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**STUDY OF EARLY ENTERAL NUTRITION IN
AEROMEDICALLY EVACUATED CRITICALLY
ILL/INJURED PATIENTS WITH A RESULTANT
VALIDATION ALGORITHM FOR THE THEATER
VALIDATING FLIGHT SURGEON**

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14. ABSTRACT Early enteral feeding in critically ill/injured, especially burn/major trauma, patients benefits gut integrity and immunocompetence and reduces infections and intensive care unit/hospital stays. Aeromedical Evacuation (AE) often takes place concurrently. As a result, AE and early enteral feeding should be inseparable. This retrospective descriptive study was a first-look at early enteral feeding <i>vis à vis</i> AE. An uptick in feeding rates was found after the 2010 nutrition support clinical practice guideline (CPG), 15%→17%. With the next two CPG iterations, rates rose significantly, 17% → 48%. At the same time, AE feeding holds rose significantly 10%→24%, later dropping to 17%. It appeared the CPGs reinforced the value of feeding, but may well have sensitized to the threat of aspiration. In addition, little difference was found between those patients not enterally fed preflight and those enterally fed, this across collected demographic, mission, and clinical parameters. Likewise, no difference was found between those enterally fed during AE and those withheld. Yet, 83% of the study's patients were not fed and 18% of those that were had feeding withheld for AE. All suggesting early enteral feeding was under prescribed and AE feeding holds were overprescribed. An algorithm devised for the Theater Validating Flight Surgeon (TVFS) incorporated relevant preflight/inflight/clinical issues and employed prescriptions designed to boost feeding, diminish AE holding, and prevent complications. Notably, no AE enteral feeding outcome and aspiration studies are extant. In the future, with such studies, the TVFS algorithm can be updated into definitive, "good to go" inflight enteral feeding prescriptions.				
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1.0 EXECUTIVE SUMMARY

Early enteral feeding in critically ill/injured casualties, especially burn and major trauma patients, has long been standard of care. (**McDonald, 1991; Heyland, 2003; CPG, 2016; McClave, 2016; Singer, 2019; Lambell, 2020; Woody, 2021**) Feeding within 24-48 hours is well-associated with gut integrity and immunocompetence, not to mention reductions in infections and intensive care unit/hospital stays. At the same time, it is not uncommon for casualties to be evacuated to the United States within 24-72 hours of injury, the key time frame for early enteral feeding. (**Gawande, 2004; Mazurek, 2006; Schreiber, 2008; Brewer, 2009; Lundy, 2010; Blackburne, 2012; Lairet, 2013**) Consequently, aeromedical evacuation (AE) and early enteral feeding should be inseparable. Notably, as yet, no enteral feeding pump has been designated AE-approved equipment, though the process is ongoing and, until complete, waiver for use remains relatively routine. See **Appendix C**.

At the beginning of Operations Iraqi Freedom and Enduring Freedom, there was no formal enteral feeding program for critically ill/injured patients. In late December 2005, the Air Mobility Command Surgeon General issued an “enteral feedings during AE” policy for transports from Europe to the United States that was then evaluated over a 14-month period (January 2006 to March 2007). Of 207 intubated trauma patients, 199 (96 percent (%)) were fed successfully and without incident, demonstrating the safety of en route enteral feeding. (**Dorlac, 2008; Fang, 2008**)

Despite this success, a combat support hospital located near Baghdad reported only 12% of eligible patients were recommended for early enteral feeding, none actually fed. The reason given, anticipation of AE within 24 hours. The potential for hypobaria-induced aspiration being the driver. (**Stankorb, 2009**) Shortly thereafter, the 2010 Joint Trauma Systems’ Clinical Practice Guideline (JTS/CPG) for nutrition support was published, followed by an updated iteration in 2012. Even with these guidelines, early enteral feeding was not widespread. In approximately 1,000 burn patients (2003-2016) admitted inside an average of 96 hours post-injury to the Army Institute of Surgical Research Burn Unit (San Antonio, Texas), enteral feeding was rarely initiated prior to arrival. The reason, again, AE with its presumed increase in aspiration risk. (**Shields, 2016**) And, in spite of another updated JTS/CPG (2016), anecdotal experience suggests little change in the delivery of early enteral feeding during AE, seemingly from a concern for aspiration and development of ventilator-associated pneumonia. (**Henning, 2008; Turner, 2008; Woody, 2021**)

This study was a retrospective first-look investigation into early enteral feeding of critically ill/injured patients *vis à vis* AE. What was found was an uptick in early enteral feeding rates after the 2010 JTS/CPG, from approximately (~)15% to ~17%. Following the next two iterations of the JTS/CPG, early enteral feeding rates rose significantly, from ~17% to ~48%. At the same time, early after the initial JTS/CPG, withholding enteral feeding during AE rose significantly from ~10% to ~24%, only to drop down to ~17% with the subsequent JTS/CPGs. It appeared the JTS/CPGs reinforced the benefit of early enteral feeding in critically ill/injured casualties. But, it also appeared the JTS/CPGs may well have sensitized to the threat of aspiration. Though with accumulated clinical experience, the rate of withholding seemed to moderate.

This study found very little difference preflight between those critically ill/injured patients not enterally fed and those enterally fed, this across the collected demographics, mission parameters, clinical features, vital signs, laboratory values, illness/injury profile, therapeutic

modalities, enteral feeding profile, and Theater Validating Flight Surgeon (TVFS) prescriptions. Likewise, across the same properties, those patients enterally fed during AE demonstrated essentially no differences from those patients having enteral feeding withheld. These findings suggest a relatively homogenous population of critically ill/injured patients. Yet, a full 83% of the study's patients were not enterally fed and 18% of those that were had feeding withheld for AE. This, flying in the face of early enteral feeding being standard of care.

Thus, this study suggested that early enteral feeding was underprescribed preflight and en route withholding of enteral feeding overprescribed. Of course, this conclusion presupposed favorable outcomes across all groups, outcomes which were not collected. In the meantime, until outcome analyses are forthcoming, specific actions to encourage preflight enteral feeding and abrogate the holding of enteral feeding were deliberated upon. Such actions are important even faced with the potential for aspiration, one of the primary stated reasons to withhold enteral feedings. (Dorlac, 2008; Duff, 2008; Henning, 2008; Turner, 2008; Stankorb, 2014; Shields, 2016; Woody, 2021)

As a result, an algorithm specifically designed for TVFS consideration during the clinical validation process was devised and described. See **Appendix B**. It incorporated preflight, inflight, and clinical concerns relevant to flying a critically ill/injured patient being enterally fed. It also brought forward numerous prescriptions designed to encourage enteral feeding and mitigate enteral feeding complications. With this algorithm, it is hoped preflight early enteral feeding can be boosted, withholding of AE enteral feedings diminished, and complications such as aspiration prevented.

In the end, these findings and recommendations highlight the need for further research. Outcome studies --- looking at postflight complications (e.g., rates of infection and ventilator-associated pneumonia), postflight procedures, time to healing, days on ventilator, days in Intensive Care Unit (ICU), and overall days of hospitalization --- are needed, comparing those patients evacuated with and without enteral feeding. Furthermore, studies focused on aspiration, the primary obstacle to inflight enteral feeding, are needed to transform a potential risk to a defined risk that is well quantified. (Metheny, 2006; Turner, 2008) With such studies in hand, the TVFS algorithm can be regularly updated such that definitive, "good to go" inflight enteral feeding prescriptions become routine.

2.0 INTRODUCTION/BACKGROUND

Nutrition is a key therapeutic modality in the overall treatment of the critically ill/injured, especially those patients with major trauma and/or major burns. Provision of caloric and protein sustenance in the face of critical illness is directly related to the metabolic consequences of that critical illness/injury which consist of an *ebb* phase, a *flow* phase, and a later *recovery* phase. (Cuthbertson, 1942; Shields, 2016; Singer, 2019; Lambell, 2020)

The *ebb* phase, or early acute phase, spans the first one to two days of critical illness. It is characterized by hemodynamic instability and endogenous glucose production and hyperglycemia. (Cuthbertson, 1942; Henning, 2008; Shields, 2016; Singer, 2019; Lambell, 2020) Life-saving interventions and resuscitation are mandatory. Transition into the *flow* phase, or late acute phase, spanning the next three to seven days of critical illness, is swift. Here, metabolic instability and intense catabolism (particularly lean muscle breakdown) predominate. Energy expenditure is high and negative nitrogen balance, a central feature. (Cuthbertson, 1942; Henning, 2008; Shields, 2016; Singer, 2019; Lambell, 2020) From this point on, the recovery phase takes hold, often extending well beyond six weeks. Its key feature is anabolism -- protein synthesis and reclamation of muscle mass. (Henning, 2008; Singer, 2019; Lambell, 2020)

In order to boost transitioning, adequate caloric and protein intake is requisite. The gold standard in determining calorie-protein requirements (aka nutrition goals) is indirect calorimetry. (Heyland, 2003; McClave, 2016; Singer, 2019) Unfortunately, indirect calorimetry is not usually available, especially in the deployed setting. As a result, predictive equations, though general estimates of calorie-protein requirements, hold sway. In major trauma and burns, the most common equations are:

$$\begin{aligned}\text{Calorie Requirements} &= 20\text{-}30 \text{ kilocalorie (kcal)/ kilogram (kg)/day} \\ &\quad (\text{McClave, 2016; Singer, 2019; Lambell, 2020}) \\ \text{Protein Requirements} &= 1.2\text{-}2.0^1 \text{ g/kg/day} \\ &\quad (\text{McClave, 2016; Singer, 2019; Lambell, 2020})\end{aligned}$$

Early on, without at least 60-70% of these nutrition goals met, gut integrity can be compromised, making for mucosal atrophy and bacterial translocation, with its increased risk for septic complications. (McDonald, 1991; Ellis, 2015; Woody, 2021) Conversely, with more than 70-80% of these goals met, decreased infections, ventilator days, and hospital days have been observed. (McClave, 2016; Singer, 2019; Woody, 2021) As the *flow* phase transitions to *recovery* phase and near-100% of goals is delivered, catabolism is moderated, gut and immune function improved, infections and complications reduced, ventilator and hospital days cut, cost slashed, and wound healing enhanced. (McDonald, 1991; Heyland, 2003; Ellis, 2015; McClave, 2016; Reignier, 2018; Singer, 2019; Woody, 2021) In short, early and progressive feeding to nutrition goals has a markedly positive impact on morbidity and mortality in the critically ill/injured patient.

¹Major burns often need protein delivery at the higher end this range. (Ridley, 2015; CPG, 2016; Hoffer, 2016)

Clearly, it is important to identify those critically ill/injured patients most at risk. Although there are many scoring schemes in the literature, the two most often mentioned are the Nutrition Risk in the Critically Ill (NUTRIC) and the Nutrition Risk Screening (NRS 2002). **(Kondrup, 2003; Heyland, 2011; Rahman, 2016)** The NUTRIC score employs age, Acute Physiology and Chronic Health Evaluation II (APACHE II) score, Sequential Organ Failure Assessment (SOFA) score, co-morbidities, days from hospital admission to ICU admission, and interleukin-6 level while the NRS 2002 score evaluates nutritional impairment and severity of disease. **(Kondrup, 2003; Heyland, 2011; APACHE II, 2021; SOFA, 2021)** Importantly, both risk assessments generally score major trauma and burns high, putting most military casualties at high nutritional risk and emphasizing the need for early nutritional support.

Military medicine recognized these facts relatively early during the most recent conflicts, Operation Iraqi Freedom and Operation Enduring Freedom. In fact, nutrition support was formalized in the Joint Trauma System's (JTS) earliest nutrition-related clinical practice guideline (CPG) dated 1 March 2010. Ideally, enteral feeding would begin within 24 hours of admission to a Role III hospital. **(CPG, 2010)**

To better understand how enteral feeding fits into the military casualty care schema, it is important to review the various echelons of care. Role I care is essentially life-saving point-of-injury care. Role II care is life-saving resuscitation and surgery, performed by forward surgical teams. Transfer between Role I to Role II and Role II to Role III is often aboard a rotary-wing aircraft. Role III care (e.g., Combat Support Hospital, Expeditionary Medical Support System) takes place at theater hospitals. This entails stabilization, damage control surgery, and AE; transfer via AE being most often aboard regulated, fixed-wing aircraft. Role IV care (i.e., Landstuhl Regional Medical Center, Germany) consists of arrival by AE, stabilization, and requisite definitive surgery, followed by AE to the United States (US). And, lastly, Role V care (e.g., Walter Reed National Military Medical Center) involves arrival by AE, stabilization, requisite definitive surgery, rehabilitation, and eventual discharge. **(Fang, 2010; Fang, 2011; Stankorb, 2014; Cunningham, 2019; Pickard-Gabriel, 2019)**

Early enteral feeding in the critically ill/injured casualty was reiterated in the JTS/CPG update of 11 June 2012 and the most recent offering of 4 August 2016. **(CPG, 2012; CPG, 2016)** In the 2016 iteration, enteral access was advocated within 24 hours, enteral feeding within 48 hours of admission, and enteral in preference to parenteral feeding, as it would not only maintain gut mucosal integrity and immunocompetence, but also drop infectious complications, ICU days, and hospital days. **(CPG, 2016)**

Indeed, enteral feeding has repeatedly been shown superior to parenteral feeding. Over the past several decades, superior reductions in infections, pneumonia, length of stay, morbidity, and mortality have been documented. To maximize these effects, recommended early start times for enteral feeding of the critically ill/injured have ranged from 24-48 hours of admission. **(McDonald, 1991; Heyland, 2003; CPG, 2016; McClave, 2016; Singer, 2019; Lambell, 2020; Woody, 2021)**

The early start times are not necessarily difficult in the critically ill/injured military patient as long as the formulas and pumps are logistically available. It is the intermittent stops in feeding that usually pose a problem. Of course, this issue is not limited to the military patient. Frequent interruptions are routinely observed with the civilian patient, averaging anywhere from 2.3 to 7.0 hours daily. These stops make up 20-32% of available feeding time, resulting in seriously reduced calorie and protein delivery. **(Kim, 2012)** The biggest offender is procedures/tests, bringing a stop to feedings in 39-66% of patients. Following, in order, are

gastrointestinal intolerance (e.g., vomiting, diarrhea, elevated gastric residual volumes), feeding tube issues, and nursing procedures (e.g., baths, bed linens, dressing changes). (**McClave, 1999; Kim, 2012**)

Interestingly, it is the complete halt of enteral feeding that leads to issues, not so much a reduced volume of feeding. In fact, trophic feeding (i.e., 10-20 ml/hour (hr) or up to about 500 milliliter (ml) per day) can preserve overall gut integrity. (**CPG, 2016; McClave, 2016; Singer, 2019**) Despite this, it is currently CPG-recommended that orogastric/nasogastric enteral feeding be halted six hours prior to AE. Moreover, such feeding is actually "...highly discouraged..." (**CPG, 2016**)

The most commonly cited reason for withholding enteral feeding during AE is the risk of aspiration. This, a presumed consequence of jostling/turbulence/vibration, restricted space, acceleration/deceleration forces, and hypobaria. (**Duff, 2008; Henning, 2008; Turner, 2008; Stankorb, 2014; Woody, 2021**) Jostling/turbulence/vibration can lead to nausea with vomiting, restricted space can prevent head of bed elevation, acceleration/deceleration forces can overwhelm a supine lower esophageal sphincter, and hypobaria can grow gastric air volume displacing feedings up into the esophagus. The risk of aspiration is real, especially should the pressure changes within an endotracheal tube cuff produce a tracheal seal failure. Notably, the trachea is sealed and aspiration avoided with cuff pressures between 20-30 centimeter (cm) water (H₂O), particularly at greater than (>) 25 cm H₂O. However, most inflight air exchange maneuvers result in overly low cuff pressures upon descent and the 10 ml saline cuff volume replacement procedure can produce excessive cuff pressures, requiring meticulous inflight clinical attention. (**Britton, 2014**) Even in the civilian setting, without inflight stressors, aspiration risk is real, particularly in patients who are ventilated, over 70 years old, supine, unconscious, neurologically compromised, gastric fed, bolus fed, and/or with gastroesophageal reflux. (**McClave, 2016; Singer, 2019**) Hence, the "...highly discouraged..." almost prohibition of gastric feeding during AE. (**CPG, 2016**)

To negate this risk, the established primary mitigation strategy, post-pyloric feeding, either into the duodenum or jejunum, is imposed. (**Heyland, 2003; Henning, 2008; Turner, 2008; McClave, 2016; Singer, 2019; Woody, 2021**) In addition to post-pyloric feeding, other AE strategies include orogastric/nasogastric tubes to suction, head of bed elevation, and head first loading. (**Dorlac, 2008; Dorlac, 2019**) When protocol-driven, enteral feeding during AE has been successful. In fact, from January 2006 through March 2007, 96% of 207 intubated trauma patients, underwent uneventful protocol-driven enteral feedings during AE from Landstuhl Regional Medical Center to the US with active enteral feeding. (**Dorlac, 2008**) In spite of these mitigation strategies and this early positive AE experience, a combat support hospital located near Baghdad reported only 12% of eligible patients were recommended early enteral feeding, none actually being fed. The reason given, anticipated AE within 24 hours. (**Stankorb, 2009**) Likewise, in approximately 1,000 burn patients admitted inside an average of 96 hours post-injury to the Army Institute of Surgical Research Burn Unit (San Antonio, Texas), enteral feeding was rarely initiated prior to arrival. The reason, again, AE with its presumed increase in aspiration risk. (**Shields, 2016**) Indeed, present anecdotal experience suggests enteral feeding is often withheld from or stopped during AE.

This research was designed to search out whether or not enteral feeding was regularly delivered during AE. If not, then the preflight, inflight, and postflight withholding of enteral feeding could well tally up to 15^{+/-} hours with fastmoving transports. For those faced with multiple delays, the critically ill/injured patient may actually be without enteral feeding for

upwards of three to five days. (**Stankorb, 2014; Woody, 2021**) Without such feedings, casualty morbidity and mortality could easily rise. Clearly, it is important to determine whether enteral feeding is or is not being administered during AE. This study focused on finding that answer.

3.0 METHODS

This research project consisted of two major goals: a systematic *literature review* and a *descriptive analysis* of the available AE enteral nutrition data.

The first goal, a systematic *literature review*, sought to collect and extract information from articles relevant to the inflight delivery of enteral nutrition in the critically ill/injured patient. The review was accomplished using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology. (Moher, 2009) The PubMed and Cumulative Index to Nursing and Allied Health Literature (CINAHL) databases were foundational in a search employing search terms “critical care,” “air ambulance,” “EN,” “enteral feeding,” “NPO status,” “patient outcomes,” “Critical Care Air Transport (CCAT)/critical care,” “permissive starvation,” “nutritional status,” and “aspiration.” From the various articles gleaned, a narrative review of the literature was drafted. Details and findings from this review were recently published, with the following citation:

Woody S, Brown KN, Bevington D, Huffman S. Enteral nutrition in the deployed critical care ground and air transport environment: a narrative review. *Mil Med.* 2021; 186(Suppl 1):311-316.

The second goal, a *descriptive analysis* of available AE enteral nutrition data, included all patients from 2007 through 2019 who were US citizens and mechanically ventilated. From the CCAT and En Route Critical Care (ERCC) Pilot Unit database, Cite Numbers of such patients were identified and collected. These Cite Numbers were then entered into the TRANSCOM Regulating and Command and Control Evacuation System (TRAC²ES) database to obtain patient names. The patient names were then searched out in the Theater Medical Data Store (TMDS) database to obtain the AF Form 3899L, *Patient Movement Record En Route Critical Care*. Seventy data fields were extracted and, from these data fields, an additional forty-four novel data fields were derived. See **Appendix A** for the specific variables.

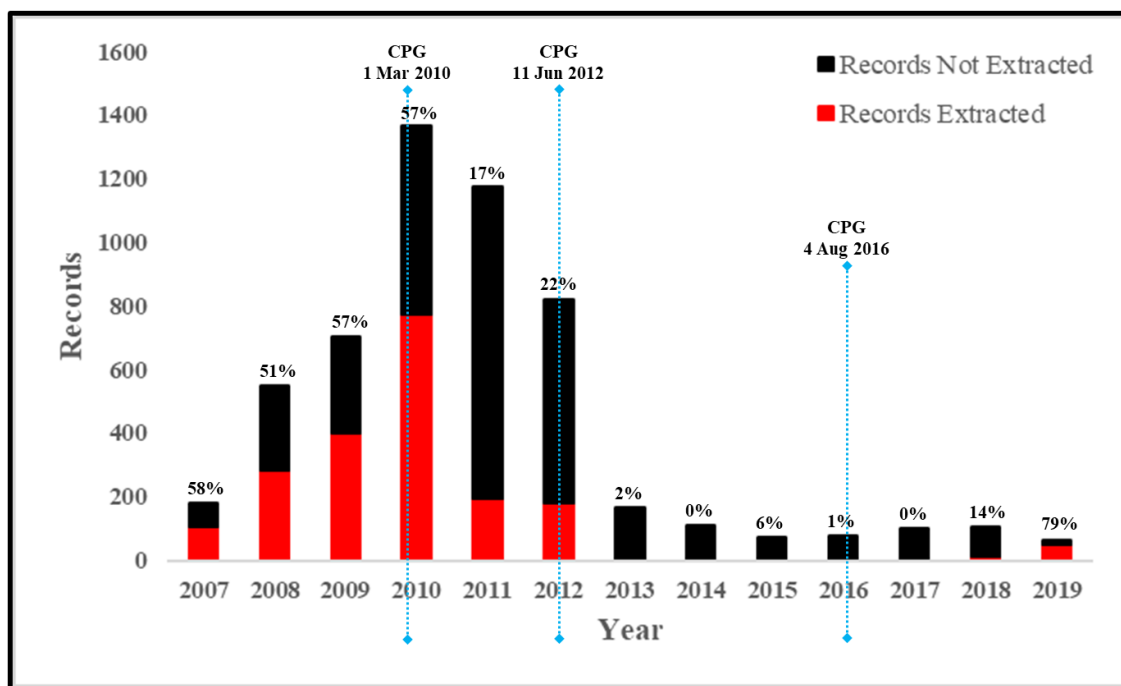
These data fields included continuous variables, reported as mean (standard deviation), and categorical variables, reported as number (percent). Comparisons between binary groups were performed, specifically patients extracted versus patients not extracted and patients treated with enteral nutrition (EN) versus those treated without EN. In addition, within the EN group, the dichotomy between AE Fed and AE Withheld was examined. And, lastly, the impact of the nutrition support JTS/CPGs was assessed using the *before* and *after* methodology. All these comparisons employed the independent means t-statistic for continuous variables and chi-square statistic for categorical variables. Statistical significance was set *a priori* at p less than (<) 0.05. Throughout the study, data were cleaned, variables derived, and analyses performed within the IBM SPSS Statistics for Windows, Version 20.0 (Armonk, NY: IBM Corp).

4.0 RESULTS

4.1 Search for Bias in Data Extraction

Data for this study was obtained in a sequential fashion first from the CCAT and ERCC Pilot Unit database, then the TRAC²ES database, and, finally, the TMDS database. This methodology proved labor intense. The ultimate extent of data extraction was limited by the funding of contracted staffing.

Critically ill/injured patients from 2007 through 2019 who were US citizens and mechanically ventilated were sought. As a result, 5,530 records were identified. Of those, 2,012 records were extracted (36%). Notably, very few records were identified or extracted from 2013-2017. Most records identified were from 2010-2012 and most records extracted were from 2008-2010. Data distribution as related to the various JTS/CPGs publication dates was also tracked. There was a pre-CPG-2010 dataset (i.e., 2007-2009), a post-CPG-2010 dataset (i.e., 2010-2012), and a post-CPG-2016 dataset (i.e., 2018-2019). See **Figure 1**.



Note: CPG (Clinical Practice Guideline), Mar (March), Jun (June), Aug (August).

Figure 1. Records Identified and Extracted (percent) by Year and JTS/CPG Publication

This graphic depiction brought forward the notion of extraction bias and, prior to any analyses looking at enteral feeding itself, the potential for extraction bias was probed. The study methodology made the Cite Number the sole common variable between those records extracted

and those not extracted. The Cite Number contained three information elements: Year of the evacuation, Julian Day of the evacuation, and Theater from which the evacuation occurred.

Because the by-year data did not appear linear in nature, a Spearman correlation was performed and proved not significant ($\rho = 0.536$, $p = 0.059$), suggesting overall there was no systematic data extraction by year. However, from 2007-2010, each year a little over 50% of records were extracted with no year significantly different from the other (chi square = 5.641, $df = 3$, $p = 0.130$). And, from 2011-2019, extraction rates ranged from 0-79%, 2019 being the only year above 50%. These findings suggested extraction progressed systematically within the early years. It further suggested, while extracting the mid-years, funding limits were realized and expeditious sampling was attempted, especially 2019. Thus, no obvious global extraction bias was detected. That said, the paucity of data from 2013-2017 limited generalization of observations to the years 2007-2012 and 2018-2019.

The Julian Day data was particularly interesting. Because the by-quarter data appeared more linear in nature, Pearson correlation was performed and proved not significant ($R = 0.756$, $p = 0.244$), suggesting there was no systematic data extraction by quarter. See **Figure 2**.

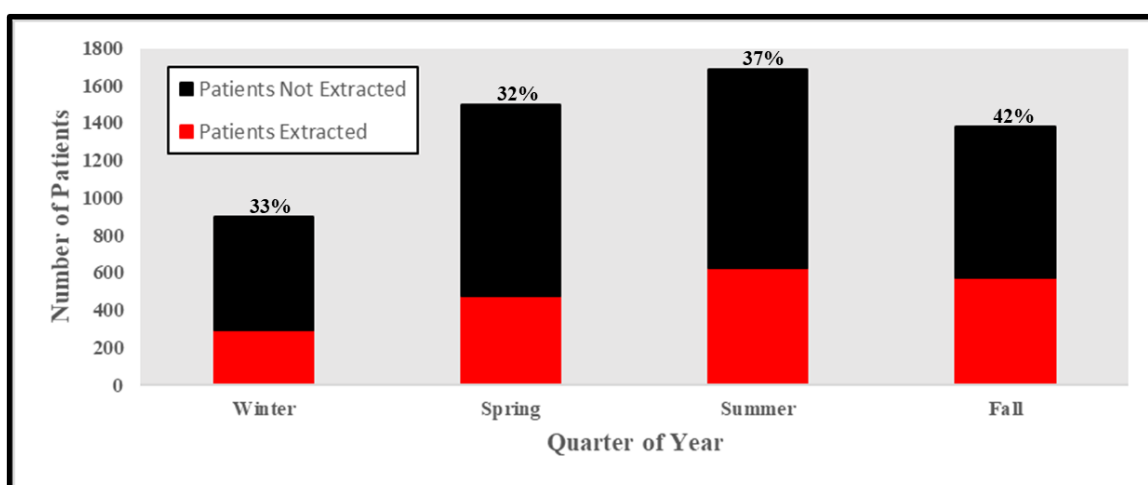
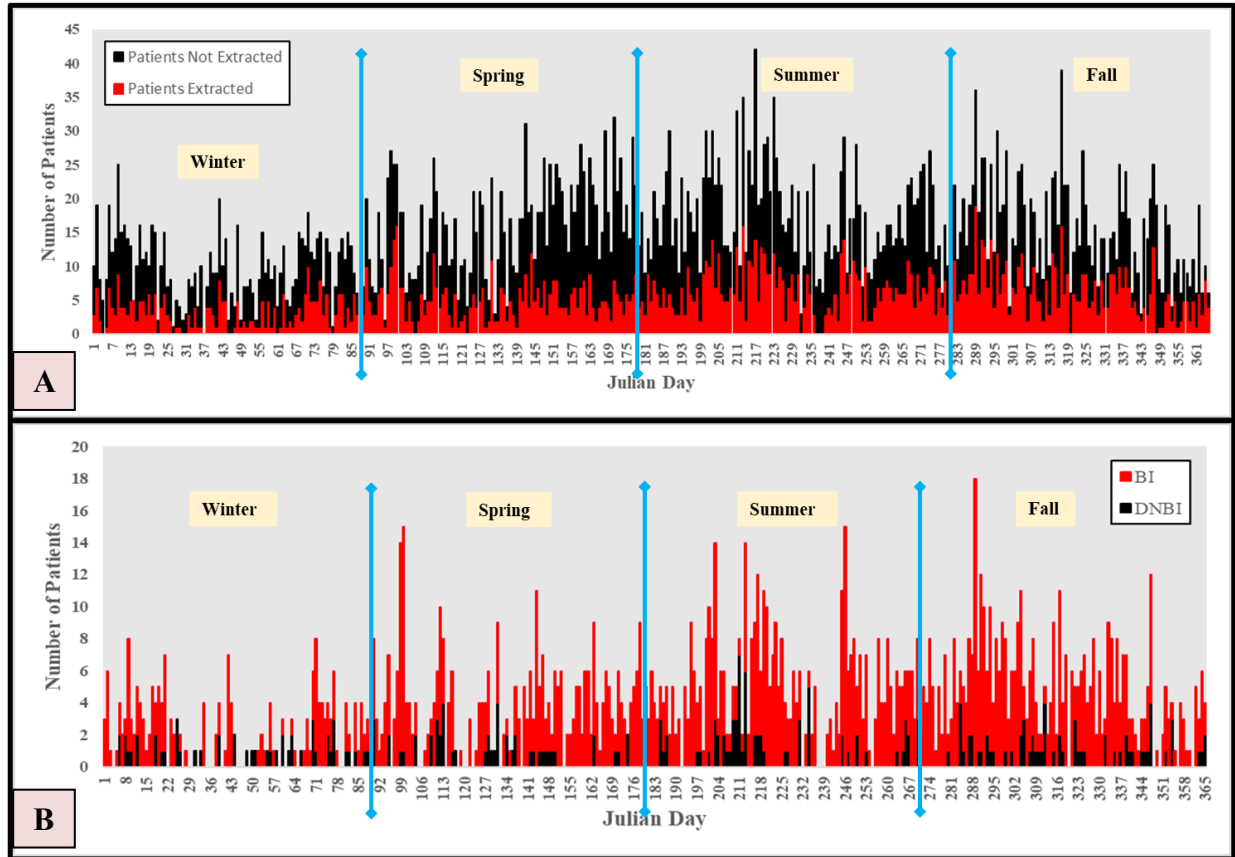


Figure 2. Records Identified and Extracted by Quarter

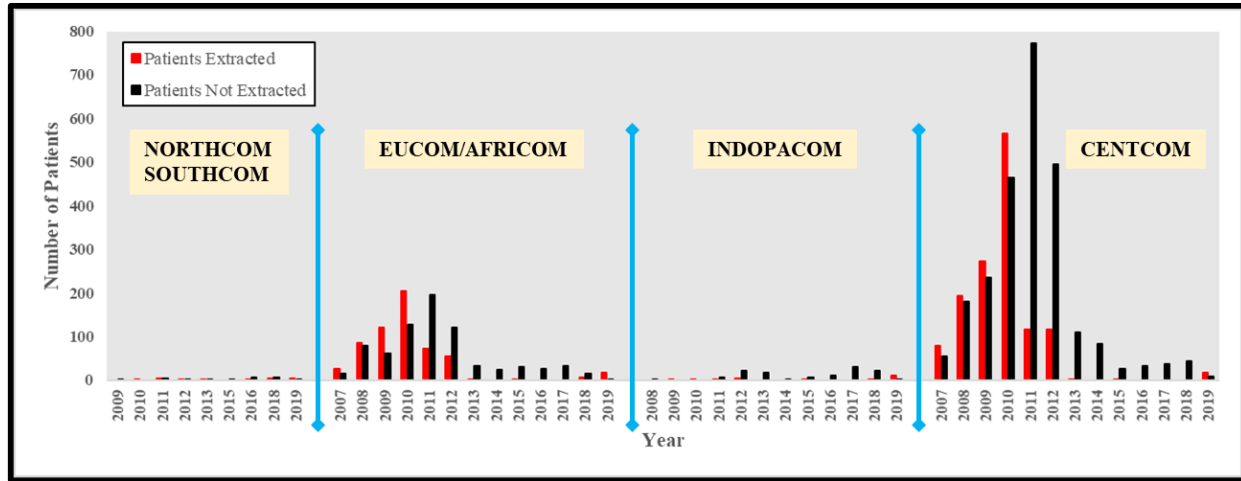
That said, no one quarter predominated over the others, extraction rates ranging 32-42%; however, the Summer and Fall had a significantly greater degree of extraction than Winter and Spring (chi square = 35.273, $df = 3$, $p < 0.001$). This observation is in keeping with conventional wisdom's circa-Summer preference for combat operations. Indeed, there were significantly fewer battle injured during the Winter (chi square = 17.197, $df = 3$, $p < 0.001$). In fact, the bulk of critical casualties, particularly battle injuries, happened during Summer and early Fall. Thus, without active extraction bias, more patients identified and extracted would be expected during the Summer and early Fall and, indeed, that was the case. See **Figure 3**.



Note: **A** → Patient records as identified and extracted. **B** → Patients as designated Battle Injury (BI) or Disease, Non-Battle Injury (DNBI).

Figure 3. Records by Julian Day and Quarter

Lastly, in considering the theater of origin for extraction bias, it was immediately apparent that Central Command (CENTCOM) followed by European Command/Africa Command (EUCOM/AFRICOM) contributed the bulk of critically ill/injured evacuations identified. See **Figure 4**. This was driven by a significantly higher level of Battle Injury observed in those theaters (chi square = 97.033, df = 3, $p < 0.001$). See **Table 1**. This observation was expected, was seen, and suggested no obvious extraction bias.



Note: NORTHCOM/SOUTHCAM (Northern Command/Southern Command), EUCOM/AFRICOM (European Command/Africa Command), INDOPACOM (Indo-Pacific Command), CENTCOM (Central Command).

Figure 4. Records Identified and Extracted by Theater

Table 1. Distribution of Battle Injury Among Theaters

Casualty Considerations			
Theater, n (%)	Battle Injury	Disease, Non-Battle Injury	p-value
CENTCOM	1101 (81)	263 (19)	< 0.001 ^b
EUCOM/AFRICOM	442 (74)	152 (26)	
INDOPACOM	3 (11)	24 (89)	
NORTHCOM/SOUTHCAM	6 (35)	11 (65)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. n (number), % (percent), NORTHCOM/SOUTHCAM (Northern Command/Southern Command), EUCOM/AFRICOM (European Command/Africa Command), INDOPACOM (Indo-Pacific Command), CENTCOM (Central Command).

In summary, the Year, Julian Day, and Theater analyses did not demonstrate any obvious extraction bias. Consequently, it was deemed reasonable to continue analyses of the patient data focusing on the delivery of early enteral feeding prior to and during AE as well as the impact of the JTS/CPGs.

4.2 Preflight: Not Enterally Fed versus Enterally Fed

Within the records extracted, 349 (17%) patients underwent preflight early enteral feeding, ranging 13-22% over the years 2007-2012. From 2013-2017, three patients were fed while five were not. And, from 2018-2019, 45% were fed. See **Figure 5**. This observation suggested the two possible populations. As a result, comparisons between those patients who were “Enterally Fed” (EN) and those “Not Enterally Fed” (No EN) were performed looking specifically at Demographics, Mission Parameters, Clinical Features, Vital Signs, Laboratory Values, Illness/Injury Profile, Therapeutic Modalities, Enteral Feeding Profiles, and TVFS Prescriptions.

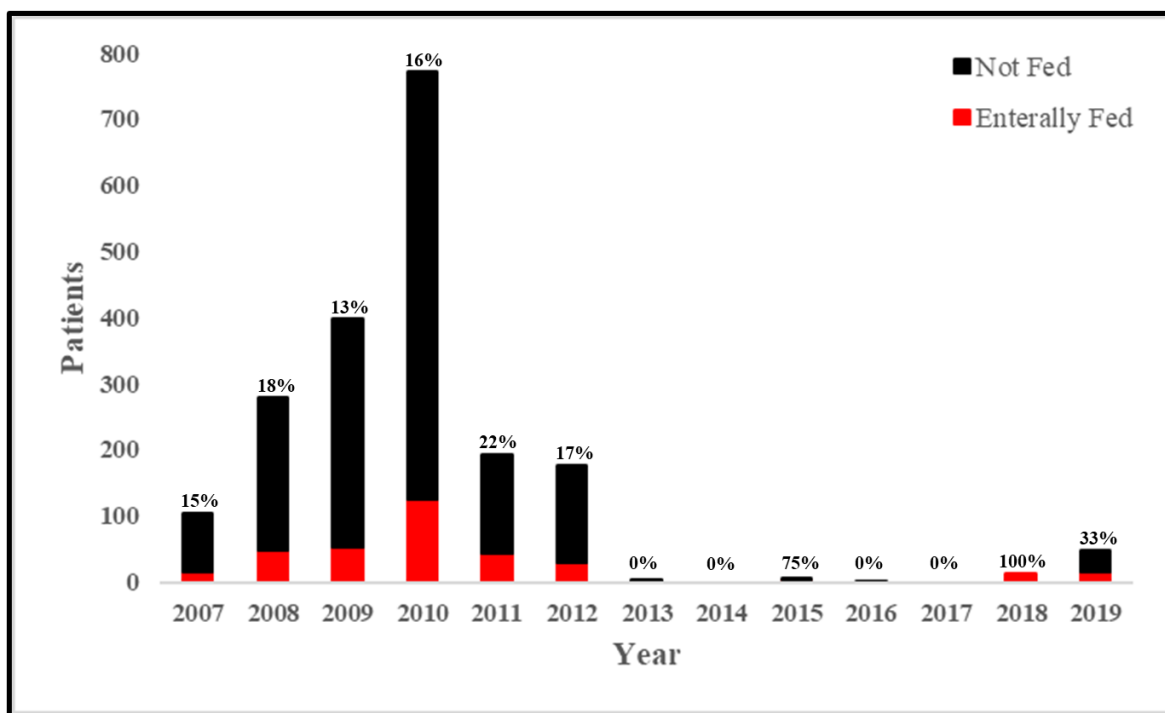


Figure 5. Patients Undergoing Early Enteral Feeding (percent)

Demographics analyses found no difference in age, gender, or rank with the stereotypic patient a 27-year old enlisted male. There was, however, a statistically significant difference with service branch driven by the Air Force experience, 30% fed versus $\leq 20\%$ fed with the other branches. See **Table 2**.

Table 2. Casualty Feeding Considerations: Demographics

Casualty Feeding Considerations			
Demographics			
Characteristic	Not Enterally Fed	Enterally Fed	p-value
Age, M (SD)	27.7 (9.3)	27.6 (9.9)	0.826 ^a
Gender, n (%)			
Male	1595 (82)	340 (18)	0.408 ^b
Female	57 (86)	9 (14)	
Branch, n (%)			
Army	981 (82)	220 (18)	0.020^b
Marine	435 (85)	78 (15)	
Navy	77 (80)	19 (20)	
Air Force*	35 (70)	15 (30)	
Other	123 (88)	16 (12)	
Rank, n (%)			
Enlisted	1397 (83)	296 (17)	0.197 ^b
Officer	111 (77)	34 (23)	
Warrant Officer	20 (83)	4 (17)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

* Denotes driver-variable(s) for chi square statistical significance. M (mean), SD (standard deviation), n (number), % (percent).

Mission Parameters analyses found the stereotypic No EN patient aboard a C-17 out of CENTCOM while the stereotypic EN patient was aboard a C-17 out of EUCOM/AFRICOM. Independent of aircraft, the EN patient had longer flight times. That said, though statistically different between groups, flight time was more a reflection of strategic intertheater missions (C-17 and KC-135: ~9-hour flights) and tactical intratheater missions (C-130 and C-21: ~3-hour flights) as opposed to EN or No EN patients. See **Table 3**.

Table 3. Casualty Feeding Considerations: Mission Parameters

Casualty Feeding Considerations			
Mission Parameters			
Characteristic	Not Enterally Fed	Enterally Fed	p-value
Theater, n (%)			
CENTCOM*	1293 (95)	69 (5)	< 0.001 ^b
EUCOM/AFRICOM	329 (56)	260 (44)	
INDOPACOM	14 (52)	13 (48)	
NORTHCOM/SOUTHCOM	10 (59)	7 (41)	
Aircraft, n (%)			
C-17*	779 (74)	278 (26)	< 0.001 ^b
C-130	317 (97)	10 (3)	
KC-135	159 (92)	14 (8)	
C-21	5 (100)	0 (0)	
Flight Time, M (SD)			
All Missions	6.8 (3.9)	9.8 (3.1)	< 0.001 ^a
C-17 Missions	8.8 (2.8)	9.9 (2.8)	< 0.001 ^a
C-130 Missions	2.0 (1.7)	4.2 (4.5)	0.001 ^a
KC-135 Missions	8.1 (1.7)	10.4 (3.7)	< 0.001 ^a
C-21 Missions	2.9 (1.9)	0 (---)	---

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

* Denotes driver-variable(s) for chi square statistical significance. M (mean), SD (standard deviation), n (number), % (percent), CENTCOM (Central Command), EUCOM/AFRICOM (European Command/Africa Command), INDOPACOM (Indo-Pacific Command), NORTHCOM/SOUTHCOM (Northern Command/Southern Command).

Clinical Features analyses found a predominance of Battle Injury in both No EN patients (79%) and EN patients (73%). The primary etiologies in both groups were improvised explosive devices and gunshots (No EN → 46% and 37%, respectively; EN → 37% and 38%, respectively). Physical findings were very similar between groups: 68% of No EN patients and 70% of EN patients had either a colostomy or bowel discontinuity while 91% of patients from both groups had abdomens that were soft, nontender, and non-distended. Of note, for all intents and purposes, “discontinuous” bowel in this study was synonymous with an ostomy. Despite the benign abdomens in both groups only 63% of No EN patients had bowel sounds versus 84% of EN patients. And, when it came to enteral feeding prohibitions, the No EN group had better than 5-fold the number of disqualifiers (11 patients versus 2 patients, respectively). See **Table 4**.

Table 4. Casualty Feeding Considerations: Clinical Features

Casualty Feeding Considerations			
Clinical Features			
Characteristic	Not Enterally Fed	Enterally Fed	p-value
Clinical Class, n (%)			
Battle Injury	1294 (84)	255 (16)	0.027 ^b
Disease, Non-Battle Injury	354 (79)	94(21)	
Trauma, n (%)			
IED/Blast	260 (87)	38 (13)	0.234 ^b
Gunshot Wound	208 (84)	39 (16)	
Rocket Propelled Grenade	13 (87)	2 (13)	
Motor Vehicle Accident	30 (77)	9 (23)	
Generalized	54 (78)	15 (22)	
Penetrating (not specified)	49	9	
Blunt (not specified)	6	6	
Bowel Status, n (%)			
Colostomy	53 (62)	32 (38)	< 0.001 ^b
Discontinuous	52 (68)	24 (32)	
Open*	26 (100)	0 (0)	
Other	11 (69)	5 (31)	
Rectal Tube	12 (46)	14 (54)	
Stooling*	1 (17)	5 (83)	
Bowel Sounds, n (%)			
Yes	565 (76)	182 (24)	< 0.001 ^b
Decreased	74 (73)	28 (27)	
No*	362 (90)	40 (10)	
Abdominal Exam, n (%)			
Soft	1521 (83)	317 (17)	0.460 ^b
Distended	36 (77)	11 (23)	
Tender	27 (77)	8 (23)	
Other	57 (86)	9 (14)	
Abdominal Disqualifiers, n (%)	11 (85) ^c	2 (15) ^d	---

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. ^c Intractable vomiting (2), peritonitis (2), mesenteric ischemia (1), bowel necrosis (2), organ system failure (4). ^d Paralytic ileus (1), intractable diarrhea (1). * Denotes driver-variable(s) for chi square statistical significance. n (number), % (percent).

Vital Signs analyses were essentially identical between groups testifying to the overall clinical stability of these patients. Although there were statistically significant blood pressure differences, they were clinically not relevant. See **Table 5**.

Table 5. Casualty Feeding Considerations: Vital Signs

Casualty Feeding Considerations			
Vital Signs			
Parameter	Not Enterally Fed	Enterally Fed	p-value
Blood Pressure, M (SD) (mmHg)			
Systolic Preflight	123 (21)	130 (20)	< 0.001 ^a
Diastolic Preflight	62 (12)	65 (12)	< 0.001 ^a
Systolic Midflight	121 (19)	130 (22)	< 0.001 ^a
Diastolic Midflight	61 (11)	62 (12)	0.135 ^a
Systolic Postflight	123 (19)	131 (21)	< 0.001 ^a
Diastolic Postflight	63 (11)	65 (12)	< 0.001 ^a
Heart Rate, M (SD) (per minute)			
Preflight	97 (22)	97 (20)	0.881 ^a
Midflight	96 (21)	95 (20)	0.694 ^a
Postflight	95 (21)	93 (20)	0.161 ^a
Temperature, M (SD) (F)			
Preflight	99.5 (1.6)	99.7 (1.8)	0.153 ^a
Midflight	99.6 (1.7)	99.6 (1.6)	0.577 ^a
Postflight	99.4 (2.1)	99.5 (1.4)	0.506 ^a
Saturation, M (SD) (SpO₂ = %)			
Preflight	98.5 (4.0)	98.2 (4.6)	0.133 ^a
Midflight	98.6 (3.4)	98.3 (1.9)	0.091 ^a
Postflight	98.9 (3.2)	98.6 (4.1)	0.199 ^a

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

M (mean), SD (standard deviation), mmHg (pressure in millimeters of mercury), F (temperature in degrees Fahrenheit), SpO₂ (percent oxygen saturation of hemoglobin by pulse oximetry).

Laboratory Value analyses proved very similar between groups. Although some of the findings were statistically significant, none denoted any serious clinical differences. Indeed, these analyses merely reinforced the notion that both the No EN and the EN patients were, for all intents and purposes, clinically stabilized. See **Table 6**.

Table 6. Casualty Feeding Considerations: Laboratory Values

Casualty Feeding Considerations			
Laboratory Values			
Parameter	Not Enterally Fed	Enterally Fed	p-value
pH, M (SD)			
Preflight	7.4 (0.1)	7.4 (0.1)	0.103 ^a
Postflight	7.4 (0.1)	7.4 (0.1)	< 0.001 ^a
PaO₂, M (SD) (mmHg)			
Preflight	123 (47)	118 (41)	0.169 ^a
Postflight	118 (41)	130 (59)	0.001^a
PaCO₂, M (SD) (mmHg)			
Preflight	41 (7)	43 (8)	<0.001 ^a
Postflight	41 (6)	41 (5)	0.399 ^a
Hemoglobin, M (SD) g/dl			
Preflight	10.1 (3.6)	9.1 (1.4)	< 0.001 ^a
Postflight	9.8 (2.5)	8.9 (1.3)	< 0.001 ^a
Hematocrit, M (SD) (%)			
Preflight	29.6 (6.8)	26.7 (4.2)	< 0.001 ^a
Postflight	28.5 (5.8)	26.1 (4.0)	< 0.001 ^a

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

M (mean), SD (standard deviation), pH (acid-base status of a solution), PaO₂ (partial pressure of arterial oxygen), O₂ (oxygen), PaCO₂ (partial pressure of arterial carbon dioxide), CO₂ (carbon dioxide), mmHg (pressure in millimeters of mercury), g (grams), dl (deciliter), % (percent).

The Illness/Injury Profile analyses saw a similar profile with both the No EN and EN patients. Maladies in order of frequency were orthopedic (27% and 27%, respectively), neurologic (15% and 17%, respectively), pulmonary (12% and 15%, respectively), gastrointestinal (10% and 10%, respectively), and otolaryngologic (10% and 9%, respectively). No other diagnosis reached even the 5% level. Notably, no difference in self-inflicted injury between the No EN (1%) and EN (1%) patients was seen (chi square = 0.007, df = 1, p = 0.935). Up to five different diagnoses (aka systems) were recorded, garnering an average of 1.5 systems per patient affected in the No EN group and 1.9 systems in the EN group. See **Figure 6** and **Table 7** and **Table 8**.

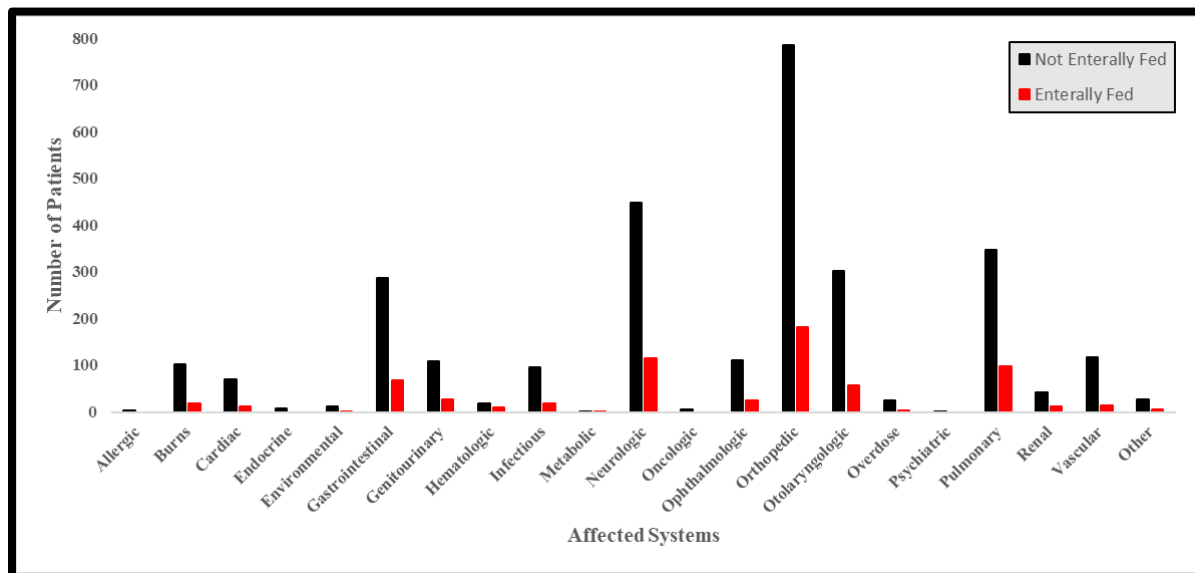


Figure 6. Illness/Injury Profile for No EN and EN Patients

Table 7. Casualty Feeding Considerations: Illness/Injury Profile

Casualty Feeding Considerations			
Illness/Injury Profile			
System	Not Enterally Fed n (%)	Enterally Fed n (%)	p-value
Allergic	3 (100)	0 (0)	0.177 ^b
Burns	103 (85)	18 (15)	
Cardiac	70 (84)	13 (16)	
Endocrine	8 (100)	0 (0)	
Environmental	11 (85)	2 (15)	
Gastrointestinal	287 (81)	68 (19)	
Genitourinary	109 (80)	28 (20)	
Hematologic	19 (66)	10 (34)	
Infectious	95 (84)	18 (16)	
Metabolic	2 (67)	1 (33)	
Neurologic	448 (80)	115 (20)	
Oncologic	6 (100)	0 (0)	
Ophthalmologic	111 (82)	24 (18)	
Orthopedic	786 (81)	182 (19)	
Otolaryngologic	302 (84)	58 (16)	
Overdose	25 (89)	3 (11)	
Psychiatric	2 (100)	0 (0)	
Pulmonary	347 (78)	99 (22)	
Renal	43 (80)	11 (20)	
Vascular	117 (89)	15 (11)	
Other	26 (81)	6 (19)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analysis employed the chi square statistic in a 2x21 table; number values < 5 suggest the statistic may be unreliable. n (number), % (percent).

Table 8. Casualty Feeding Considerations: Self-Inflicted Injury

Casualty Feeding Considerations			
Self-Inflicted Injury			
Mechanism	Not Enterally Fed n (%)	Enterally Fed n (%)	p-value
Overdose	14 (88)	2 (12)	0.797 ^b
Gunshot	8 (80)	2 (20)	
Hanging	1 (100)	0 (0)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. n (number), % (percent).

Therapeutic Modalities analyses looked specifically at Paralytic and Vasoactive medications. Paralytics were employed similarly between groups (No EN = 8% versus EN = 5%; chi square = 2.264, df = 1, p 0.132), while Vasoactives were significantly more prevalent in the No EN group (17% versus 11%; chi square = 9.022, df = 1, p = 0.003). Of all the patients so treated, the No EN group contributed around 87% and 88% of them, respectively. The No EN group also bore the brunt of the high dosing regimens, though not statistically significant (chi square = 2.420, df = 1, p = 0.119). See **Table 9**.

Table 9. Casualty Feeding Considerations: Therapeutic Modalities

Casualty Feeding Considerations			
Therapeutic Modalities			
Parameter	Not Enterally Fed	Enterally Fed	p-value
Paralytics, n (%)	129 (87)	19 (13)	0.719 ^b
Vasoactives, n (%)	280 (88)	37 (12)	
Vasopressin, n (%)			0.077 ^b
≤ 0.04 U/min	54 (93)	4 (7)	
> 0.04 U/min	10 (77)	3 (13)	
Norepinephrine, n (%)			0.032^b
≤ 5 ug/min	38 (90)	4 (10)	
> 5 ug/min	46 (100)	0 (0)	
Phenylephrine, n (%)			0.115 ^b
≤ 50 ug/min	12 (80)	3 (20)	
> 50 ug/min	11 (100)	0 (0)	
Dopamine, n (%)			---
≤ 10 ug/min	5 (100)	0 (0)	
> 10 ug/min	8 (100)	0 (0)	
Epinephrine, n (%)	6 (100)	0 (0)	---

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.
n (number), % (percent), U (unit), min (minute), ug (micrograms).

Enteral Feeding Profile analyses found 95-99% of patients with either an orogastric tube or a nasogastric tube, most commonly an orogastric tube (60-61%), not really surprising as gastric decompression is routine in ventilated CCATT patients. In contrast, the EN patients had almost a three-fold greater number of jejunal tubes when compared to the No EN patients; however, that amounted to only about 1% of all the patients. At the same time, only about 3% of all the patients had in place a Dobhoff™ tube, a tube specifically designed for enteral feeding. The most commonly prescribed formulas were Impact™, Promote™, and Jevity™. The summary amounts fed fell almost equally at < 250 ml, 250-500 ml, and > 500 ml, mostly by bolus as only around 11% of the EN patients were fed by continuous drip. See **Table 10**.

Table 10. Casualty Feeding Considerations: Enteral Feeding Profile

Casualty Feeding Considerations			
Enteral Feeding Profile			
Characteristic			p-value
Tubes, n (%)	Not Enterally Fed	Enterally Fed	
Orogastric Tube	829 (82)	183 (18)	< 0.001 ^b
Nasogastric Tube	541 (84)	105 (16)	
Jejunal Tube*	5 (28)	13 (72)	
Dual Tubes, n (%)	No Dobhoff™	Dobhoff™	
Orogastric Tube	158 (86)	25 (14)	0.314 ^b
Nasogastric Tube	86 (82)	19 (18)	
Enteral Formulas, n (%)			
Impact™	Enterally Fed	69 (48)	
Promote™		30 (21)	
Jevity™		21 (14)	
Isosource™		4 (3)	
Pivot™		4 (3)	
Osmolyte™		4 (3)	
Other ^c		14 (10)	
Volume Recorded, n (%)			
Summary Amount	Enterally Fed		
--- 10-250 ml		77 (36)	
--- 251-500 ml		74 (34)	
--- 501-750 ml		44 (21)	
--- 751-1,000 ml		14 (7)	
--- > 1,000 ml		5 (2)	
Rate of Delivery			
--- 0-50 ml/hr		15 (45)	
--- 51-100 ml/hr		18 (55)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. * Denotes driver-variable(s) for chi square statistical significance. n (number), % (percent), TM (trademark), ml (milliliter), hr (hour).

Analyses of the TVFS Prescriptions found most of the EN and No EN patients positioned head first at the aircraft's rear, a generally standard position and location for all CCATT patients, being the last enplaned and first deplaned. Interestingly, the EN patients had significantly higher rates of those positions (head first → 83% versus 59%, respectively; rearward placed → 94% versus 79%, respectively), while only about 9% of both EN patients and No EN patients had the head of bed elevated. No difference in spinal precautions was detected, with cervical spine protections even between the groups at 78%. Likewise, no difference in cabin altitude restriction (CAR) prescribing was detected (EN = 20% and No EN = 22%). See **Table 11**.

All these various analyses taken together suggest there were no serious differences between the EN and No EN patients.

Table 11. Casualty Feeding Considerations: TVFS Prescriptions

Casualty Feeding Considerations			
Theater Validating Flight Surgeon Prescriptions			
Intervention	Not Enterally Fed	Enterally Fed	p-value
Backrest/Head of Bed Elevation, n (%)	142 (81)	33 (19)	---
Patient Orientation, n (%)			
Feet First	589 (92)	49 (8)	<0.001 ^b
Head First	854 (78)	241 (22)	
Patient Positioning, n (%)			
Front of Aircraft	303 (95)	16 (5)	<0.001 ^b
--- Stanchion Loaded	303	15	
--- Floor Loaded	0	1	
Rear of Aircraft	1159 (81)	276 (19)	
--- Stanchion Loaded	1155	276	
--- Floor Loaded	4	0	
Spinal Precautions, n (%)			
Cervical Spine	170 (83)	36 (17)	0.269 ^b
--- C-Collar	157	34	
--- HALO Device	8	0	
--- Other	5	2	
Vacuum Spine Board/Spine Board	39 (87)	6 (13)	
Other	8 (67)	4 (33)	
--- Thoracic Spine	0	1	
--- Lumbar Spine	0	2	
--- Oversize Litter (OSL)	1	0	
--- Not Specified	7	1	
Cabin Altitude Restriction, n (%)			
Yes	349 (84)	67 (16)	0.362 ^b
--- < 3000 feet	5	3	
--- 3000-4000 feet	7	1	
--- 4000-5000 feet	17	7	
--- 5000-6000 feet	175	15	
--- 6000-7000 feet	64	18	
--- 7000-8000 feet	75	21	
No	1232 (82)	271 (18)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. n (number), % (percent), C-Collar (cervical collar), HALO (cervical stabilizing device), OSL (oversize litter).

4.3 Aeromedical Evacuation: Enterally Fed versus Withheld

Within the early enteral feeding records extracted, 285 (82%) patients underwent enteral feeding during AE, ranging 63-92% over the years 2007-2012. From 2013-2017, only three patients were fed. And, from 2018-2019, 83% were fed. See **Figure 7**.

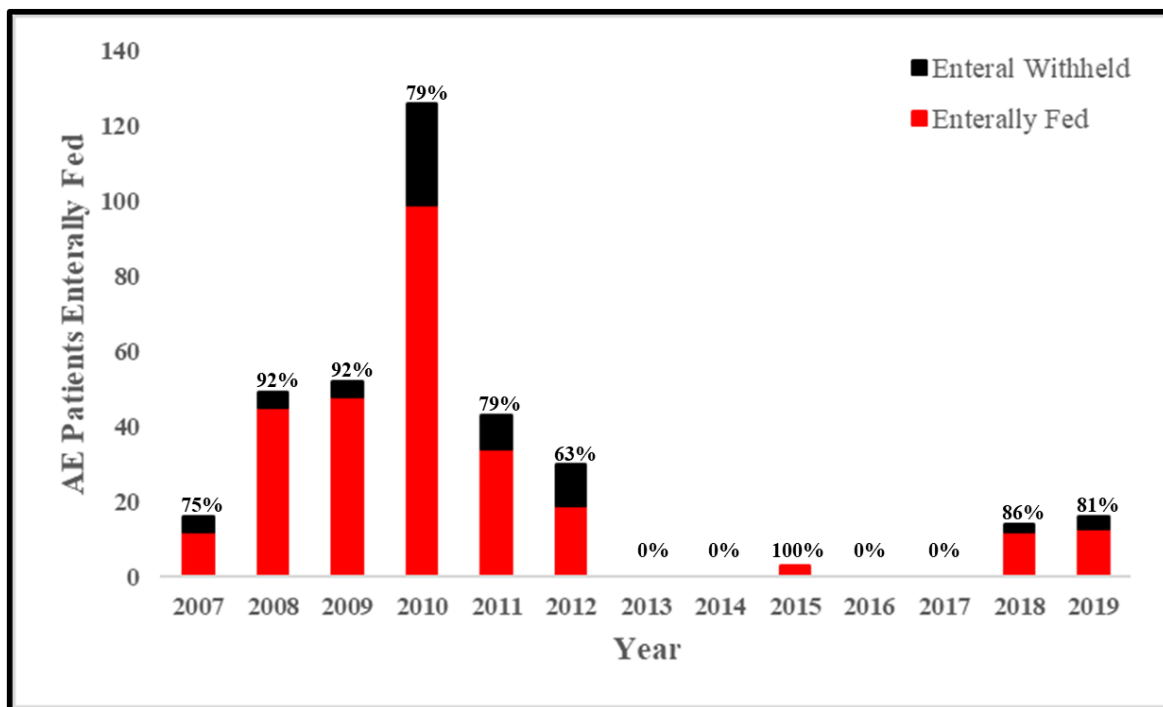


Figure 7. Patients Undergoing AE Enterally Fed (percent) and Enterally Withheld

In the 64 (18%) patients not enterally fed, feedings were held for a variety of reasons --- preflight, gastrointestinal and tube issues predominated (80%); inflight, concern over aspiration (50%). See **Table 12**.

Table 12. AE Enteral Feeding Considerations: Withheld Feeding Reasons

AE Enteral Feeding Considerations			
Withheld Feeding Reasons			
Reason	Preflight n (%)	Inflight n (%)	p-value
Aspiration Concern	1 (25)	3 (75)	0.127 ^b
Gastrointestinal Issue	6 (86)	1 (14)	
Firm Abdomen	1	0	
Hypoactive Bowel Sounds	1	0	
Ileus	2	0	
Nausea/Vomiting	1	1	
No Bowel Movement	1	0	
Abdominal Issue	2 (100)	0 (0)	
Abnormal Liver Function Tests	1	0	
Renal Failure	1	0	
Tube Issue	6 (86)	1 (14)	
Pump Issue	0 (0)	1 (100)	
Not Recorded	29 (67)	14 (33)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. n (number), % (percent).

These observations suggest the two populations might well be different. As a result, comparisons between those patients who were “Enterally Fed during AE” (Not Withheld) and those “Enterally Withheld during AE” (Withheld) were performed looking specifically at Demographics, Mission Parameters, Clinical Features, Vital Signs, Laboratory Values, Illness/Injury Profile, Therapeutic Modalities, Enteral Feeding Profiles, and TVFS Prescriptions.

The many analyses demonstrated the Not Withheld and Withheld patients to be very similar in most aspects. Indeed, the stereotypic patient in both groups was a 27-year old male enlisted Army soldier, evacuated most commonly from EUCOM/AFRICOM aboard a C-17 for a flight of around 10 hours. See **Table 13** and **Table 14**.

Table 13. AE Enteral Feeding Considerations: Demographics

AE Enteral Feeding Considerations			
Demographics			
Characteristic	Withheld	Not Withheld	p-value
Age, M (SD)	26.6 (9.0)	27.8 (10.1)	0.252 ^a
Gender, n (%)			
Male	63 (19)	277 (81)	0.570 ^b
Female	1 (11)	8 (89)	
Branch, n (%)			
Army	35 (16)	185 (84)	0.201 ^b
Marine	20 (26)	58 (74)	
Navy	4 (21)	15 (79)	
Air Force	4 (27)	11 (73)	
Other	1 (6)	15 (94)	
Rank, n (%)			
Enlisted	61 (21)	235 (79)	0.113 ^b
Officer	2 (6)	32 (94)	
Warrant Officer	1 (25)	3 (75)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

M (mean), SD (standard deviation), n (number), % (percent).

Table 14. AE Enteral Feeding Considerations: Mission Parameters

AE Enteral Feeding Considerations			
Mission Parameters			
Characteristic	Withheld	Not Withheld	p-value
Theater, n (%)			
CENTCOM*	20 (29)	49 (71)	< 0.043 ^b
EUCOM/AFRICOM	41 (16)	219 (84)	
INDOPACOM	3 (23)	10 (77)	
NORTHCOM/SOUTHCOM	0 (0)	7 (100)	
Aircraft, n (%)			
C-17	47 (17)	231 (83)	0.105 ^b
C-130	4 (40)	6 (60)	
KC-135	4 (29)	10 (71)	
Flight Time, M (SD)			
All Missions	9.4 (3.5)	9.8 (3.1)	0.472 ^a
C-17 Missions	10.1 (2.6)	9.9 (2.8)	0.755 ^a
C-130 Missions	1.7 (0.3)	5.7 (5.3)	0.252 ^a
KC-135 Missions	11.3 (4.1)	10.1 (3.7)	0.651 ^a

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

* Denotes driver-variable(s) for chi square statistical significance. M (mean), SD (standard deviation), n (number), % (percent), CENTCOM (Central Command), EUCOM/AFRICOM (European Command/Africa Command), INDOPACOM (Indo-Pacific Command), NORTHCOM/SOUTHCOM (Northern Command/Southern Command).

Battle Injury (73%) predominated in both groups, most commonly from improvised explosive devices and gunshots. For the most part, both groups had either a colostomy or bowel discontinuity (70%) together with soft, non-tender, non-distended abdomens (~90%) and bowel sounds (80-85%). Of note, for all intents and purposes, “discontinuous” bowel in this study was synonymous with an ostomy. See **Table 15**.

Table 15. AE Enteral Feeding Considerations: Clinical Features

AE Enteral Feeding Considerations			
Clinical Features			
Characteristic	Withheld	Not Withheld	p-value
Clinical Class, n (%)			
Battle Injury	47 (18)	208 (82)	0.941 ^b
Disease, Non-Battle Injury	17 (19)	77 (82)	
Trauma, n (%)			
IED/Blast	9 (24)	29 (76)	0.346 ^b
Gunshot Wound	12 (31)	27 (69)	
Rocket Propelled Grenade	0 (0)	2 (100)	
Motor Vehicle Accident	0 (0)	9 (100)	
Generalized	4 (27)	11 (73)	
Penetrating (not specified)	3	6	
Blunt (not specified)	1	5	
Bowel Status, n (%)			
Colostomy	4 (13)	28 (87)	0.908 ^b
Discontinuous	3 (13)	21 (87)	
Other	0 (0)	5 (100)	
Rectal Tube	2 (14)	12 (86)	
Stooling	1 (20)	4 (80)	
Bowel Sounds, n (%)			
Yes	31 (17)	151 (83)	0.665 ^b
Decreased	6 (21)	22 (79)	
No	9 (23)	31 (77)	
Abdominal Exam, n (%)			
Soft	57 (18)	260 (82)	0.965 ^b
Distended	2 (18)	9 (82)	
Tender	1 (13)	7 (83)	
Other	2 (22)	7 (78)	
Abdominal Disqualifiers, n (%)	1 (50) ^c	1 (50) ^d	---

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

^c Paralytic ileus (1). ^d Intractable diarrhea (1). n (number), % (percent), IED (improvised explosive device).

There was essentially no difference clinically between the Not Withheld and Withheld patients within either the Vital Signs or the Laboratory Values analyses. See **Table 16** and **Table 17**.

Table 16. AE Enteral Feeding Considerations: Vital Signs

AE Enteral Feeding Considerations			
Vital Signs			
Parameter	Withheld	Not Withheld	p-value
Blood Pressure, M (SD) (mmHg)			
Systolic Preflight	132 (18)	130 (22)	0.415 ^a
Diastolic Preflight	64 (12)	66 (12)	0.334 ^a
Systolic Midflight	132 (21)	130 (23)	0.404 ^a
Diastolic Midflight	62 (12)	62 (12)	0.917 ^a
Systolic Postflight	135 (19)	130 (22)	0.124 ^a
Diastolic Postflight	67 (13)	65 (12)	0.221 ^a
Heart Rate, M (SD) (per minute)			
Preflight	97 (20)	97 (21)	0.953 ^a
Midflight	91 (20)	96 (20)	0.046^a
Postflight	90 (20)	94 (20)	0.233 ^a
Temperature, M (SD) (F)			
Preflight	99.9 (1.4)	99.6 (1.5)	0.108 ^a
Midflight	99.9 (1.4)	99.5 (1.6)	0.039^a
Postflight	99.6 (1.2)	99.5 (1.4)	0.544 ^a
Saturation, M (SD) (SpO₂ = %)			
Preflight	98.5 (1.9)	98.2 (5.0)	0.571 ^a
Midflight	98.4 (2.0)	98.2 (1.9)	0.445 ^a
Postflight	99.0 (1.3)	98.5 (4.5)	0.402 ^a

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

M (mean), SD (standard deviation), n (number), % (percent), mmHg (pressure in millimeters of mercury), F (temperature in degrees Fahrenheit), SpO₂ (percent oxygen saturation of hemoglobin by pulse oximetry).

Table 17. AE Enteral Feeding Considerations: Laboratory Values

AE Enteral Feeding Considerations			
Laboratory Values			
Parameter	Withheld	Not Withheld	p-value
pH, M (SD)			
Preflight	7.4 (0.1)	7.4 (0.1)	0.628 ^a
Postflight	7.4 (0.1)	7.4 (0.1)	0.677 ^a
PaO₂, M (SD) (mmHg)			
Preflight	121 (40)	118 (41)	0.635 ^a
Postflight	140 (64)	128 (58)	0.302 ^a
PaCO₂, M (SD) (mmHg)			
Preflight	43 (8)	43 (8)	0.794 ^a
Postflight	42 (7)	41 (5)	0.299 ^a
Hemoglobin, M (SD) (g/dl)			
Preflight	9.1 (1.6)	9.1 (1.4)	0.945 ^a
Postflight	9.1 (1.5)	8.9 (1.3)	0.439 ^a
Hematocrit, M (SD) (%)			
Preflight	26.4 (4.2)	26.7 (4.2)	0.518 ^a
Postflight	26.6 (4.5)	26.0 (3.9)	0.468 ^a

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

M (mean), SD (standard deviation) pH (acid-base status of a solution), PaO₂ (partial pressure of arterial oxygen), O₂ (oxygen), PaCO₂ (partial pressure of arterial carbon dioxide), CO₂ (carbon dioxide), mmHg (pressure in millimeters of mercury), g (grams), dl (deciliter), % (percent).

The Illness/Injury Profile saw a similar profile with both the Not Withheld and Withheld patients. Maladies in order of frequency were orthopedic (27% and 26%, respectively), neurologic (18% and 15%, respectively), pulmonary (14% and 18%, respectively), gastrointestinal (10% and 10%, respectively), and otolaryngologic (8% and 11%, respectively). No other diagnosis reached even the 5% level. Notably, no Withheld patient had a self-inflicted injury, while four Not Withheld patients were self-injured. Up to five different diagnoses (aka systems) were recorded, garnering an average of 1.9 systems per patient affected in the Not Withheld group and 2.2 systems in the Withheld group. See **Figure 8** and **Table 18** and **Table 19**.

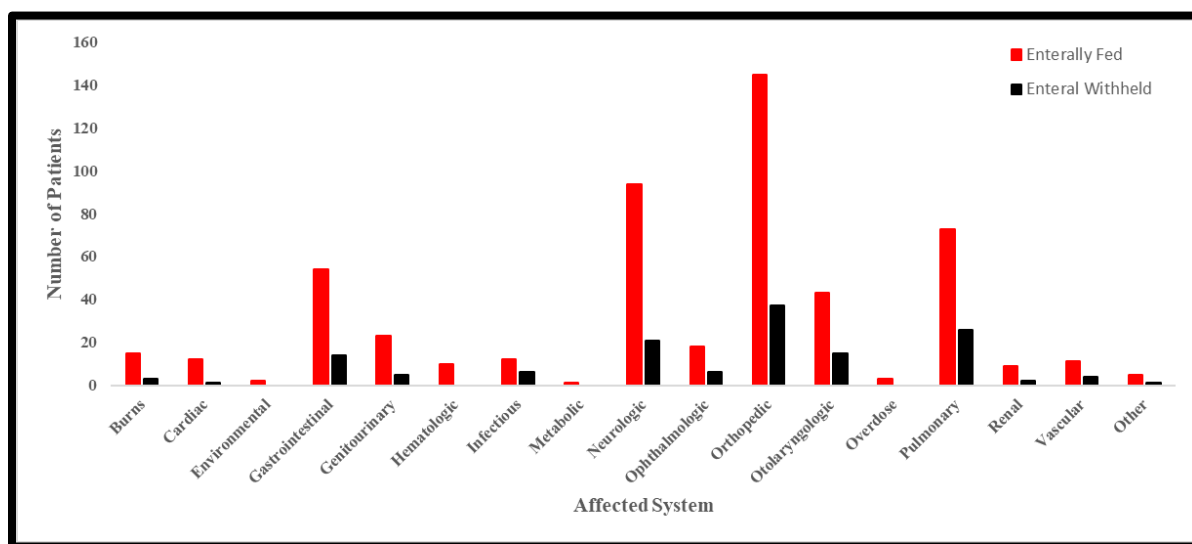


Figure 8. Illness/Injury Profile for Not Withheld and Withheld Patients

Table 18. AE Enteral Feeding Considerations: Illness/Injury Profile

AE Enteral Feeding Considerations			
Illness/Injury Profile			
System	Withheld n (%)	Not Withheld n (%)	p-value
Burns	3 (17)	15 (83)	0.776 ^b
Cardiac	1 (8)	12 (02)	
Environmental	0 (0)	2 (100)	
Gastrointestinal	14 (21)	54 (79)	
Genitourinary	5 (18)	23 (82)	
Hematologic	0 (0)	10 (100)	
Infectious	6 (33)	12 (67)	
Metabolic	0 (0)	1 (100)	
Neurologic	21 (18)	94 (82)	
Ophthalmologic	6 (33)	18 (67)	
Orthopedic	37 (20)	145 (80)	
Otolaryngologic	15 (26)	43 (74)	
Overdose	0 (0)	3 (100)	
Pulmonary	26 (26)	73 (74)	
Renal	2 (18)	9 (82)	
Vascular	4 (27)	11 (73)	
Other	1 (17)	5 (83)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic in a 2x17 table; number values < 5 suggest the statistic may be unreliable. n (number), % (percent).

Table 19. AE Enteral Feeding Considerations: Self-Inflicted Injury

AE Enteral Feeding Considerations			
Self-Inflicted Injury			
Mechanism	Withheld n (%)	Not Withheld n (%)	p-value
Overdose	0 (0)	2 (100)	---
Gunshot	0 (0)	2 (100)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. n (number), % (percent).

Therapeutic Modalities, Paralytics and Vasoactives, were dosed at low levels and relatively evenly split between groups (Not Withheld = 4% and 9%, respectively; Withheld = 13% and 16%, respectively; Paralytics → chi square = 7.579, df = 1, p = 0.059; Vasoactives → chi square = 2.087, df = 1, p = 0.149). In fact, there were only three patients dosed with high levels of Vasoactives (Not Withheld = 2; Withheld = 1). See **Table 20**.

Table 20. AE Enteral Feeding Considerations: Therapeutic Modalities

AE Enteral Feeding Considerations			
Therapeutic Modalities			
Parameter	Withheld	Not Withheld	p-value
Paralytics, n (%)	8 (42)	11 (58)	0.253 ^b
Vasoactives, n (%)	10 (27)	27 (73)	
Vasopressin, n (%)			0.809 ^b
≤ 0.04 U/min	1 (25)	3 (75)	
> 0.04 U/min	1 (33)	2 (67)	
Norepinephrine, n (%)			---
≤ 5 ug/min	1 (25)	3 (75)	
> 5 ug/min	---	---	
Phenylephrine, n (%)			---
≤ 50 ug/min	1 (33)	2 (67)	
> 50 ug/min	---	---	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.
n (number), % (percent), U (units), min (minute), ug (micrograms).

The Enteral Feeding Profile analyses did not significantly differ between groups, excepting the fact that the Withheld group did not see enteral feedings during AE. Impact™, Promote™, and Jevity™ were most frequently dosed. Orogastric (52%) tubes and nasogastric tubes (28%) were common modes of AE feeding, with concurrent Dobhoff™ tubes sometimes seeing use (9% and 7%, respectively). See **Table 21**. Presumably, the orogastric/nasogastric tube feedings took place in the more stabilized critically ill/injured, while the post-pyloric feedings were in the less stabilized patients.

Table 21. AE Enteral Feeding Considerations: Enteral Feeding Profile

AE Enteral Feeding Considerations			
Enteral Feeding Profile			
Characteristic	Withheld	Not Withheld	p-value
Tubes, n (%)			
Orogastric Tube	33 (18)	150 (82)	0.877 ^b
Nasogastric Tube	21 (20)	84 (80)	
Jejunal Tube	2 (15)	11 (85)	
Dual Tubes, n (%)			
Orogastric Tube with Dobhoff™	3 (12)	22 (88)	0.717 ^b
Nasogastric Tube with Dobhoff™	3 (16)	16 (84)	
Enteral Formulas, n (%)			
Impact™	8 (12)	61 (88)	0.281 ^b
Promote™	2 (7)	28 (93)	
Jevity™	3 (14)	18 (86)	
Isosource™	1 (25)	3 (75)	
Pivot™	2 (50)	2 (50)	
Osmolyte™	0 (0)	4 (100)	
Other ^c	2 (14)	12 (86)	
Volume Recorded, n (%)			
Summary Amount			
--- 10-250 ml	9 (12)	69 (88)	0.248 ^b
--- 251-500 ml	4 (5)	70 (95)	
--- 501-750 ml	1 (2)	43 (98)	
--- 751-1,000 ml	2 (14)	12 (86)	
--- > 1,000 ml	0 (0)	5 (100)	
Rate of Delivery			
--- 0-50 ml/hr	0 (0)	15 (100)	---
--- 51-100 ml/hr	0 (0)	18 (100)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. n (number), % (percent), ™ (trademark), ml (milliliter), hr (hour).

With the TVFS Prescriptions analyses, there were no apparent differences in patient positioning, head first/feet first or forward/aft, though backrest/head of bed elevation was more common with the Not Withheld patients. Moreover, there were no apparent differences in the employment of spine precautions or the imposition of CAR. See **Table 22**.

All told, the Not Withheld and the Withheld groups of patients proved alike and without significant difference in essentially all aspects examined.

Table 22. AE Enteral Feeding Considerations: TVFS Prescriptions

AE Enteral Feeding Considerations			
Theater Validating Flight Surgeon Prescriptions			
Intervention	Withheld	Not Withheld	p-value
Backrest/Head of Bed Elevation, n (%)	11 (33)	22 (67)	---
Patient Orientation, n (%)			
Feet First	10 (20)	39 (80)	0.724 ^b
Head First	44 (18)	197 (82)	
Patient Positioning, n (%)			
Front of Aircraft	5 (31)	11 (69)	0.176 ^b
--- Stanchion Loaded	5	10	
--- Floor Loaded	0	1	
Rear of Aircraft	49 (18)	227 (82)	
--- Stanchion Loaded	49	227	
Spinal Precautions, n (%)			
Cervical Spine	7 (19)	29 (81)	0.354 ^b
--- C-Collar	6	28	
--- Other	1	1	
Vacuum Spine Board/Spine Board	1 (17)	5 (83)	
Other	2 (50)	2 (50)	
--- Thoracic Spine	1	0	
--- Lumbar Spine	0	2	
--- Not Specified	1	0	
Cabin Altitude Restriction, n (%)			
Yes	17 (25)	50 (75)	0.082 ^b
--- < 3000 feet	1	2	
--- 3000-4000 feet	0	1	
--- 4000-5000 feet	2	5	
--- 5000-6000 feet	4	11	
--- 6000-7000 feet	3	15	
--- 7000-8000 feet	6	15	
No	44 (16)	227 (84)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic. ^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable. n (number), % (percent), C-Collar (cervical collar).

4.4 Impact of Joint Trauma System Clinical Practice Guidelines

Spanning the study timeframe, 2007-2019, three iterations of the JTS nutritional support CPG were issued. The initial *Nutritional Support of the Traumatically Injured Patient* was published 1 March 2010 (2010 JTS/CPG) and updated 11 June 2012 (2012 JTS/CPG). (CPG, 2010; CPG, 2012) The most recent iteration, *Nutrition Support Using Enteral and Parenteral Methods*, was published 4 August 2016 (2016 JTS/CPG). (CPG, 2016)

Patients within this study fell into the No EN and EN groups, preflight. In addition, the EN group's patients fell into the Not Withheld and Withheld groups, inflight. At the same time, the patients also fell into four natural time groupings: Pre-CPG₂₀₀₇₋₂₀₀₉ (aka those patients evacuated prior to any nutrition support CPG, years 2007-2009), Post-CPG₂₀₁₀₋₂₀₁₂ (aka those patients evacuated after the publication of the 2010 JTS/CPG and prior to the publication of the 2012 JTS/CPG, years 2010-2012), Post-CPG₂₀₁₀₋₂₀₁₉ (aka those patients evacuated after publication of the 2010 JTS/CPG, years 2010-2019), and Post-CPG₂₀₁₈₋₂₀₁₉ (aka those patients evacuated after the publication of the 2016 JTS/CPG, years 2018-2019). Consequently, the two sets of patient groupings could be examined in light of the JTS/CPGs' publication timing.

Following the 2010 JTS/CPG, Post-CPG₂₀₁₀₋₂₀₁₉, early enteral feeding rose significantly from ~15% to ~19%. Interestingly, in the Post-CPG₂₀₁₀₋₂₀₁₂ time, early enteral feeding rose from ~15% to ~17%, though not meeting statistical significance (chi square = 2.074, df = 1, p = 0.149). And, then, from the Post-CPG₂₀₁₀₋₂₀₁₂ time to the Post-CPG₂₀₁₈₋₂₀₁₉ time, early enteral feeding significantly rose from ~17% to ~48%. See **Table 23**.

Concurrently, following the 2010 JTS/CPG, Post-CPG₂₀₁₀₋₂₀₁₉, withholding of AE enteral feeding rose significantly from ~10% to ~23%. In the Post-CPG₂₀₁₀₋₂₀₁₂ time, withholding of AE enteral feeding also significantly rose from ~10% to ~24% (chi square = 8.663, df = 1, p = 0.003). And, then, from the Post-CPG₂₀₁₀₋₂₀₁₂ time to the Post-CPG₂₀₁₈₋₂₀₁₉ time, withholding of AE enteral feeding dropped from ~24% to ~17%, though not meeting statistical significance. See **Table 23**.

Table 23. Impact of Clinical Practice Guidelines

Enteral Feeding Considerations						
Impact of Clinical Practice Guidelines (CPG)						
Clinical Practice Guideline Timing	Not Enterally Fed n (%)	Enterally Fed n (%)	p-value	AE Enterally Fed n (%)	AE Feeding Withheld n (%)	p-value
Pre-CPG ₂₀₀₇₋₂₀₀₉	667 (85)	117 (15)	0.019 ^b	105 (90)	12 (10)	0.005 ^b
Post-CPG ₂₀₁₀₋₂₀₁₉	978 (81)	229 (19)		177 (77)	52 (23)	
Post-CPG ₂₀₁₀₋₂₀₁₂	945 (83)	199 (17)	< 0.001 ^b	152 (76)	47 (24)	0.397 ^b
Post-CPG ₂₀₁₈₋₂₀₁₉	33 (52)	30 (48)		25 (83)	5 (17)	

Note: **Bold** denotes statistical significance. ^a Statistical analyses employed the independent means t-test statistic.

^b Statistical analyses employed the chi square statistic; number values < 5 suggest the statistic may be unreliable.

The three nutrition support JTS/CPGs were key to this examination. (CPG, 2010; CPG, 2012; CPG, 2016)
n (number), % (percent), CPG (clinical practice guideline), JTS (Joint Trauma System).

5.0 DISCUSSION

5.1 Review of Results

Early enteral feeding of critically ill/injured patients, within 24-48 hours of admission, is standard of care. That is especially true of trauma and burn patients. (**McDonald, 1991; Heyland, 2003; CPG, 2016; McClave, 2016; Singer, 2019; Lambell, 2020; Woody, 2021**) Not infrequently, military casualties are critically ill/injured, particularly battle injured casualties. Also, not infrequently, military casualties find themselves in the US evacuated within 24-72 hours of injury. (**Gawande, 2004; Mazurek, 2006; Schreiber, 2008; Brewer, 2009; Lundy, 2010; Blackbourne, 2012; Lairet, 2013**) Consequently, early enteral feeding in the critically ill/injured military patient means feeding at altitude in an aircraft during AE.

At the beginning of Operations Iraqi Freedom and Enduring Freedom, there was no formal enteral feeding program for critically ill/injured patients. This fact led to the development of an enteral feeding protocol at Landstuhl Regional Medical Center consisting of

1. Orogastric or nasogastric tube to suction,
2. Orojejunal or nasojejunal feeding tube placement within 24 hours of admission, and
3. Delivery of an immune enhancing enteral formula accompanied by antioxidant supplements. (**Dorlac, 2008; Fang, 2008**)

At that time, no specific AE guidance existed. On 21 December 2005, the Air Mobility Command Surgeon General (AMC/SG) issued an “enteral feedings during AE” policy for transports from EUCOM to the Continental United States (CONUS). Notably, in the present study, this route carried 77% of the patients enterally fed during AE. This policy consisted of

1. Abdominal x-ray (Kidney-Ureter-Bladder = KUB) confirming placement of jejunal feeding tube,
2. Orogastric or nasogastric tube to suction,
3. Separate feeding tube using an intravenous pump, flushed every 8 hours,
4. Head of bed elevation with backrest, and
5. Head first patient positioning. (**Dorlac, 2008; Fang, 2008**)

This policy was then evaluated over a 14-month period (January 2006 to March 2007). Of 207 intubated trauma patients, 199 (96%) were fed successfully and without incident, demonstrating the safety of en route enteral feeding. (**Dorlac, 2008**)

Despite this success, a combat support hospital located near Baghdad shortly thereafter reported only 12% of eligible casualties were recommended early enteral feeding, none actually fed. The reason given, anticipated AE within 24 hours. (**Stankorb, 2009**)

Subsequently, the initial nutrition support JTS/CPG was published 1 March 2010. The present study well-demonstrated an uptick in early enteral feeding rates, from ~15% to ~17%. Following the next two iterations of the JTS/CPG, early enteral feeding rates rose significantly, from ~17% to ~48%. At the same time, early after the initial JTS/CPG, withholding enteral feeding during AE rose significantly from ~10% to ~24%, only to drop down to ~17% with the subsequent JTS/CPGs. It appeared the JTS/CPGs reinforced the benefit of early enteral feeding in critically ill/injured patients. But, it also appeared the JTS/CPGs sensitized to the threat of

aspiration, with the rate of withholding eventually moderating, presumably, from the accumulated experience after the 2012 and 2016 JTS/CPGs.

These findings run counter to the en route goals of higher preflight enteral feeding rates and lower AE enteral withholding rates. Consequently, it was supposed there might be explanatory population differences between those critically ill/injured patients not fed enterally, those enterally fed, and those withheld from enteral feeding during AE. The present study found very little difference between those preflight patients not enterally fed and those enterally fed, this across demographics, mission parameters, clinical features, vital signs, laboratory values, illness/injury profile, therapeutic modalities, enteral feeding profile, and TVFS prescriptions. Likewise, across these same properties, those patients enterally fed during AE demonstrated essentially no differences from those patients having enteral feeding withheld. Yet, a full 83% of the present study's patients were not enterally fed preflight and 18% of those that were had feeding withheld for AE.

At the same time, it is important to note that initial enteral feeding was administered with an IV pump and specialized IV tubing. Once this practice was discontinued, dedicated enteral feeding pumps were employed via the equipment waiver process. Today, an enteral feeding pump is being tested/evaluated for inclusion into the AE-approved equipment listing. See **Appendix C**.

In summary, the present study suggested early enteral feeding was under prescribed and en route withholding of enteral feeding overprescribed. Of course, this conclusion presupposed good outcomes across all groups, outcomes which were not available. In the meantime, until outcome analyses were forthcoming, specific TVFS actions to encourage preflight enteral feeding and abrogate the holding of AE enteral feeding had to be attended. Such actions were important even in the face of possible aspiration, a primary reason to withhold enteral feedings. **(Dorlac, 2008; Duff, 2008; Henning, 2008; Turner, 2008; Stankorb, 2014; Shields, 2016; Dorlac, 2019; Woody, 2021)** In this way, preflight early enteral feeding might be boosted, withholding AE enteral feedings diminished, and complications from aspiration prevented.

The present study also highlights the need for further research. Outcome studies are needed focusing on postflight complications (e.g., rates of infection and ventilator-associated pneumonia), postflight procedures, time to healing, days on ventilator, days in ICU, and overall days of hospitalization. In addition, studies focused on aspiration are needed. Tracheal aspirate studies looking for glucose, methylene blue, and/or pepsin, comparing those patients enterally fed with those not, have been suggested. **(Metheny, 2006; Turner, 2008)** Indeed, one study demonstrated poorer outcomes, to include ventilator-associated pneumonia, in tracheal pepsin-detected frequent aspirators. **(Metheny, 2006)** Along the same line, prospective observational studies focused on detecting actual inflight aspiration should be a priority. With such studies in hand, a potential risk can be transformed into a defined risk, making more quantified TVFS actions possible and definitive, "good to go" inflight enteral feeding prescriptions routine.

5.2 Role of the Theater Validating Flight Surgeon

The TVFS is the final approval authority for manifesting any patient aboard an AE flight. As such, the TVFS is the final clinical screen prior to a patient's evacuation. He/she validates the patient is "fit to fly," often prescribing clinical and/or aircraft interventions. Among the clinical prescriptions is enteral feeding. Although the TVFS is neither a nutritionist nor intensivist, he/she can configure the patient-aircraft interface to best ensure enteral feeding is "good to go" in these critically ill/injured patients. (**Butler, 2020a; Butler, 2020b**)

As noted above, the patients in the present study demonstrated no serious differences in overall character that could explain the dearth of enteral feeding prior to or during AE. Notably, there are a number of specific contraindications to enteral feeding, but only a very few were documented. (**CPG, 2016**) Included were life threats such as organ system failure (4), peritonitis (2), bowel necrosis (2), and mesenteric ischemia (1), not to mention physiologic dysfunction counting intractable vomiting (2), intractable diarrhea (1), and paralytic ileus (1), all making up just under 1% of those patients not enterally fed and 3% of those AE patients withheld enteral feeding. Only two patients, one with intractable diarrhea and one with paralytic ileus, were specifically withheld enteral feedings during AE. On the other hand, two-thirds of the 64 patients whose enteral feeding was withheld during AE had no specific reason documented. Of those with issues documented, clinical problems (43%) held sway, though no single one problem stood out. Mechanical troubles, tube issues (33%) and pump issues (5%) followed. Behind clinical problems and mechanical troubles came the threat of aspiration (19%). See **Table 4, Table 12, and Table 15.**

These findings suggest other less than obvious reasons might underlie the large number of patients not enterally fed. Examination of the literature offers up several withholding rationales.

1. Disqualifiers: certain clinical entities are considered absolute contraindications to enteral feeding --- generalized peritonitis, intestinal obstruction, surgical discontinuity of bowel, mesenteric ischemia, major gastrointestinal bleed, high output uncontrolled fistula, paralytic ileus, and intractable vomiting/diarrhea. (**CPG, 2016**)
2. Operational blocks: operational actions can interfere with delivery of enteral feeding or extend the time without it --- weather delays, high operational tempo, aircraft availability, patient re-prioritization, and rapid evacuation. (**Fang, 2010; Woody, 2021**)
3. Patient care interruptions: patient care activities can interfere with the delivery of enteral feeding or extend the time without it --- procedures/tests, feeding tube issues, pump issues, nursing tasks. (**McClave, 1999; Kim, 2012; Wanik, 2019**)
4. Risk of bowel necrosis: settings whereby the bowel may well be compromised include shock, mean arterial pressures < 60 mmHg, and vasopressor dosing (inception, upping dose, or high dose). (**CPG, 2016; McClave, 2016; Singer, 2019**)
5. Gastrointestinal intolerance: inability of the gastrointestinal tract to tolerate enteral feedings, most commonly defined by high gastric residual volumes, increasing the risk for aspiration. (**AFI, 2017; CPG, 2016; McClave, 2016**)
6. Risk of aspiration: patients characterized as ventilator-dependent, supine, unconscious, neurologically compromised, gastric-fed, bolus-fed, suffering reflux, and being transported. (**Metheny, 2006; McClave, 2016; Singer, 2019**) Of note, the risk of aspiration with its ventilator-associated pneumonia is the most commonly cited reason to

withhold enteral feeding during AE. (Duff, 2008; Henning, 2008; Turner, 2008; Stankorb, 2014; Woody, 2021)

For the TVFS to systematically evaluate enteral feeding in a patient under consideration for AE validation, an orderly and coherent approach is required. An algorithm ensures a comprehensive methodology. See **Appendix B**. This begins with a consideration of the patient's *preflight* situation. First, is there an absolute disqualifier (aka contraindications) for enteral feeding? (CPG, 2016) Is there a serious risk for bowel necrosis? (CPG, 2016; McClave, 2016; Singer, 2019) If not, then enteral feeding during AE should be considered. Seldom should operational blocks interfere with clinical care, short of weather-based, threat-based, or mechanical-based mission diversions where medical re-supply could become an actual issue. Likewise for patient care interruptions, excepting inflight tube or pump issues, both generally amenable to interventions from the highly skilled AE crew and/or CCATT team.

Next considered is gastrointestinal tolerance. Is there any evidence for paralytic ileus? Without serious injury or major abdominal surgery, the stomach will empty rapidly, usually within 2-3 hours. (Scarr, 1989; Splinter, 1990) In contrast, postoperative ileus generally affects the small intestine over the initial 0-24 hours, stomach 24-48 hours, and large intestine 48-72 hours. (Luckey, 2003) Electrolyte abnormalities can stretch out these times, particularly low levels of potassium, magnesium, or phosphate. (CPG, 2016) Consequently, normal electrolytes must be confirmed as well as a normal abdomen with active bowel sounds and a soft, nontender, non-distended exam. (CPG, 2016; McClave, 2016; Singer, 2019) Concurrently, it is essential to know the gastric residual volumes for patients being fed. Depending on the author, gastric residual volumes in excess of 200 ml, 300 ml on two successive samplings, or 500 ml may be just cause for interrupting enteral feeding. (CPG, 2016; McClave, 2016; AFI, 2017) For the TVFS, large gastric residual volumes suggest the need for post-pyloric feeding with accompanying orogastric/nasogastric tube suction, trophic feedings, prokinetics (metoclopramide or erythromycin), and/or naloxone via feedings. (Heyland, 2003; CPG, 2016; McClave, 2016; Singer, 2019)

And, lastly, what is the risk of aspiration? Patients on a ventilator, supine, neurologically compromised (e.g., injury, sedation/analgesia), gastric-fed, bolus-fed, with gastroesophageal reflux, the act itself of moving/transporting, and/or flying with nose-high attitudes have an increased risk for aspiration. (Metheny, 2006; Fang, 2010; McClave, 2016; Singer, 2019) The TVFS must ensure the endotracheal tube cuff is attended (e.g., air-managed, saline-filled), head of bed elevated (if clinically reasonable), opioid gut impact reduced (e.g., dose naloxone enterally), feedings post-pyloric (e.g., DobhoffTM tube), feedings continuous (e.g., trophic feedings), reflux minimized (e.g., head first load, prokinetics dosed), position settled well before take off (e.g., unhurried loading), and nose-high attitude countered (e.g., load and position head first), respectively. (Heyland, 2003; Dorlac, 2008; Fang, 2010; CPG, 2016; McClave, 2016; AFI, 2017; Singer, 2019; Beninati, 2019; Dorlac, 2019; Woody, 2021) See Table 24.

Table 24. TVFS Considerations: Preflight

TVFS Considerations	
Preflight	
Contraindications	Serious Intolerances
Generalized Peritonitis	Paralytic Ileus
Intestinal Obstruction	Intractable Vomiting
Bowel Discontinuity	Intractable Diarrhea
Major Gastrointestinal Bleed	Large Gastric Residual Volumes
High Output Uncontrolled Fistula	
Abdominal Compartment Syndrome	<u>Risk of Aspiration</u>
Mesenteric Ischemia	Mechanically Ventilated
	Supine
<u>Risk of Bowel Necrosis</u>	Neurologically Compromised
Shock	Gastrointestinal Reflux
Active Shock (MAP < 60 mmHg)	Gastric-Fed
Vasopressors	Bolus-Fed
	Act of Transporting
	Nose-high flight attitude
Patient Care Interruptions	Operational Blocks
Procedures/Tests	Weather Delay
Feeding Tube Issues	High Operational Tempo
Pump Issues	Aircraft Availability
Nursing Tasks	Patient Re-Prioritization
	Rapid Evacuation

Note: MAP (mean arterial pressure), mmHg (pressure in millimeters of mercury).

The TVFS must then consider the *inflight* environment. Here, there are a number of physiological stressors common to crew and patients alike flying at a standard cabin altitude of 8,000 feet. Among them are gravitational forces (aka acceleration/deceleration), reduced humidity, hypoxia, vibration (aka engine/jostling/turbulence), thermal instability (aka hypothermia), hypobaria, and noise. (Topley, 2003; AFI, 2017; Butler, 2020a; Butler, 2020b) Those deserving special attention from the TVFS when it comes to enteral feeding include acceleration/deceleration, engine/jostling/turbulence, hypothermia, and hypobaria. (Duff, 2008; Henning, 2008; Turner, 2008; Stankorb, 2014; Woody, 2021) Acceleration/deceleration promotes gastroesophageal reflux and aspiration; engine/jostling/turbulence incites motion sickness with nausea and vomiting; hypothermia fuels shivering and ups energy requirements; and, hypobaria produces gastric bubble expansion, promoting gastroesophageal reflux and aspiration. In addition, the confined/restricted cabin space fosters supine positioning with its accompanying rise in aspiration risk. (AFI, 2017; Butler, 2020a; Butler, 2020b) Countering interventions from the TVFS include head first enplanement, centered positioning remote from the engines, increased cabin temperature, CAR, and head of bed elevation, respectively. See Table 25.

Table 25. TVFS Considerations: Inflight.

TVFS Considerations	
Inflight	
Stressors	Risks
Acceleration/Deceleration	Gastroesophageal Reflux (aspiration)
Jostling/Vibration/Turbulence	Motion Sickness (nausea/vomiting)
Thermal Instability (hypothermia)	Shivering (ups energy requirements)
Hypobaria	Gastroesophageal Reflux (aspiration)
Restricted Space	Supine Position (aspiration)

All the while considering the *preflight* and *inflight* settings, the TVFS deliberates the patient's *clinical* picture and its many varied aspects. See **Table 26**.

Table 26. TVFS Considerations: Clinical

TVFS Considerations	
Clinical	
Actions	Medications
Oral Care w/ Chlorhexidine bid	Prokinetic Medications
ETT Cuff Care	Erythromycin
OGT/NGT/Post-Pyloric Tube Care	Metoclopramide
Enteral Feeding Prescription	Vasoactive Medications
Gastric Residual Volume Testing	Dopamine
Electrolyte Monitoring	Vasopressin
Potassium	Phenylephrine
Magnesium	Norepinephrine
Phosphate	Epinephrine
Transport to & from ICU	Opioids/Sedatives
	Naloxone via Enteral Feedings

Note: w/ (with), bid (twice daily), ETT (endotracheal tube), OGT (orogastric tube), NGT (nasogastric tube), ICU (intensive care unit).

Oral chlorhexidine care must be assured, otherwise, ventilator-associated pneumonia risk with aspiration escalates. (McClave, 2016) In fact, reported in the most recent Cochrane Review update, oral care with chlorhexidine dropped ventilator-associated pneumonia from around 26% to 18%. (Zhao, 2020) Standard oral concentrations range from 0.12% to 2%. (Veltz-Keenan, 2017; Zand, 2017) Although the higher concentrations are more effective, even the 0.12% works. (DeRiso, 1996; Zand, 2017) And, toothbrushing added to the regimen appears to deliver extra benefit. (Vidal, 2017) Unfortunately, dating back as early as 1977, chlorhexidine has been shown to have *in vitro* cytotoxicity, most commonly affecting fibroblasts and less commonly myoblasts and osteoblasts. This effect appears most pronounced during tissue healing and is dependent upon concentration and duration of exposure. (Goldschmidt, 1977; Liu, 2018; Coelho, 2020) At the same time, chlorhexidine has potent antibacterial, antiviral, and antifungal activity. (DeRiso, 1996) Hence, with standard chlorhexidine oral care procedures, especially at the 0.12% concentration, benefit appears to override detriment. Having oral care performed just prior to leaving the ICU for the flight line seems reasonable. Indeed, oral care kits are part of the CCATT allowance making it equally reasonable to reinforce en route oral care for these critically ill/injured patients.

In addition, the TVFS should emphasize endotracheal tube cuff care consisting of air exchange with ascent/descent or cuff-air replacement with saline, the result being a sealed and protected airway. Indeed, tight control of air exchange pressures or saline cuff volume replacement (i.e., < 10 ml saline) is imperative. Though lately, movement away from saline-replacement has been advocated as saline-filled cuff pressures at altitude have exceeded the 20-30 cm H₂O (15-22 mmHg) safe range. (Britton, 2014; AFI, 2017; Beninati, 2019; Butler, 2020b) Orogastric, nasogastric, and post-pyloric tube placement should be verified, currently best done with a pre-flight abdominal x-ray. (Dorlac, 2008; AFI, 2017) Needless to say, the bedside clinicians and the AE crew and the CCATT team routinely evaluate both airway and gastrointestinal tube placement and function preflight, inflight, and postflight.

Review of the enteral feeding prescription (e.g., gastric-fed, bolus-fed) is a must. Although there appears to be little difference in outcome between gastric and post-pyloric feeding, post-pyloric feeding appears to be the better route for AE, since the Boyle's Law effect of hypobaria on the gastric bubble encourages gastroesophageal reflux and aspiration. (McClave, 2016; Singer, 2019; Butler, 2020b) Bolus feeding should be avoided as there is a higher risk for aspiration, a smaller amount of feedings delivered, and a higher rate of gastrointestinal intolerance. (McClave, 2016; Singer, 2019) And, as mentioned earlier, gastric residual volumes should be reviewed. A residual in excess of 200 ml should suggest intervention. Although the AFI advises feedings stop with residuals > 200 ml, consensus, including the 2016 JTS/CPG, favors > 500 ml. (CPG, 2016; McClave, 2016; AFI, 2017; Singer, 2019) Prior to withholding feedings, orogastric or nasogastric tube to suction, prokinetics (metoclopramide 10 milligram (mg) dosed every 6 hours (q6h) or erythromycin 250 mg q6h) as well as trophic feeding rates (10-20 ml/hr) should be entertained. (Dorlac, 2008; CPG, 2016; McClave, 2016; Singer, 2019) Thus, the TVFS enteral feeding prescription can best be described *as continuous, post-pyloric with or without orogastric/nasogastric suction, prokinetics, and/or trophic rates.*

Vasopressors in the face of enteral feeding can put bowel viability at risk. Relatively low, stable dosing of dopamine, vasopressin, phenylephrine, and norepinephrine appear compatible with enteral feeding. Indeed, trophic rates of feeding have been suggested in this setting. (McClave, 2016) However, upping the dose or high doses (i.e., dopamine > 10 ug/min,

vasopressin > 0.04 U/min, phenylephrine > 50 ug/min, norepinephrine > 5 ug/min) or epinephrine should prompt withholding the feedings or, at the very least, extra scrutiny. (CPG, 2016; McClave, 2016; Singer, 2019)

Opioids and sedation can also pose risk to the critically ill/injured AE patient. Sedation may neurologically compromise the patient, increasing the risk for aspiration. With mechanical ventilation, sedation is almost mandatory. On the other hand, with opioids, the TVFS can offer up naloxone (8 mg q6h) via the feeding tube. In this way, the opioid effect on the bowel can be reversed without necessarily affecting the parenteral analgesic effects. (Meissner, 2003; McClave, 2016)

These *preflight*, *inflight*, and *clinical* considerations bring together a group of TVFS prescriptions designed to facilitate delivery of enteral feeding while minimizing the potential for complications such as aspiration. Indeed, each should be given due consideration in every critically ill/injured patient, but only after each patient has been assessed for enteral feeding. In other words, should the TVFS find a critically ill/injured patient not being enterally fed, he/she should immediately raise the issue. The sole caveat would involve limited feeding resources. In that setting, patients evacuated on longer duration AE flights should be prioritized over those on shorter duration flights. Thereafter, the other prescriptions can be entertained. In fact, they can be addressed serially as if a checklist. See Table 27. This systematic and coherent methodology is best applied via an algorithm. See Appendix B.

Table 27. TVFS Considerations: Prescriptions/Algorithm

TVFS Considerations		
Prescriptions		
Intervention	Effect	Citation
- Delivery of Enteral Feeding (yes/no)	Gut Integrity; Immunocompetence; Healing	Ellis, 2015; McClave, 2016; Singer, 2019; Woody, 2021
- Prioritize Enteral Feeding to Longer Flights	In limited resource setting, maximizes allocations	---
- Ensure Normal Electrolytes	Minimizes inflight paralytic ileus	CPG, 2016; McClave, 2016; Singer, 2019
- Preflight/Inflight Oral Care w/ Chlorhexidine	Minimizes inflight oral flora	McClave, 2016
- Inflight ETT Cuff Care**	Ensures cuff-trachea seal	Britton, 2014; Butler, 2020b
- Post-Pyloric Feeding	Delivers feeding distal to stomach	Dorlac, 2008; CPG, 2016; McClave, 2016; Singer, 2019
- OGT/NGT to Suction	Removes gastric contents	Dorlac, 2008; CPG, 2016
- Consider Trophic Feeding (10-20 ml/hr)	Maintains gut integrity; Reduces gastric residuals	CPG, 2016; McClave, 2016; Singer, 2019
- Consider Prokinetics	Maximizes gastric emptying	Heyland, 2003; CPG, 2016; McClave, 2016; Singer, 2019
- Consider Naloxone via Enteral Feeding	Reduces opioid gut effects	Meissner, 2003; McClave, 2016
- Scrutinize Vasopressor Dosing	Avoids possible gut ischemia with high dosing	CPG, 2016; McClave, 2016; Singer, 2019
- Decrease Sedation/Analgesia*	Better patient airway control*	McClave, 2016
- Head First Loading	Minimizes acceleration effect at GE jcn	Butler, 2020b
- Center Patient Remote to Engines	Minimizes vibration impact	Butler, 2020b
- Elevate Head-of-Bed 30-35 Degrees	Maximizes gravity effect at GE jcn	CPG, 2016; McClave, 2016; Singer, 2019
- Reverse Trendelenberg Position (floor load)	Maximizes gravity effect at GE jcn	Butler, 2020b; McClave, 2016
- Consider Long Slow Take off	Minimizes acceleration effect at GE jcn	Butler, 2020b
- Consider Long Slow Landing	Minimizes deceleration effect at GE jcn	Butler, 2020b
- Hold Feeds 30 min Prior to Take off/Landing	Minimizes acceleration/deceleration effect at GE jcn	AFI, 2017
- Consider Cabin Altitude Restriction	Diminishes Boyle's Law effect	Butler, 2020b

Note: * Not a real consideration in mechanically ventilated patients. ** Tight control of air exchange pressures or individualized saline cuff volume replacement (i.e., < 10 ml saline) is imperative. w/ (with), ETT (endotracheal tube), OGT (orogastric tube), NGT (nasogastric tube), ml (milliliter), hr (hour), min (minute), GE gastroesophageal), jcn (junction).

6.0 LIMITATIONS

This study was retrospective research subject to the limitations any after-the-fact data collection is subject to, that is missing data, incomplete data, and/or inaccurate data. Great care was taken to optimize data quality through individualized review of each record entered into the dataset. However, some missing data could not be avoided. Though deemed not probable, it is possible that the missing data could alter some observations and/or conclusions taken from the available data.

In addition, a large number of identified records were not extracted, bringing forth the potential for extraction bias. This happened because of a funding shortage and the inability to continue employment of the contracted data extractor. Consequently, the records extracted were compared to the records identified in the three common data fields --- Year, Julian Day, and Theater. No obvious extraction bias was identified.

Similarly, the years 2013-2019 had limited numbers of both identified and extracted records. This is consistent with the drop in overall casualties, especially battle injured, as reported from a major Role II facility (2016-2019). (**Richards, 2021**) Indeed, after 2012, identified records of critically ill/injured, mechanically ventilated patients plummeted to well under 200 annually and extracted records, excepting 2018-2019, made up only 0-6% depending on the year. This could have been from a dearth of ventilated patients. Indeed, from October 2014 to April 2015, no ventilator-dependent patients were evacuated from Bagram Air Base, Afghanistan. (*personal communication, Colonel Michael Richards*) As a result, post-2012 observations were heavily weighted with those from 2018-2019. It is possible this weighting could affect observations and/or interpretations; however, the conclusions reached were coherent and cogent and, thusly, thought valid.

This study did not directly examine the nutritional risk in these critically ill/injured patients. Specifically, preflight and postflight measurement of Body Mass Index, visceral proteins (e.g., albumin, prealbumin, transferrin), and blood cultures for gram negative rods were not collected. As most of the patients suffered major trauma and/or burns, it was felt all were at excess nutritional risk, an assumption well supported in the literature.

This study was essentially a large case series. That said, it was possible to examine with case-control methodology those patients not enterally fed preflight with those enterally fed and those patients enterally fed during AE with those whose enterally feedings were held. This examination characterized the various groups of patients, finding them all very similar. However, as outcome data was not readily available, the clinical impact of being enterally fed or not was indeterminable. Despite this failure, the impact of the JTS/CPGs could be ascertained, affirming the value of well thought out and well disseminated guidelines and revealing the unintended consequence of those same guidelines.

Regrettably, even with a fairly large population to draw from, those patients enterally fed made up a relatively small percentage. As a result, data field analyses often involved small numbers of patients, sometimes less than five, making statistical calculations at times unreliable. Regardless, the overall conclusions based on the statistical analyses were rational, plausible and, thusly, felt to be valid.

Lastly, for the TVFS, an enteral feeding clinical validation algorithm was devised, to some extent, from the observations in this study, but, to a greater extent, from those found in the nutrition literature. It is fully anticipated that early enteral feeding outcome studies in the AE setting may well offer up additions and/or deletions to the algorithm.

7.0 CONCLUSION

This study was a retrospective investigation looking at early enteral feeding *vis à vis* AE. Early enteral feeding in the critically ill/injured patient, especially burn and major trauma patients, has long been standard of care.

Early into Operations Iraqi Freedom and Enduring Freedom, enteral feeding policy disseminated from the AMC/SG demonstrated the feasibility of enteral feeding during AE from EUCOM to CONUS. Subsequently, the 2010 JTS/CPG was published. This study found an uptick in preflight enteral feeding afterwards, along with a significant uptick in feeding holds during AE. Following the 2012 and 2016 JTS/CPGs, preflight enteral feeding rose even more while the AE feeding holds dropped. It is reasonable to think the JTS/CPGs reinforced the benefit of early enteral feeding. But, equally reasonable, the JTS/CPGs may well have sensitized to the threat of aspiration.

This study also found a generally uniform population of patients. There was essentially no preflight difference between those patients not enterally fed and those enterally fed, this across demographics, mission parameters, clinical features, vital signs, laboratory values, illness/injury profile, therapeutic modalities, enteral feeding profile, and TVFS prescriptions. Likewise, across the same properties, those patients enterally fed during AE demonstrated no real differences from those patients having enteral feeding withheld. However, 83% of the present study's patients were not enterally fed preflight and 18% of those that were had feeding withheld for AE.

Thus, this study suggested that early enteral feeding preflight was under prescribed and en route withholding of enteral feeding overprescribed. As a result, an algorithm specifically designed for the TVFS was devised and described. It incorporated preflight, inflight, and clinical concerns relevant to flying an enterally fed critically ill/injured patient and offered up numerous prescriptions to facilitate enteral feeding inflight. With this algorithm, it was hoped early enteral feeding preflight could be boosted, withholding AE enteral feedings diminished, and complications such as aspiration prevented.

In the end, this study highlighted the need for further research. Outcome studies are needed focusing on postflight complications (e.g., rates of infection and ventilator-associated pneumonia), postflight procedures, time to healing, days on ventilator, days in ICU, and overall days of hospitalization. In addition, studies focused on aspiration are needed, specifically tracheal pepsin-aspirate studies as well as prospective inflight observational studies. With such research in hand, the potential risk from aspiration can be transformed into a defined risk, making an updated, more quantified TVFS algorithm possible and definitive, "good to go" inflight enteral feeding prescriptions routine.

As something of a postscript, with more prolonged field care projected for future conflicts, establishment of standard in-field enteral feeding supplies (e.g., NGTs/OGTs, DobhoffTM tubes, enteral feeding formulas, etc.) and standardization of in-field tube placement verification procedures must be priorities. In fact, this study's initial literature review confirmed the utility of ultrasound for tube placement. (Woody, 2021) Presciently, ultrasound is already part of the allowance standards for operational teams (e.g., CCATT). Indeed, some of this study's authors have already begun to investigate these in-field needs.

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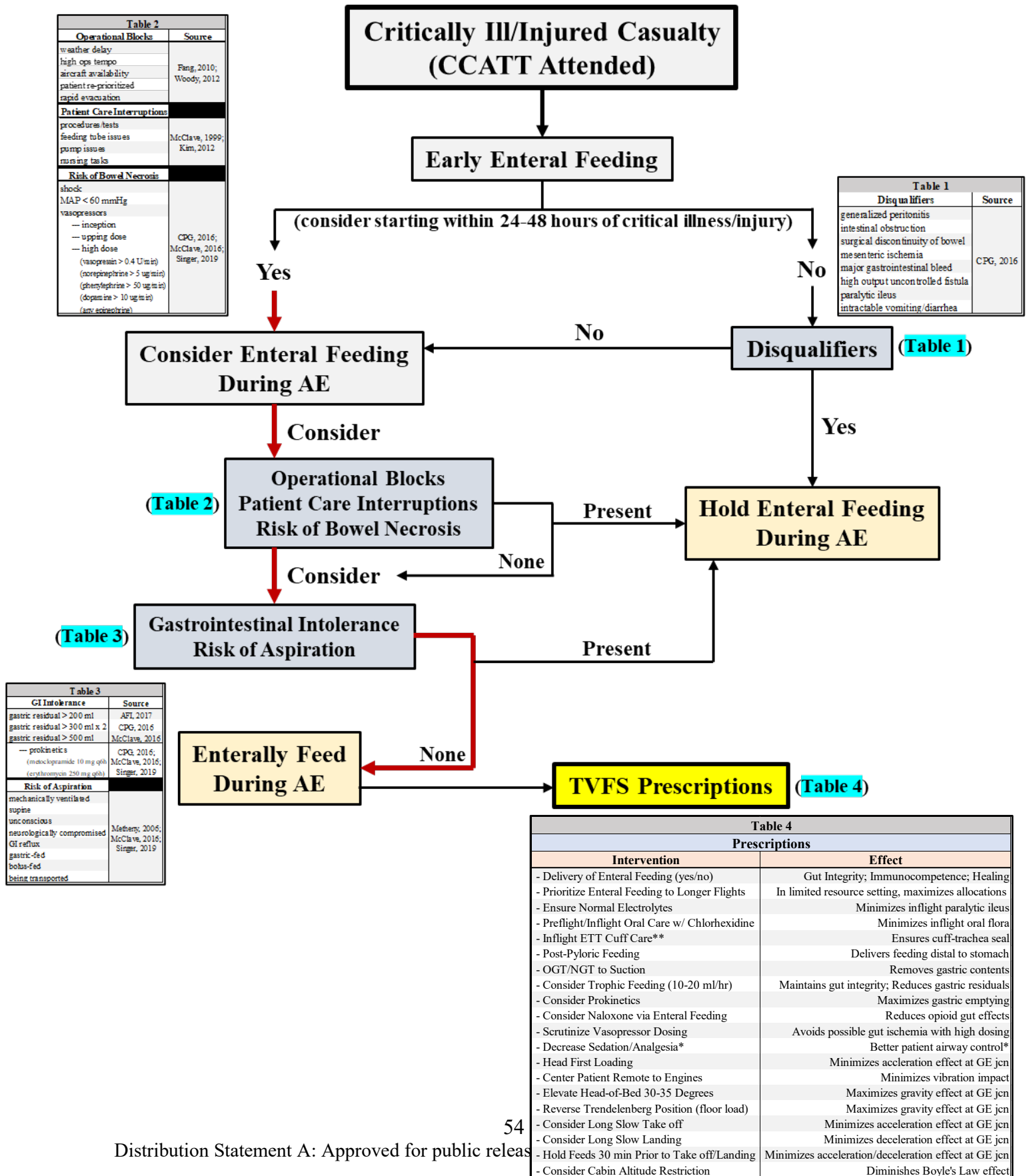
APPENDIX A --- Variables Examined

There were a large number of variables considered. Among them were 70 extracted variables and 44 derived variables. The following table fully enumerates them.

Enteral Nutrition Data Fields			
Extracted Data Fields			
Cite Number	Preflight Temperature	Postflight PaO ₂	Norepinephrine > 5 ug/min
Branch	Preflight FiO ₂	Preflight PaCO ₂	Phenylephrine > 50 ug/min
Date of Birth	Midflight Blood Pressure	Postflight PaCO ₂	Epinephrine Given
Grade	Midflight Heart Rate	Abdominal Tenderness	Enteral Nutrition Withheld - Reason
Gender	Midflight Temperature	Stool Defined	Organ System Failure
Aircraft Type	Midflight FiO ₂	Bowel Necrosis	Preflight Albumin
Battle Injury	Postflight Blood Pressure	Peritonitis	Inflight Albumin
En Route Time	Postflight Heart Rate	Surgical Discontinuity of Bowel	Postflight Albumin
Primary Diagnosis	Postflight Temperature	Paralytic Ileus	Preflight Total Protein
Secondary Diagnosis	Postflight FiO ₂	Intractable Vomiting	Postflight Total Protein
Tertiary Diagnosis	White Blood Cell Count	Intractable Diarrhea	Backrest/Head of Bed Elevation
Ventilated	Preflight Hemoglobin	Mesenteric Ischemia	Load Position
Ventilatory Type	Preflight Hematocrit	Major Gastrointestinal Bleed	Spine Precautions/Type
Tubes	Postflight Hemoglobin	High Output Uncontrolled Fistula	Immobilization
Tube Feed/Volume	Postflight Hematocrit	Paralytics Given	Cabin Altitude Restriction/Level
Bowel Sounds	Preflight pH	Vasoactives Given	Comments
Preflight Blood Pressure	Postflight pH	Vasopressin > 0.04 U/min	
Preflight Heart Rate	Preflight PaO ₂	Dopamine > 10 ug/min	
Derived Data Fields			
Year	Tube Feed Amount	Postflight Systolic	Norepinephrine (dose)
Day	Tube Feed Type	Postflight Diastolic	Phenylephrine (yes/no)
Theater	Extra Abdominal Exam	Postflight Temperature (F)	Phenylephrine (dose)
Age at Injury	Bowel Sounds (yes/no)	Bowel Status	Enteral Nutrition Held (yes/no)
Primary System	Abdominal Exam	Vasopressin (yes/no)	Enteral Nutrition Held Timing
Trauma	Preflight Systolic	Vasopressin (dose)	Enteral Nutrition Held Reason
Secondary System	Preflight Diastolic	Dopamine (yes/no)	Positioning - Head/Feet First
Tertiary System	Preflight Temperature (F)	Dopamine (dose)	Positioning - Front/Rear
Extra System 1	Midflight Systolic	Dobutamine (yes/no)	Spine Precautions Specifics
Extra System 2	Midflight Diastolic	Dobutamine (dose)	Immobilization Specifics
Tube Feed (yes/no)	Midflight Temperature (F)	Norepinephrine (yes/no)	Cabin Altitude Restriction (altitude)

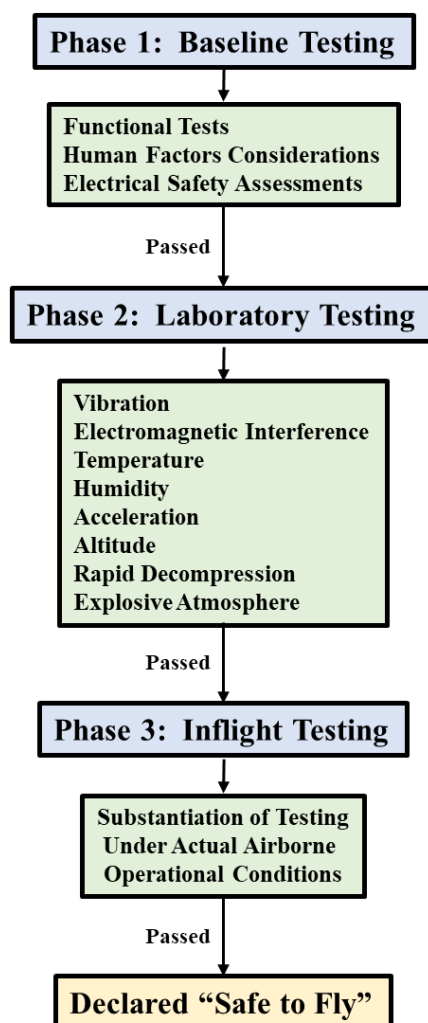
Note: O₂ (oxygen), CO₂ (carbon dioxide), FiO₂ (oxygen partial pressure of inspired air), pH (acid-base status of a solution), PaO₂ (arterial partial pressure of oxygen), PaCO₂ (arterial partial pressure of carbon dioxide), U (unit), ug (microgram), min (minute), F (Fahrenheit).

APPENDIX B --- TVFS Enteral Feeding Considerations Algorithm



APPENDIX C --- AE Equipment Waiver Request Process and Form

In order to manifest and utilize equipment for patient care during an AE flight, it must first be determined “safe to fly” (STF) via extensive testing. (Beninati, 2019) Such testing is devised and designed to determine whether or not the equipment under consideration poses an adverse risk to aircraft operations and whether or not aircraft operations pose an adverse risk to the proper function of the equipment. The testing consists of the serial application of three phases: baseline testing, laboratory testing, inflight testing. *Baseline testing* verifies the equipment operates as marketed and includes functional checks, human factors considerations, and electrical safety assessments. *Laboratory testing* places the equipment under simulated worst-case operational settings to identify potential safety concerns and/or physical/functional degradation. To this end, the equipment undergoes trials of vibration, electromagnetic interference, temperature, humidity, acceleration, altitude, rapid decompression, and explosive atmosphere. And, lastly, *inflight testing* subjects the equipment to actual operational conditions where actual airborne crewmembers substantiate the previous testing results. Successful negotiation of these three testing phases results in a “safe to fly” declaration. (Cicek, 2014) The following figure depicts this process.



The present enteral feeding pump has not undergone such testing as yet; however, it is in the queue. Until fully determined “safe to fly,” waiver for employment of the Kangaroo™ Enteral Feeding Pump must be effected.

The *in lieu of* STF waiver request is submitted by the Theater Patient Movement Requirements Center to AMC A3VM, Air Mobility Command Aeromedical Standardization/Evaluation Branch, following a medical recommendation by the TVFS. After consultation with the AE Equipment Laboratory, AMC A3VM makes a waiver determination. The Kangaroo™ Enteral Feeding Pump has been waived in the past. An example of the form to effect such a waiver is below. Interestingly, long term (aka permanent) waivers can be requested. (AFM, 2019)

1. CLASSIFICATION: UNCLASSIFIED		2. DATE PREPARED (YYYY-MM-DD): [REDACTED]		3. PAGE 1 OF 1	
4. CONTROLLER CHECKLIST TITLE AND NUMBER: A3VM WAIVER REQUEST					
ACFT TYPE: [REDACTED]		Tail Number: [REDACTED]		Mission Number: [REDACTED]	
2. Date/Time initiated: (Julian date/Zulu time) [REDACTED]					
3. Request HQ AMC/A3VM Waiver for: (i.e. one time waiver for non-approved medical equipment)				One time waiver for non-approved equipment: Kangaroo Enteral Feeding pump ePUMP	
4. Obtain/Validate the following information from the PMRC:					
A. Requestor (Name and Agency):		[REDACTED]			
B. Originating MTF / Onload Airfield:		[REDACTED]		Destination MTF / Offload Airfield: [REDACTED]	
C. Actual/Estimated mission departure: JD/Time		[REDACTED]		Leg(s) requiring wavier: 1	
D. Equipment and Model #:		Maker: Covidien Medtronic Model: Kangaroo Enteral Feeding ePump Serial#: [REDACTED]			
E. Patient Precedence:		Routine		Pt Cite Number:	
F. Attending Physician:		[REDACTED]		Validating Flt Surgeon: [REDACTED]	
EQUIPMENT QUICK REFERENCE					
Power Requirement:		9V DC			
Amperage Draw:		1.5 Amps			
Battery Charge Time:		8 Hours			
Battery Life:		15 Hours			
Oxygen Required:		N/A			
Dimension:		Size: W: 16.3cm D: 11.7 cm H: 16.8 CM weight: 2.4lbs			
5. Send written request to TACC or, if urgent, contact HQ AMC/A3VM (DSN 312-779-1578 on-call phone 618-593-0520)					
A. Person contacted (name and time):					
B. Schedule conference call with HQ AMC/A3VM & TVFS if clinical consideration required: (JD/Time)					
C. Waiver: Approved or Disapproved					
D. Date and Time approved:					
E. HQ AMC/A3VM will notify AE Cell which of the following stipulations are applicable: (Check applicable)					
I).	☒	Patient/device requires close observation.			
II).	☒	Vibration may cause inaccurate readings. Further, the device may generate low radio frequency energy and cause interference to radio communications.			
III).	☒	MCD will confirm that the device will run on 110-120V 60Hz and interface with Avionics/Unitron Frequency Converter. NOTE: The internal battery Must Be Fully Charged prior to flight/use.			
IV).	☒	MCD will brief the A/C on use of this device and the product will be turned-off if interference to avionics system is experienced.			
V).	☒	Patient will not be seated near major avionics systems.			
VI).	☒	Please provide the MCD with the following instructional information on equipment: Copies of user guide information will be provided to the MCD			
VII).	☒	MCD will complete DD Form 2852 (Near Miss Form) and forward IAW AFI 11-2AE Volume 3.			
6. Contact requesting agency and inform of approval or disapproval and any stipulations:					
7. Send completed QRC to requesting agency and HQ AMC/A3VM org boxes:					
8. Update XOZ and XOCG AE DO of waiver approval/disapproval for their awareness:				N/A	
9. Update XOZ electronic waiver log, file in IMR, and document all actions in AE Notepad:				N/A	
10. Checklist completed by: (Name/JD/Zulu time)					
5. REFERENCES H:/XOPA/XOPAC/QRC AE5 A3VM Waiver Request ANNUAL REVIEW/UPDATED 16 Dec 2016/Kootstra				6. CLASSIFICATION UNCLASSIFIED	

LIST of ABBREVIATIONS and ACRONYMS

A3VM	Aeromedical Standardization/Evaluation Branch (within AMC)
AE	aeromedical evacuation (tactical and strategic); usually regulated, fixed wing
AF	Air Force
AF Form 3899L	Air Force Form 3899-Long, <i>Patient Movement Record En Route Critical Care</i>
AFRICOM	Africa Command
AMC	Air Mobility Command
AMC/SG	Air Mobility Command Surgeon General
APACHE II	Acute Physiology and Chronic Health Evaluation mortality risk score system
Aug	August
BI	Battle Injury
bid	twice daily (<i>bis in die</i>)
C-Collar	cervical collar
CAR	cabin altitude restriction
CCAT	Critical Care Air Transport
CCATT	Critical Care Air Transport Team
CENTCOM	Central Command
CINAHL	Cumulative Index to Nursing and Allied Health Literature
cm	centimeter
cm H₂O	pressure in centimeters of water
CO₂	carbon dioxide
CONUS	Continental United States
CPG	Clinical Practice Guideline

dl	deciliter
DNBI	Disease, Non-Battle Injury
EN	Enterally Fed group; enteral nutrition
ERCC	En Route Critical Care
ETT	endotracheal tube
EUCOM	European Command
F	temperature in degrees Fahrenheit
FiO₂	oxygen fraction of inspired air
g	gram
GE	gastroesophageal
H₂O	water
HALO	medical device for stabilizing the cervical spine
Hg	mercury
hr(s)	hour(s)
ICU	Intensive Care Unit
IED	improvised explosive device
INDOPACOM	Indo-Pacific Command
jcn	junction
JTS	Joint Trauma System
JTS/CPG	Joint Trauma System Clinical Practice Guideline
2010 JTS/CPG	2010 Joint Trauma System Clinical Practice Guideline for nutrition support
2012 JTS/CPG	2012 Joint Trauma System Clinical Practice Guideline for nutrition support
2016 JTS/CPG	2016 Joint Trauma System Clinical Practice Guideline for nutrition support

Jun	June
kcal	kilocalorie
kg	kilogram
KUB	“ <u>K</u> idney- <u>U</u> reter- <u>B</u> ladder” abdominal x-ray
M	mean
MAP	mean arterial pressure
Mar	March
mg	milligram
min	minute
ml	milliliter
mm	millimeter
mmHg	pressure in millimeters of mercury
n	number
NGT	nasogastric tube
No EN	Not Enterally Fed group
NORTHCOM	Northern Command
NPO	<i>non per os</i> or <i>nil per os</i> (aka nothing by mouth)
NRS 2002	Nutrition Risk Screening 2002 risk assessment scoring system
NUTRIC	Nutrition Risk in the Critically Ill risk assessment scoring system
O₂	oxygen
OGT	orogastric tube
OSL	oversize litter
PaCO₂	partial pressure of arterial carbon dioxide (mmHg)

PACOM	Pacific Command
PaO₂	partial pressure of arterial oxygen (mmHg)
pH	“power of hydrogen,” denotes acid-base status of a solution (pH = 7 = neutral)
PRISMA	Preferred Reporting Items for Systemic Reviews and Meta-Analyses
q6h	dosed every 6 hours
SD	standard deviation
SG	Surgeon General
SOFA	Sequential Organ Failure Assessment mortality risk score system
SOUTHCOM	Southern Command
SpO₂	percent oxygen saturation of hemoglobin by pulse oximetry
STF	safe to fly
TMDS	Theater Medical Data Store
TRAC²ES	TRANSCOM Regulating and Command and Control Evacuation System
TRANSCOM	Transportation Command
TVFS	Theater Validating Flight Surgeon
U	unit
ug	microgram
US	United States
w/	with
~	approximately
>	greater than
<	less than
%	percent
™	trademark designator