Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Safety and efficacy of intraoperative gastric feeding during burn surgery

Heather Carmichael [a], *Stephanie Joyce* [a], *Tyler Smith* [a], *Lacey Patton* [b], *Anne Lambert Wagner* [c], *Arek J. Wiktor* [c,*]

[a] *University of Colorado, United States*
[b] *University of Colorado Hospital, United States*
[c] *University of Colorado School of Medicine, United States*

ARTICLE INFO

Article history:
Accepted 13 December 2018

Keywords:
Enteral nutrition
Burn injury
Mechanical ventilation

ABSTRACT

Background: Large burns are associated with a dramatic increase in metabolic demand, and adequate nutrition is vital to prevent poor wound healing and septic complications. However, enteral nutrition (EN) support is frequently withheld perioperatively, risking nutritional deficits. We retrospectively examined the safety and feasibility of continuing EN during surgery in patients with an established airway, and estimated the impact of perioperative fasting on overall caloric intake.

Methods: Mechanically ventilated patients admitted to our urban, verified burn center between January 2012 and July 2017 with greater than 20% total body surface area (TBSA) burns were included in this retrospective analysis. The total volume of EN received by the patient during each 24-h period and goal EN volume as determined by a clinical dietitian were collected.

Results: A total of 45 patients met criteria with mean TBSA of 44% (range 20–84%). Most patients had a gastric feeding tube (86%). Each patient underwent a median of 4 operations (range 1–33) for a total of 249 operative days and 991 non-operative days. There were no aspiration events. On non-operative days, patients met 85% of estimated caloric needs. EN was held on 170 operative days (69%), and on these days, only 34% of total caloric needs were met. EN was continued on 77 operative days (31%), and on these days, 95% of total caloric needs were met ($p < 0.001$). Patients who had EN held for at least 50% of operative procedures ($n = 30$) met only 69% of caloric goals while intubated. By comparison, patients who had EN continued for a majority of procedures ($n = 15$) met 81% of caloric goals ($p = 0.002$).

Conclusions: Continuing EN intraoperatively in patients with an established airway appears to be a safe and efficacious way to meet patients' nutritional needs, including when feeding is delivered via a gastric route. This is particularly important given that placement of nasojejunal feeding tubes can be difficult, particularly in resource-poor settings where endoscopic or fluoroscopic-guided placement may not be practical.

* *Corresponding author at*: 12631 E 17th Ave., C305, Aurora, CO 80045, United States.
E-mail addresses: heather.carmichael@ucdenver.edu (H. Carmichael), stephanie.joyce@mainegeneral.org (S. Joyce), tyler.2.smith@ucdenver.edu (T. Smith), lacey.patton@uchealth.org (L. Patton), anne.wagner@uchealth.org (A. Lambert Wagner), arek.wiktor@ucdenver.edu (A.J. Wiktor).

https://doi.org/10.1016/j.burns.2018.12.009
0305-4179/

1. Background

Thermal injuries are associated with the greatest metabolic demand of all critical illness [1]. The result can be an increase in basal metabolic rate up to two-fold, which can rapidly lead to malnutrition, impaired immunity, and delayed wound healing [2,3]. Early enteral nutrition (EN) in critically ill patients improves wound healing rates, reduces length of stay and reduces septic complications [4]. Overall intensive care unit and in-hospital mortality are also decreased significantly [5]. Guidelines from multiple societies including the International Society for Burn Injury (ISBI), Society of Critical Care Medicine (SCCM), and both the American and European Societies for Parenteral and Enteral Nutrition (ASPEN and ESPEN) all recommend nutritional support for patients with greater than 20% total body surface area (TBSA) burns [6–8]. EN should be initiated early in the patient's hospital course, preferably within the first 24 h, and then advanced to a goal rate. Achieving at least 80% of goal calories has been set as a benchmark for adequate nutrition and optimal outcomes [7].

Unfortunately, despite the recognized importance of adequate nutrition in thermal injury, many barriers exist to achieving nutrition goals for calorie and protein intake. Perhaps the most significant barrier to achieving nutritional goals is the practice of holding EN prior to, during, and occasionally after operative procedures. Discontinuing enteral nutrition at midnight prior to diagnostic tests or procedures accounts for more than 25% of EN cessation time, and feeding can be delayed for up to 24 h each time a surgical procedure is planned [9]. Burn patients, especially those who are mechanically ventilated and undergo multiple operative procedures, can quickly develop substantial energy and protein deficits [3].

There is sparse literature addressing the safety of intraoperative feeding during operative procedures when patients are intubated or have a tracheostomy. A handful of prior studies have addressed this question, but all have focused on patients with confirmed post-pyloric feeding access [10–12]. All previous studies found that post-pyloric feeding was safe for these patients, without any evidence of intraoperative aspiration events. Indeed, guidelines from the Eastern Association for the Surgery of Trauma (EAST) recommend that EN be continued via a nasojejunal feeding tube intraoperatively in intubated patients who undergo frequent debridement [13]. However, placement of nasojejunal feeding tubes at the bedside is difficult, with less than one-third of blindly placed tubes passing spontaneously through the pylorus [14]. Although endoscopic or fluoroscopic placement is more successful, these techniques are not universally available, particularly in resource-poor settings [15].

Our goals in this study were two-fold. First, we sought to evaluate the safety of continuing EN through operative interventions, including patients with nasogastric enteral access. Second, we wanted to establish whether caloric deficits occur when tube feeds are held prior to operative interventions, and quantify the extent of this deficit.

2. Methods

This was a retrospective study of patients admitted to our urban, American Burn Association verified burn unit between the years 2012–2017 who had sustained greater than 20% TBSA burns and had been intubated at some point during their hospital course. Eligible patients were identified from our burn unit census and national burn repository data. Patients who were never intubated or who were extubated prior to the time of their first operative procedure were not included. Patients younger than 18 years of age were also excluded from the study. Additionally, patients who were admitted to the burn unit for toxic epidermal necrolysis, Stevens-Johnson syndrome, necrotizing soft tissue infections, electrical burns and chemical burns were excluded from the study. Patients who received total parenteral nutrition were also excluded.

During this time period, our practice was to initiate EN support in all patients with greater than 20% TBSA burn. A nasogastric or post-pyloric feeding tube was placed within 24 h of admission and EN was initiated at that time. Feeds were initiated at a rate of 10–25 mL per hour and typically advanced by 25 mL every 4–6 h until a goal rate was achieved. The clinical dietitian calculated an initial goal rate using a formula that incorporates TBSA of the burn, and this was subsequently adjusted using an indirect calorimetry study if the patient received prolonged EN.

Operative procedures were defined as any procedure requiring the patient to be taken to the operating room, and included burn debridement, reconstructive skin grafting procedures, and airway procedures, amongst others. Prior to operative procedures, EN was always held for cases involving the airway (i.e. tracheostomy) as well as for procedures with prone positioning. If the operative positioning was supine, the decision to hold EN was made at the discretion of the operating surgeon and attending anesthesiologist. When EN was held, this generally occurred at least 6 h prior to the planned surgical procedure (typically at 1:30 AM). Because the decision to hold EN was made at the discretion of the operating surgeon, there was significant practice variability during the study time period with regard to continuation of enteral nutrition in the operating room.

A retrospective chart review was conducted, with variables collected including age, sex, percent TBSA burned, cause of burn, length of stay, number of ventilator days, mortality, and aspiration events during operative procedures. Aspiration events were defined as the following: (1) if enteric contents or tube feeds were suctioned from the endotracheal tube by flexible suction catheter during the procedure or (2) if there was evidence of regurgitation that coincided with an acute change in oxygenation or ventilator status, as documented by the anesthesiologist.

Clinical dietitian notes were reviewed to find the estimated daily caloric delivery and goal rate for continuous tube feeds for each patient as well as type of formula recommended. Radiology reports were reviewed to determine the type and positioning of the feeding tube used. Nursing documentation was reviewed to calculate the total volume of charted tube feeds given during each day that the patient was intubated and ventilated. Medication volume, tube patency flushes, and free water were excluded from these totals. Daily volume was calculated as a percentage of the goal volume for each 24-h period. Chart review continued until the day of extubation, or, if the patient underwent tracheostomy, until the day when the patient was noted in the record to be successfully weaned off of

ventilatory support. Chart review was also discontinued if the patient was transitioned to cycled tube feeds. Nursing documentation was also reviewed on each operative day to determine if EN was held prior to the operation or continued through the procedure.

Because multiple attending surgeons cared for patients in the study, many patients had EN continued for some operative procedures and held for some operative procedures. Thus, the patients who had EN continued for at least 50% of all surgical procedures ("a majority of procedures") were compared to those where EN was held prior to more than half of all procedures. This comparison was made to get a global sense of the impact that holding EN during operative procedures had on patients' overall caloric intake during the study period.

Data was compiled using Microsoft Excel 2010. The R Project for Statistical computing was used for all data analysis. Unpaired t-tests were used for comparison statistics, with a p-value of less than 0.05 representing significance. When comparing proportions, a chi-square test was used except where the prevalence was less than 5%, in which case a Fisher's exact test was used.

3. Results

A total of 75 patients were identified in our burn repository data who had sustained greater than 20% TBSA burns and had been intubated during their hospital course. Three patients were excluded due to age less than 18 years at the time of admission. Further chart review indicated that 24 patients had been extubated prior to undergoing any procedure, and these patients were also excluded. An additional three patients were noted to have toxic epidermal necrolysis, Stevens-Johnson syndrome, or necrotizing soft tissue infections and were excluded. This left a total of 45 patients included in the final analysis.

Of these included patients, 33 were male and 12 were female. Median age was 43 years with range 18–65. Patients included in the study had a mean TBSA of 44% (range 20–84%). Median length of stay was 48 days (range 5–340) and number of ventilated days was 13 (range 3–234).

The majority of patients had a gastric feeding tube for the entire period studied (n=39, 86%). In the majority of cases this was a small-bore, flexible feeding tube. All other patients had a post-pyloric tube (n=3, 7%) or were transitioned to a post-pyloric tube during the period when they were intubated (n=3, 7%). (Fig. 1). Each patient underwent a median of 4 operative procedures (range 1–33) during the time that they were intubated, for a total of 249 operative days and a total of 991 non-operative days. Importantly, there were no documented aspiration events during any of the operative procedures reviewed.

Overall, patients received significantly more nutrition on non-operative days as compared to operative days, meeting 85% versus 53% of their estimated caloric needs ($p < 0.001$). Nutrition was held on 170 operative days (69%), and on these days, only 34% of total caloric needs were met. By comparison, EN was continued through the procedure on 77 operative days (31%) and on these days, 95% of total caloric needs were met (see Table 1).

Patients were further stratified into those who had EN held for more than 50% of procedures (n=30) or had EN continued for at least 50% of procedures while intubated (n=15). There were no statistically significant differences in baseline demographics or TBSA burned between these groups (see Table 2, Fig. 2). Patients who had nutrition held for a majority of procedures met only 69% of overall caloric goals during the time that they were mechanically ventilated. By comparison, patients who had nutrition continued for a majority of procedures met 81% of caloric goals (p=0.002). There was a trend towards longer overall length of stay and number of ventilator days in the group where tube feeds were held, although this was not statistically significant. A small subset of patients (n=4) had EN continued through all operations. These patients on average met 82.9% of overall caloric goals. Comparatively, patients who had EN held for all procedures (n=15) met only 58.7% of caloric goals (p=0.011).

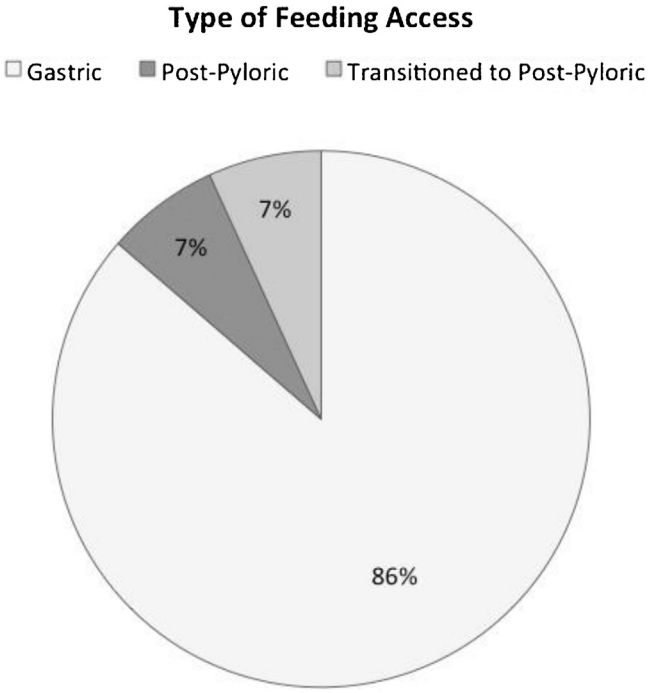

Fig. 1 – Distribution of type of feeding access for delivery of enteral nutrition.

4. Discussion

ontinuing EN during operative procedures is not only safe, but is beneficial to mechanically ventilated burn patients. There were no documented intraoperative aspiration events, even in cases where EN was continued intraoperatively. Furthermore, because of the frequency of procedures in this patient population, holding tube feeds during the perioperative periods has a demonstrable impact on the overall nutrition received by patients. In this study, patients who had tube feeds continued for at least half of their operations while intubated were able to meet at least 80% of their total caloric goals, thus meeting benchmarks for nutrition in burn patients according to current guidelines [7]. Comparatively, patients who had EN withheld during the perioperative period only met 69% of overall caloric goals while intubated.

Table 1 – Comparison of percent of caloric goals achieved for all patients on operative days versus non-operative days.

	Non-operative days	Operative days	P-value
Number of days	991	249	
Percent total caloric goals received (mean (sd))	85.1 (31.9)	52.7 (33.5)	<0.001*
	EN held prior to operation	EN continued during operation	
Number of days	172	77	
Percent total caloric goals received (mean (sd))	34.0 (20.0)	94.6 (13.9)	<0.001*

Table 2 – Comparison of patients who received EN during a majority of operations versus those who had EN held for a majority of operations.

	Continued for ≥50% of operations	Held for >50% of operations	P-value
Number of patients	15	30	
Age (mean (sd))	37 (17)	41 (14)	0.39
Sex=male (%)	10 (67)	23 (77)	0.72
% TBSA (mean (sd))	41 (13)	46 (18)	0.35
Ventilator days (mean (sd))	24 (45)	42 (55)	0.29
Length of stay (mean (sd))	59 (82)	86 (90)	0.36
Average percent of caloric needs met on operative days (mean (sd))	77 (15)	42 (17)	<0.001*
Average percent of caloric needs met on non-operative days (mean (sd))	82 (9)	77 (17)	0.23
Average percent of caloric needs met overall (mean (sd))	81 (9)	69 (15)	0.01*

*P<0.05 was considered significant.

While prior studies have also shown that the practice of perioperative feeding in mechanically ventilated patients is safe, to our knowledge this study is unique in that the majority of feeding tubes used were gastric as opposed to post-pyloric. Varon et al. considered outcomes after implementation of a protocol where patients with severe burn injuries underwent post-pyloric placement of an enteral feeding tube with initiation of tube feeds within 24 h of injury. EN was continued through all operative procedures that did not involve the airway for patients who were intubated or who had previously undergone tracheostomy. They considered outcomes before and after the implementation of this protocol and found no differences in rates of pneumonia or mortality, and there were no clinical aspiration events in either population. Moreover, patients who received tube feeds during operative procedures achieved a greater percent of their caloric needs (98% vs. 70%) [12]. Similarly, Jenkins et al. examined the safety and efficacy of continuing EN during operative procedures in a randomized control trial using post-pyloric feeding tubes and found no clinical aspiration events or difference in rates of pneumonia [10].

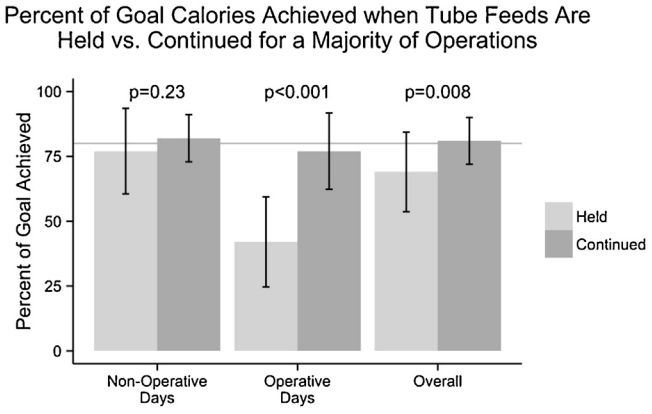

Fig. 2 – Comparison of percent of goal calories achieved by patients who had tube feeds held versus continued for a majority of operations.

Overall, rates of achieving caloric goals were low in this study as compared to the previous studies mentioned. Even on non-operative days, patients met only 85% of caloric goals. Prior studies have shown that stricter protocols can increase chances of meeting EN caloric goals [16]. Varon et al. were able to reach 98% of caloric goals in patients who were fed intraoperatively, likely because they instituted a specific protocol [12]. EN protocols can help increase the chances of reaching nutrition goals, but even with protocols in place, feeding is often interrupted. One large retrospective study found that even with a robust EN protocol in place, only half of patients met an 80% goal, with disruptions due to CT scans, procedures, lack of compliance with the protocol, and increases in gastric residual volumes [16]. Indeed, cessation of EN occurs in over 85% of patients for an average of 8-20% of the infusion time [9].

Since conducting this retrospective review, our burn center has revised our protocol to include continuing EN during operative procedures for all patients who are intubated or who have undergone tracheostomy, regardless of positioning of the enteral feeding tube. This practice has also been adopted in our surgical trauma intensive care unit. When EN is held, we have transitioned to a volume-based re-feeding protocol, which

allows for recuperation of calorie deficits accumulated during the subsequent 48-h period.

A clear limitation of this study is its retrospective nature. Furthermore, because we examined patients during a time there was no strict protocol regarding intraoperative feeding, most patients had both operative interventions where tube feeds were continued and operative interventions where tube feeds were held. This precluded strict division of patients into groups where tube feeds were continued or held, as has been done in prior studies. Because of this, we elected to divide patients into groups of those who had EN continued for more than 50% of operative procedures or held for at least 50% of operative procedures. We recognize that this is a limitation of our data that could lead to bias in our analysis. When the small groups of patients who had EN either continued or held for all operations were examined, we found an even more extreme difference between percentages of caloric goals achieved (83% versus 59%, p=0.011).

Further research is required to evaluate the safety of intraoperative feeding in patients who are placed in a prone position during operations, as well as the safety of post-pyloric intraoperative feeding in patients who are not intubated. We believe that these practices are likely also safe, and could achieve improved nutritional outcomes and better long-term patient results.

Author contributions

Heather Carmichael contributed to the literature search, data collection, data analysis and interpretation, writing and critical revision. Stephanie Joyce contributed to study design, data collection, data interpretation and critical revision. Tyler Smith contributed to data collection, data analysis, and critical revision. Lacey Patton contributed to study design, data collection, and critical revision. Anne Lambert Wagner contributed to study design, data interpretation, and critical revision. Arek Wiktor contributed to study design, data interpretation, writing and critical revision.

Conflicts of interest

The authors have no conflicts of interest to declare. This work was presented at the American Burn Association 2018 Annual Meeting in Chicago, IL.

Funding

There is no external funding source for the work presented. All authors are salaried at their respective institutions.

REFERENCES

[1] Rodriguez NA, Jeschke MG, Williams FN, Kamolz L-P, Herndon DN. Nutrition in burns. J Parenter Enteral Nutr 2011;35:704–14, doi:http://dx.doi.org/10.1177/0148607111417446.

[2] Shields BA, Doty KA, Chung KK, Wade CE, Aden JK, Wolf SE. Determination of resting energy expenditure after severe burn. J Burn Care Res 2013;34:e22–8, doi:http://dx.doi.org/10.1097/BCR.0b013e318254d2d5.

[3] Czapran A, Headdon W, Deane AM, Lange K, Chapman MJ, Heyland DK. International observational study of nutritional support in mechanically ventilated patients following burn injury. Burns 2015;41:510–518, doi:http://dx.doi.org/10.1016/j.burns.2014.09.013.

[4] Shields BA, Brown JN, Aden JK, Salgueiro M, Mann-Salinas EA, Chung KK. A pilot review of gradual versus goal re-initiation of enteral nutrition after burn surgery in the hemodynamically stable patient. Burns 2014;40:1587–92, doi:http://dx.doi.org/10.1016/j.burns.2014.02.015.

[5] Artinian V, Krayem H, DiGiovine B. Effects of early enteral feeding on the outcome of critically ill mechanically ventilated medical patients. Chest 2006;129:960–7, doi:http://dx.doi.org/10.1378/chest.129.4.960.

[6] Prelack K, Dylewski M, Sheridan RL. Practical guidelines for nutritional management of burn injury and recovery. Burns 2007;33:14–24, doi:http://dx.doi.org/10.1016/j.burns.2006.06.014.

[7] McClave SA, Taylor BE, Martindale RG, Warren MM, Johnson DR, Braunschweig C, et al. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.). J Parenter Enteral Nutr 2016;40:159–211, doi:http://dx.doi.org/10.1177/0148607115621863.

[8] Rousseau AF, Losser MR, Ichai C, Berger MM. ESPEN endorsed recommendations: nutritional therapy in major burns. Clin Nutr 2013;32:497–502, doi:http://dx.doi.org/10.1016/j.clnu.2013.02.012.

[9] Taylor BE, McClave SA, Martindale RG, Warren MM, Johnson DR, Braunschweig C, et al. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient. Crit Care Med 2016;44:390–438, doi:http://dx.doi.org/10.1097/CCM.0000000000001525.

[10] Jenkins ME, Gottschlich MM, Warden GD. Enteral feeding during operative procedures in thermal injuries. J Burn Care Rehabil 1994;15:199–205.

[11] Hemington-Gorse SJ, Sheppard NN, Martin R, Shelley O, Philp B, Dziewulski P. The use of the Cortrak Enteral Access System™ for post-pyloric (PP) feeding tube placement in a Burns Intensive Care Unit. Burns 2011;37:277–80, doi:http://dx.doi.org/10.1016/j.burns.2010.07.011.

[12] Varon DE, Freitas G, Goel N, Wall J, Bharadia D, Sisk E, et al. Intraoperative feeding improves calorie and protein delivery in acute burn patients. J Burn Care Res 2017, doi:http://dx.doi.org/10.1097/BCR.0000000000000514.

[13] Jacobs DG, Jacobs DO, Kudsk KA, Moore FA, Oswanski MF, Poole GV, et al. Practice management guidelines for nutritional support of the trauma patient. J Trauma 2004;57:660–78 discussion 679.

[14] Rees RGP, Payne-James JJ, King C, Silk DBA. Spontaneous transpyloric passage and performance of fine bore polyurethane feeding tubes: a controlled clinical trial. J Parenter Enteral Nutr 1988;12:469–72, doi:http://dx.doi.org/10.1177/0148607188012005469.

[15] Foote JA, Kemmeter PR, Prichard PA, Baker RS, Paauw JD, Gawel JC, et al. A randomized trial of endoscopic and fluoroscopic placement of postpyloric feeding tubes in critically ill patients. J Parenter Enteral Nutr 2004;28:154–7, doi:http://dx.doi.org/10.1177/0148607104028003154.

[16] Binnekade J, Tepaske R, Bruynzeel P, Mathus-Vliegen E, de Hann R. Daily enteral feeding practice on the ICU: attainment of goals and interfering factors. Crit Care 2005;9:R218, doi:http://dx.doi.org/10.1186/cc3504.