6 | 28.6 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Study A: Thin Liquids Trial 2**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 17 | 24.3 | 24.3 | 24.3 |
| | 2 | 5 | 7.1 | 7.1 | 31.4 |
| | 3 | 2 | 2.9 | 2.9 | 34.3 |
| | 4 | 2 | 2.9 | 2.9 | 37.1 |
| | 5 | 11 | 15.7 | 15.7 | 52.9 |
| | 6 | 1 | 1.4 | 1.4 | 54.3 |
| | 7 | 12 | 17.1 | 17.1 | 71.4 |
| | 8 | 20 | 28.6 | 28.6 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX G

**Study A: Puree Trial 1**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 38 | 54.3 | 54.3 | 54.3 |
| | 2 | 6 | 8.6 | 8.6 | 62.9 |
| | 3 | 9 | 12.9 | 12.9 | 75.7 |
| | 4 | 1 | 1.4 | 1.4 | 77.1 |
| | 5 | 1 | 1.4 | 1.4 | 78.6 |
| | 6 | 1 | 1.4 | 1.4 | 80.0 |
| | 7 | 4 | 5.7 | 5.7 | 85.7 |
| | 8 | 10 | 14.3 | 14.3 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Study A: Puree Trial 2**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 38 | 54.3 | 54.3 | 54.3 |
| | 2 | 6 | 8.6 | 8.6 | 62.9 |
| | 3 | 9 | 12.9 | 12.9 | 75.7 |
| | 5 | 2 | 2.9 | 2.9 | 78.6 |
| | 6 | 1 | 1.4 | 1.4 | 80.0 |
| | 7 | 5 | 7.1 | 7.1 | 87.1 |
| | 8 | 9 | 12.9 | 12.9 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX H

**Study A: Solids Trial 1**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | | 1 | 1.4 | 1.4 | 1.4 |
| | 1 | 25 | 35.7 | 35.7 | 37.1 |
| | 2 | 1 | 1.4 | 1.4 | 38.6 |
| | 3 | 2 | 2.9 | 2.9 | 41.4 |
| | AR | 9 | 12.9 | 12.9 | 54.3 |
| | CAN | 32 | 45.7 | 45.7 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Study A: Solids Trial 2**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 26 | 37.1 | 37.1 | 37.1 |
| | 3 | 2 | 2.9 | 2.9 | 40.0 |
| | AR | 10 | 14.3 | 14.3 | 54.3 |
| | CAN | 32 | 45.7 | 45.7 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

# APPENDIX I

**Study B: Admission Diagnosis Frequencies**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | s/p fall | 1 | 1.4 | 1.4 | 1.4 |
| | AAA | 2 | 2.9 | 2.9 | 4.3 |
| | ACS | 1 | 1.4 | 1.4 | 5.7 |
| | Anasarca | 1 | 1.4 | 1.4 | 7.1 |
| | Anemia/ ETOH abuse | 1 | 1.4 | 1.4 | 8.6 |
| | ARF | 1 | 1.4 | 1.4 | 10.0 |
| | Asp PNA/ Respiratory Failure | 1 | 1.4 | 1.4 | 11.4 |
| | Aspiration PNA | 2 | 2.9 | 2.9 | 14.3 |
| | Aspiration PNA; Sepsis | 2 | 2.9 | 2.9 | 17.1 |
| | Asthma Exacerbation/ Respiratory Failure | 1 | 1.4 | 1.4 | 18.6 |
| | Cardiogenic shock | 1 | 1.4 | 1.4 | 20.0 |
| | CHF | 1 | 1.4 | 1.4 | 21.4 |
| | COPD Exacerbation | 6 | 8.6 | 8.6 | 30.0 |
| | Diverticulitis; Abdominal abscess | 1 | 1.4 | 1.4 | 31.4 |
| | Diverticulitis; intestinal Perforation | 1 | 1.4 | 1.4 | 32.9 |
| | DKA | 1 | 1.4 | 1.4 | 34.3 |
| | DKA; sepsis | 1 | 1.4 | 1.4 | 35.7 |
| | Drug Overdose | 3 | 4.3 | 4.3 | 40.0 |
| | ETOH Withdrawal | 3 | 4.3 | 4.3 | 44.3 |
| | ETOH Withdrawal/ Asp PNA | 1 | 1.4 | 1.4 | 45.7 |
| | Fall/ Hemothorax | 1 | 1.4 | 1.4 | 47.1 |
| | Gallstone/ Pancreatitis | 1 | 1.4 | 1.4 | 48.6 |
| | GIB | 3 | 4.3 | 4.3 | 52.9 |
| | GIB; ETOH Withdrawal | 1 | 1.4 | 1.4 | 54.3 |
| | GIB/Anemia | 1 | 1.4 | 1.4 | 55.7 |
| | GSW | 1 | 1.4 | 1.4 | 57.1 |
| | GSW abdomen | 1 | 1.4 | 1.4 | 58.6 |
| | Hemorrhagic Shock | 1 | 1.4 | 1.4 | 60.0 |
| | Lung Mass/PNA | 1 | 1.4 | 1.4 | 61.4 |
| | Maxillary artery epistaxis | 1 | 1.4 | 1.4 | 62.9 |
| | Necrotizing Fascitis Hernia | 1 | 1.4 | 1.4 | 64.3 |
| | Pedestrian Struck | 2 | 2.9 | 2.9 | 67.1 |
| | Pedestrian struck; Hip fx; | 1 | 1.4 | 1.4 | 68.6 |
| | Perforated Viscous | 1 | 1.4 | 1.4 | 70.0 |
| | Pleural Effusion | 1 | 1.4 | 1.4 | 71.4 |
| | PNA | 2 | 2.9 | 2.9 | 74.3 |
| | PNA; Sepsis | 1 | 1.4 | 1.4 | 75.7 |
| | PNA/ Respiratory Distress | 1 | 1.4 | 1.4 | 77.1 |
| | PNA/ Respiratory Failure | 1 | 1.4 | 1.4 | 78.6 |
| | PNA/ACS | 1 | 1.4 | 1.4 | 80.0 |
| | Pneumothorax | 1 | 1.4 | 1.4 | 81.4 |
| | Respiratory Distress; COPD Exacerbation | 1 | 1.4 | 1.4 | 82.9 |
| | Respiratory Distress/ Cardiac Arrest | 1 | 1.4 | 1.4 | 84.3 |
| | Respiratory Failure/ PNA | 1 | 1.4 | 1.4 | 85.7 |
| | Respiratory Failure | 1 | 1.4 | 1.4 | 87.1 |
| | SBO | 1 | 1.4 | 1.4 | 88.6 |
| | Seizures | 2 | 2.9 | 2.9 | 91.4 |
| | Sepsis | 2 | 2.9 | 2.9 | 94.3 |
| | Sepsis; Asp PNA | 1 | 1.4 | 1.4 | 95.7 |
| | Status Epilepticus | 1 | 1.4 | 1.4 | 97.1 |
| | STEMI | 1 | 1.4 | 1.4 | 98.6 |
| | UTI | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX J

**Study B: Age Frequencies**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 21 | 1 | 1.4 | 1.4 | 1.4 |
| | 22 | 1 | 1.4 | 1.4 | 2.9 |
| | 35 | 1 | 1.4 | 1.4 | 4.3 |
| | 38 | 1 | 1.4 | 1.4 | 5.7 |
| | 39 | 1 | 1.4 | 1.4 | 7.1 |
| | 40 | 1 | 1.4 | 1.4 | 8.6 |
| | 41 | 1 | 1.4 | 1.4 | 10.0 |
| | 42 | 2 | 2.9 | 2.9 | 12.9 |
| | 45 | 1 | 1.4 | 1.4 | 14.3 |
| | 46 | 3 | 4.3 | 4.3 | 18.6 |
| | 47 | 1 | 1.4 | 1.4 | 20.0 |
| | 53 | 1 | 1.4 | 1.4 | 21.4 |
| | 54 | 2 | 2.9 | 2.9 | 24.3 |
| | 55 | 2 | 2.9 | 2.9 | 27.1 |
| | 56 | 2 | 2.9 | 2.9 | 30.0 |
| | 57 | 4 | 5.7 | 5.7 | 35.7 |
| | 58 | 1 | 1.4 | 1.4 | 37.1 |
| | 59 | 1 | 1.4 | 1.4 | 38.6 |
| | 60 | 1 | 1.4 | 1.4 | 40.0 |
| | 61 | 2 | 2.9 | 2.9 | 42.9 |
| | 63 | 2 | 2.9 | 2.9 | 45.7 |
| | 65 | 1 | 1.4 | 1.4 | 47.1 |
| | 66 | 4 | 5.7 | 5.7 | 52.9 |
| | 67 | 1 | 1.4 | 1.4 | 54.3 |
| | 68 | 1 | 1.4 | 1.4 | 55.7 |
| | 69 | 2 | 2.9 | 2.9 | 58.6 |
| | 70 | 2 | 2.9 | 2.9 | 61.4 |
| | 72 | 1 | 1.4 | 1.4 | 62.9 |
| | 74 | 1 | 1.4 | 1.4 | 64.3 |
| | 75 | 2 | 2.9 | 2.9 | 67.1 |
| | 76 | 4 | 5.7 | 5.7 | 72.9 |
| | 77 | 2 | 2.9 | 2.9 | 75.7 |
| | 78 | 2 | 2.9 | 2.9 | 78.6 |
| | 79 | 1 | 1.4 | 1.4 | 80.0 |
| | 80 | 1 | 1.4 | 1.4 | 81.4 |
| | 82 | 1 | 1.4 | 1.4 | 82.9 |
| | 83 | 1 | 1.4 | 1.4 | 84.3 |
| | 84 | 1 | 1.4 | 1.4 | 85.7 |
| | 85 | 3 | 4.3 | 4.3 | 90.0 |
| | 86 | 3 | 4.3 | 4.3 | 94.3 |
| | 87 | 1 | 1.4 | 1.4 | 95.7 |
| | 88 | 1 | 1.4 | 1.4 | 97.1 |
| | 91 | 1 | 1.4 | 1.4 | 98.6 |
| | 92 | 1 | 1.4 | 1.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX K

**Study B: Days Intubated Frequencies**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 3 | 14 | 20.0 | 20.3 | 20.3 |
| | 4 | 8 | 11.4 | 11.6 | 31.9 |
| | 5 | 13 | 18.6 | 18.8 | 50.7 |
| | 6 | 7 | 10.0 | 10.1 | 60.9 |
| | 7 | 3 | 4.3 | 4.3 | 65.2 |
| | 8 | 9 | 12.9 | 13.0 | 78.3 |
| | 9 | 1 | 1.4 | 1.4 | 79.7 |
| | 10 | 2 | 2.9 | 2.9 | 82.6 |
| | 11 | 3 | 4.3 | 4.3 | 87.0 |
| | 12 | 2 | 2.9 | 2.9 | 89.9 |
| | 13 | 1 | 1.4 | 1.4 | 91.3 |
| | 14 | 4 | 5.7 | 5.8 | 97.1 |
| | 16 | 2 | 2.9 | 1.4 | 98.6 |
| | 25 | 1 | 1.4 | 1.4 | 100.0 |
| Total | | 70 | 100.0 | | |

## APPENDIX L

**Study B: Reason for Intubation Frequencies**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Airway protection | 5 | 7.1 | 7.1 | 7.1 |
| | Airway Protection | 7 | 10.0 | 10.0 | 17.1 |
| | ARDS | 9 | 12.9 | 12.9 | 30.0 |
| | Cardiac Arrest | 2 | 2.9 | 2.9 | 32.9 |
| | Cardiogenic Shock | 3 | 4.3 | 4.3 | 37.1 |
| | Cardiopulmonary arrest | 1 | 1.4 | 1.4 | 38.6 |
| | COPD Exacerbation | 5 | 7.1 | 7.1 | 45.7 |
| | DKA/ Septic Shock | 1 | 1.4 | 1.4 | 47.1 |
| | ETOH Withdrawal | 1 | 1.4 | 1.4 | 48.6 |
| | Hypercapneic Respiratory Failure | 5 | 7.1 | 7.1 | 55.7 |
| | Hypovolemic shock | 7 | 10.0 | 10.0 | 65.7 |
| | Hypovolemic Shock | 2 | 2.9 | 2.9 | 68.6 |
| | Hypoxic Respiratory Failure | 6 | 8.6 | 8.6 | 77.1 |
| | Metabolic Acidosis | 3 | 4.3 | 4.3 | 81.4 |
| | Sepsis | 1 | 1.4 | 1.4 | 82.9 |
| | Septic Shock | 12 | 17.1 | 17.1 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX M

**Study B: Thin Liquids Trial 1**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 18 | 25.7 | 25.7 | 25.7 |
| | 2 | 10 | 14.3 | 14.3 | 40.0 |
| | 3 | 6 | 8.6 | 8.6 | 48.6 |
| | 4 | 1 | 1.4 | 1.4 | 50.0 |
| | 5 | 18 | 25.7 | 25.7 | 75.7 |
| | 6 | 1 | 1.4 | 1.4 | 77.1 |
| | 7 | 8 | 11.4 | 11.4 | 88.6 |
| | 8 | 8 | 11.4 | 11.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Study B: Thin Liquids Trial 2**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 19 | 27.1 | 27.1 | 27.1 |
| | 2 | 9 | 12.9 | 12.9 | 40.0 |
| | 3 | 6 | 8.6 | 8.6 | 48.6 |
| | 5 | 18 | 25.7 | 25.7 | 74.3 |
| | 6 | 2 | 2.9 | 2.9 | 77.1 |
| | 7 | 8 | 11.4 | 11.4 | 88.6 |
| | 8 | 8 | 11.4 | 11.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX N

**Study B: Puree Trial 1**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 24 | 34.3 | 34.3 | 34.3 |
| | 2 | 11 | 15.7 | 15.7 | 50.0 |
| | 3 | 25 | 35.7 | 35.7 | 85.7 |
| | 5 | 5 | 7.1 | 7.1 | 92.9 |
| | 6 | 1 | 1.4 | 1.4 | 94.3 |
| | 7 | 2 | 2.9 | 2.9 | 97.1 |
| | 8 | 2 | 2.9 | 2.9 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Study B: Puree Trial 2**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 24 | 34.3 | 34.3 | 34.3 |
| | 2 | 11 | 15.7 | 15.7 | 50.0 |
| | 3 | 24 | 34.3 | 34.3 | 84.3 |
| | 4 | 1 | 1.4 | 1.4 | 85.7 |
| | 5 | 4 | 5.7 | 5.7 | 91.4 |
| | 6 | 2 | 2.9 | 2.9 | 94.3 |
| | 7 | 2 | 2.9 | 2.9 | 97.1 |
| | 8 | 2 | 2.9 | 2.9 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

## APPENDIX O

**Study B: Solids Trial 1**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 40 | 57.1 | 57.1 | 57.1 |
| | 2 | 2 | 2.9 | 2.9 | 60.0 |
| | 3 | 6 | 8.6 | 8.6 | 68.6 |
| | AR | 7 | 10.0 | 10.0 | 78.6 |
| | CAN | 15 | 21.4 | 21.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |

**Study B: Solids Trial 2**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1 | 40 | 57.1 | 57.1 | 57.1 |
| | 2 | 2 | 2.9 | 2.9 | 60.0 |
| | 3 | 5 | 7.1 | 7.1 | 67.1 |
| | 4 | 1 | 1.4 | 1.4 | 68.6 |
| | AR | 7 | 10.0 | 10.0 | 78.6 |
| | CAN | 15 | 21.4 | 21.4 | 100.0 |
| | Total | 70 | 100.0 | 100.0 | |