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Part III Jejunal Enteral Feeding: The Tail is Wagging the Dog(ma)

Dispelling Myths with Physiology, Evidence, and Clinical Experience

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Jejunal feeding is the next best option for patients who cannot tolerate gastric feedings and would otherwise be placed on parenteral nutrition. Yet, it remains beleaguered by dogmatic rules with very little substantiating evidence or conformity with physiology. Part III of this enteral series serves to dispel some of the long-standing myths that are still widely practiced today and result in unsuccessful jejunal feeding.

Already Published or Upcoming in this Series:

- **Part I Enteral Feeding Barriers: Pesky Bowel Sounds & Gastric Residual Volumes**
- **Part II Enteral Feeding: Eradicate Barriers with Root Cause Analysis and Focused Intervention**
- **Part IV Enteral Feeding: Hydrating the Enterally-Fed Patient – It Isn't Rocket Science**

INTRODUCTION

Since the first documented feeding via jejunostomy in the late 19th century, jejunal feedings (JF) have become a viable and common route for enteral nutrition (EN) in many patients for reasons ranging from GI obstructions, to necrotizing pancreatitis, to high aspiration risk.

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At the same time, certain "rules" regarding JF have arisen and taken on the force of dogma without rigorous evidence or regard for our understanding of gastrointestinal physiology. Examples of such dogma include:

1. Only elemental EN can be used
2. Only isotonic formulas can be used
3. JF causes diarrhea

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4. JF cannot infuse over 80-100mL/hr or via bolus or gravity drip
5. Residuals from a J-tube should be routinely checked
6. Water flushes over 100mL cause necrotic bowel

These types of rules often prevent our JF patients from receiving optimal, or even adequate, nutrition. The purpose of this article is to review the literature, gastrointestinal physiology, and clinical experience that lead us to question many of these long-standing conventions and dispel the mysticism surrounding JF.

Indications for Jejunal Feeding and Types of J-Tubes

"In some circumstances, the evidence for jejunal over gastric feeding is questionable, but the reality is that there are times when JF is needed simply because gastric feeding is just not working (Table 1). As Table 2 notes, each type of J-tube carries its own set of specifications. Bear in mind that any tube that originates in the jejunum or is threaded through the stomach into the jejunum can migrate into the stomach, leading to complications."

At our institution, if long term access is required, we often use percutaneous endoscopic gastrostomy-jejunostomy (PEG-J) tubes where the PEG is strategically placed in the lower antrum facing the pylorus. This reduces the length of the J-arm traversing through the stomach, thereby minimizing the risk for coiling and migration back into the stomach. We also use 24-Fr PEGs to accommodate a 12-Fr J-arm (largest J-arm on the market). PEGs < 24-Fr can only accommodate J-arms ≤ 10-Fr, which clog much more easily. In addition, we use nasojejunal or orojejunal tubes in ICU patients who need to be fed post-pylorically over the short-term, but these frequently coil and/or migrate back into the stomach. NG-Js are theoretically a good approach, but we have not had much success with these at our institution as they are prone to clogging and are uncomfortable for the patient.

A sudden onset of GI symptoms in a patient who has demonstrated tolerance of JF should call into question whether the J-tube is appropriately positioned, and an abdominal film may be necessary to determine location. If clogging of jejunal tubes or j-arms is a frequent problem in your facility, consider the size of the J-tube in use; the larger the French size, the less likely it will clog.

Table 1. Indications for Jejunal Feeding

- Severe gastroparesis (not just history of)
- Proximal enterocutaneous fistula and jejunal access possible below
- Severe acute pancreatitis
- Chronic pancreatitis (if oral intake causes ongoing abdominal pain and malnutrition)
- Gastric or proximal small bowel obstruction
- Recurrent aspirations from below the stomach (not oropharyngeal secretions or food, or a patient who fails a modified barium swallow)
- Incompetent gastroesophageal junction (e.g. scleroderma)
- Esophageal dysmotility
- Significant gastric compression for any reason – e.g. tumor, enlarged kidneys, etc.
- Intolerance of gastric feeding (see Table 6)

The next several sections address the most widespread myths about JF and present alternatives based on physiology, evidence, and clinical experience.

Myth #1: Only Elemental Formulas Can be Used

Consider the physiology first. Pancreatic enzymes are needed to break down proteins, large polysaccharides, and fat. Bile salts are also needed for fat absorption. Any functioning pancreas and biliary system will produce pancreaticobiliary secretions that will reach the jejunum (as long as there is no external drain or luminal obstruction below the site where these important secretions

Table 2. Types of Jejunal Feeding Tubes

Type	Comments
Nasojejunal / Orojejunal	• Commonly used in ICUs • Clogs easily, especially if using < 12-Fr
NG-J	• Salem sump type tube with jejunal extension ○ Uncomfortable for patients over the long-term • J-tube extension is < 10-Fr, leading to frequent clogs
PEG-J / Jet-PEG	• Place PEG in lower antrum to the right of spine • Use 24-Fr PEG to accommodate 12-Fr J-arm ○ If G- or J-tube clogs, only replace the clogged portion, not the entire thing
G-J Single Tube	• J-arms are < 10-Fr, leading to frequent clogging • Since it is a single tube, if either the J-portion or the G-portion clogs, the entire tube must be replaced
Direct PEJ	• More difficult to place in endoscopy • Used in those with partial/total gastric resections (jejunum is higher up)
Surgical J	• Requires OR • Costly
Fistuloclysis[17]	• Tube placed through fistula into jejunum • Need to determine if patient has enough small bowel surface area below vs. above fistula to absorb adequately • Not for short-term use or for patients whose fistula is trying to close

enter), allowing for the use of polymeric formulas, regardless of whether a patient is fed gastrically or jejunally. Even in the fasting state, the pancreas secretes enzymes at around 20% of maximal output, and bile secretions amount to roughly 620mL/day, which will enter the jejunum and help digest polymeric formulas.

Our efficiency at digesting and absorbing nutrients is supported in the literature. Hecketsweiler, et al., for example, compared elemental vs. polymeric absorption rates in JF by infusing either a 1.0 kcal/mL elemental solution (amino acids, glucose and glucose oligosaccharides), or a 1.25 kcal/mL polymeric mixture (chicken meat, egg-yolk power, soya flour, glucose, saccharose, maltose and dextrin maltose, corn and wheat oils), in 25 healthy subjects and showed that polymeric EN is absorbed within the first 105cm of the small bowel.[2] Similarly, Raimundo, et al. demonstrated near complete assimilation of carbohydrates, nitrogen, and fat in intraduodenal feeders.[3] Even in patients with total pancreatectomies, it has been shown that 60% of intact protein can still be assimilated, owing to the role of the small intestine itself in protein digestion.[4]

Myth #2: Only Isotonic Formulas Can be Used

Physiologically, whatever we eat or drink is automatically "diluted." Indeed, food or EN constitutes only a small fraction of the total contents of the gastrointestinal (GI) tract. As Table 3 shows, between saliva, gastric secretions, pancreaticobiliary secretions, and succus entericus, the average person's GI tract secretes and reabsorbs around 7 L of gastrointestinal fluid (including 3-5 L originating above the pylorus alone). These 7 L of gastrointestinal fluid will significantly dilute whatever we consume or infuse, which is usually around 2 L/day.

Even substances that are considered very

hypertonic and hyperosmotic are diluted through osmosis to achieve isotonicity once they reach the small bowel. It has been demonstrated that 50mL of a 43% glucose solution doubles in volume within 15 minutes of introduction into the small bowel.[5] Hypertonic solutions were also shown to reach isotonicity or near-isotonicity 35cm distal to the stomach when introduced gastrically, and 70cm distal to the ligament of Treitz when introduced jejunally.[1,6]

It is also worth noting that most enteral formulas have a much lower osmolality than medications, foods, and beverages that are put into the GI tract (see Table 4). Many of these hypertonic items are routinely used in the acute care setting, yet no one ever orders an isotonic clear or full liquid diet, nor to make that 8800mOsm dose of diphenoxylate and atropine suspension isotonic before giving it. So what is it about infusing EN via a feeding tube (gastric or jejunal) that changes that thinking? Futhermore, when one considers that EN infuses much slower than one could possibly eat (60mL/hr = 1mL/minute [1/5th of a teaspoon]; 120mL/hour = 2mL/minute [< ½ teaspoon]), and as soon as it leaves the ports of the feeding tube, it is mixed immediately with gastric or intestinal secretions and diluted--this inconsistency in practice is difficult to rationalize.

Table 3. Total Daily Gastrointestinal Secretions

Secretion Type	Volume (mL)
Saliva	500-1000
Gastric	2000-4000
Pancreaticobiliary	2000
Succus entericus	1000
Total	5500 – 8000

Myth #3: Jejunal Feeding Causes Diarrhea

This particular myth has been applied to both jejunal and gastric feedings alike, when in reality, diarrhea is a common complaint among hospitalized patients, regardless of whether they are receiving EN.

Because of the many factors associated with diarrhea in the hospital setting, the challenge for the clinician is that EN-associated diarrhea is a diagnosis of exclusion rather than the most likely cause. It is imperative to review the medication list for diarrheagens. Some medications, such as antibiotics, cannot be modified. Others, however, can be changed or eliminated, especially liquid preparations, which often contain sugar alcohols (sorbitol in particular) that are highly fermentable and diarrheagenic (Table 4). By de-emphasizing extraneous substances entering the gut, it will be easier to identify the root cause of the diarrhea. If medications cannot be entirely eliminated, try switching from liquid to tablet "crush and flush" or capsule preparations if available. It is also important to rule out infectious causes, such as *C. diff* (see Part II of this series). If negative, consider using an anti-diarrheal agent. It is vital that all possible reasons for diarrhea are considered before

Table 4. Osmolality of Selected Liquids and Medications

Liquid	mOsm/kg	Medication	mOsm/kg
EN formulas	250-800	Tylenol elixir	5400
Prune juice	>1000	Diphenoxylate/ atropine suspension	8800
Jello/juices	535/950	KCl elixir	3000
Popsicles	720	Lasix solution	8975
7-up/cola	640/750	Reglan	8350
Ice cream	1150	Sodium phosphate	7250
Sherbet	1225	Liquid multivitamin	5700
Meal replacement shake	715	Lactulose syrup	3600
Milk	300	Ergocalciferol liquid	16,100

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holding or reducing JF so that the patient not only continues to meet nutrition needs, but also receives appropriate treatment for the root cause.

Myth #4: JF Cannot Infuse Over 80-100mL/hr or via Bolus or Gravity Drip.

The clinical prohibition on high EN infusion rates into the jejunum is widespread, but it is

Table 5. History of Documented Bolus and High-Rate Jejunal Feedings in the Literature

Year	Author(s)	Remarks
1885	Golding-Bird[18]	Patient with pyloric obstruction fed 300mL boluses via jejunostomy
1902	Moynihan[19]	Starts JF at "only 180mL," but after a few days, "up to 480mL may be given over 10 minutes"
1929	Kirshner[20]	60 patients fed jejunally on a formula of whole milk, cream of wheat, maltose, dextrin, cream, and salt divided into meals at a rate of 100mL over 3 minutes for a total daily volume of 2 L
1931	Scott, et al.[21]	3 patients given a "pabulum" initially at 200mL over 30-40 min and advancing to a rate of 500-600mL/hr over 1-3 weeks' time
1935	Wolfer[22]	Administers feedings of 500-600mL over 15-30 minutes every hour for a total daily allotment of 3000-3600mL
1941	Clute, et al.[23]	Feeds advanced from 50mL/hr to 100mL/hr within the first 24-48 hours; on the 3rd day, feeds advanced to 2-3L over 24 hours on top of upper GI secretions reintroduced following aspiration
1943	Colp, et al.[24]	51 patients with recurrent peptic ulcers fed "Scott-Ivy Pabulum" with a total daily volume of 3450mL on top of vitamins and in some cases reintroduced Levin tube drainage
1949	Hollander, et al.[7]	17-yr-old male with "cardiospasm" started on JF at 200mL/hr and advanced to 300mL/hr over 10 months. Thereafter, the patient requested a gradual increase in rate to ~700mL/hr. It occasionally ran as high as 2000mL/hr for one single feeding. The patient's weight increased from 70 to 116 lb, and he routinely had 1-2 stools daily.
1949	Case, et al.[25]	Formula of whole milk, vi-syneral, protein hydrolysate, starch hydrolysate, and pureed liver given at 200mL over 2 hrs with a total volume of 3 L over 24 hours "tolerated by many patients"
1952	Fallis, et al.[26]	"Many patients" given a formula at 200-300mL/hr
1952	Boles, et al.[27]	Administer 1500-2000mL of formula (homogenized milk, starch hydrolysate, protein hydrolysate, vitamins, potassium salts, and bile if needed) via asepto syringes starting at 50mL/hr on day 1 and advancing to 200mL/hr until 1500-2000mL infused by day 3.
1985	Rumley, et al.[28]	11 out of 12 patients with unresectable upper GI malignancies and J-tube placement tolerate bolus feedings of Osmolite at 125-300mL/hr every 1-2 hours for a total of 800-2000 kcal/day.
1993	Kandil, et al.[29]	5 healthy volunteers given standard polymeric formula via nasoduodenal infusion at an average rate of 275mL/hr (range of 198-340mL/hr providing 5000-8650 kcal/day).

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unclear where this recommendation originated. Physiologically, it is worth noting that patients with a total gastrectomy in which the esophagus is anastomosed directly to the jejunum essentially "bolus" their jejunum every time they eat or drink (Figure 1). In a retrospective study of total gastrectomy patients, Jang et al. recently compared early post-op feeding (oral day 1 with clears then soft diet) vs conventional post-op feeding (after passing flatus). They found that the early-fed group had significantly earlier time to first flatus and shorter hospital stay with no difference in morbidity and mortality compared to the conventionally fed group.[7] Now one might ask what does this have to do with jejunal feeding via a pump over time through a tube, and we would answer: if patients can eat and drink regular diets early after stomach removal, all of which drops directly into their jejunum, why would jejunal feedings delivered at rates of 2-3mL/minute (120-150mL over an hour) be embarked upon with such caution (or not at all)? Bolus feeding of a regular diet would surely be a greater physiologic stressor to the jejunum than a few mL per minute of enteral feeding.

Historically, there are numerous early case reports that describe both bolus JF and rates well over 100mL/hr using various recipes (Table 5). Perhaps most remarkably, in 1949, Hollander, et al. described a 17-year-old male who was fed jejunally at a routine rate of 700mL/hr. The rate was occasionally increased to as high as 2000mL/hr (this is NOT a typo), for a single feeding at the patient's request, but this sometimes resulted in "abdominal discomfort, slight nausea, headache, and a diffuse feeling of warmth."[8]

In our own experience, we have had numerous cases at our institution in which patients have tolerated bolus or high-rate JF:

- Case 1: 48-year-old male admitted for severe necrotizing pancreatitis s/p PEG-J and started on Vivonex @ 110mL/hr from 0600 until 8 cans

Figure 1. Total Gastrectomy—esophago-jejunostomy anastomosis

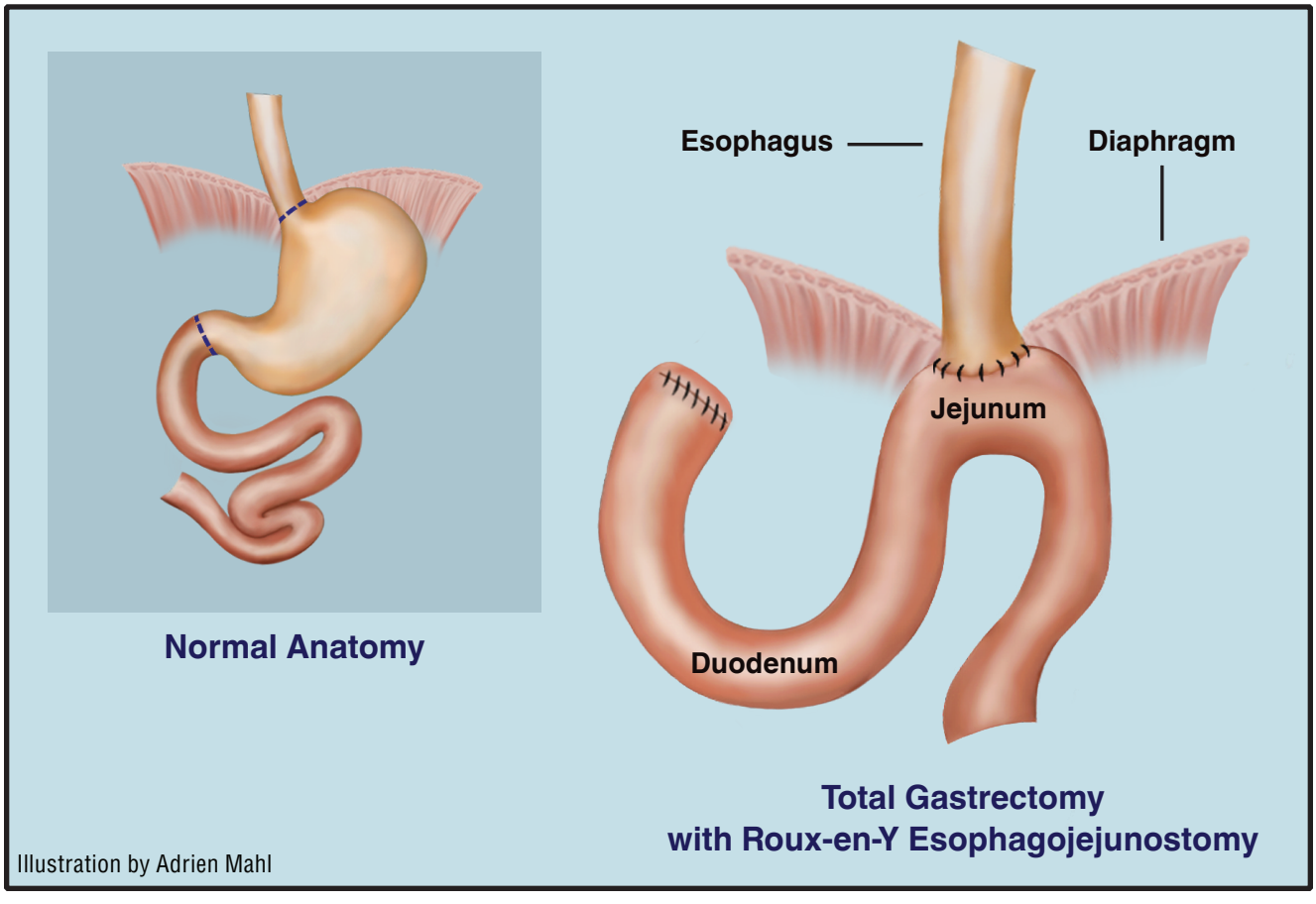

Table 6. Common Patient Specific Barriers – Often Referred to as "GI Intolerance" or "EN Complications"

- "Abdominal discomfort"
  - Abdominal pressure
  - Fullness
  - Nausea
  - Vomiting
  - Cramping
  - Belching
  - Gas/bloating/distension
  - Dumping
  - Diarrhea
  - Constipation
- Aspiration risk/no gag
- Pain/mucositis
- Flow rate advancement "fear"
- Bolusing EN too fast (2-5 minutes)
- Anatomical changes
- Untoward effects of medications
- Active disease process
- Psychosocial
  - Stress
  - Depression
  - Health condition/diagnosis
  - Financial issues, etc.

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infused. He followed up in GI clinic 1 month later and had advanced his rate to 145mL/hr. After 1 more month, he was tolerating Vivonex @ 180mL/hr until 9 cans were infused.

- Case 2: 59-year-old male with thyroid and oral cancer s/p surgery and chemo-radiation along with PEG placement. After multiple aspiration events, a J-arm was added. After 3 months, he reached 210mL/hr x 4 cans at night + 350mL/hr x 5 cans during the day and water flushes of 140mL q4h for a total of 1000mL/day.
- Case 3: 62-year-old male with necrotizing gallstone pancreatitis found to have esophageal cancer at the time of ERCP and PEG/J placement. Over the next 2 months, he was able to run 2 cans of a 1.3 kcal/mL product @ 300mL/hr with 120mL water in the morning; 1 can @ 300mL/hr twice during the afternoon; and 3 cans @ 210mL/hr at night.
- Case 4: 43-year-old male with persistent encephalopathy s/p PEG-J following emesis and aspiration pneumonia. Patient experienced bouts of wild movement often requiring restraints, resulting in the loss of multiple J-arms. To avoid having him hooked up to a pump all day, he was switched to an intermittent schedule giving him formula and water 5x/day @ 350mL/hr over 1.5 hours.
- Case 5: 35-year-old male with severe acute pancreatitis complicated by an AKI and mechanical ventilation s/p PEG-J. One month after discharge, he was running 2 cans of a 1.3 kcal/mL product @ 275mL/hr over 2 hrs and eventually worked up to 6 cans @ 225mL/hr overnight + 200mL water 5x/day.

Ultimately, the rate-limiting factor for JF is the patient. If a stable patient desires a bolus or high-rate regimen, this is perfectly acceptable to try as long as the patient tolerates it. Some patients advance the rate over several days or weeks. For patients going home on JF, we advise them to increase the flow rate by 5-10mL/hr every 2-4 days as tolerated until they are running the number of hours that suits their lifestyle. If tolerance is an issue (see Table 6 for potential signs and symptoms), rather than halting JF altogether, treat patients' specific complaints - e.g. with an anti-emetic, an analgesic, a change in a problematic medication, or as a last resort, an alternative enteral formula with a different composition or caloric density.

Myth #5
Residuals from a J-tube Should be Routinely Checked

The question sometimes arises, "should a residual volume (RV) be checked with a jejunal tube?"

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There is no data supporting RV checks with a jejunal tube, as there is no "reservoir" in the jejunum to hold EN. The intestine is a propulsive tube, and fluid flows distally once infused. In fact, if JF are accumulating, then the patient must be partially obstructed or have a severe dysmotility, or the tube could have coiled or retracted into the stomach. This will become readily apparent by signs and symptoms of distension, fullness, and even vomiting. The argument to check "just in case the patient becomes obstructed," is not supported, as the patient will have clear signs and symptoms if they are functionally or mechanically obstructed. The practice of checking residual from a jejunal tube "just in case" would be equivalent to putting all patients on telemetry just in case their heart acts erratically.

Myth #6: Water Flushes Over 100mL Cause Bowel Necrosis

Water flushes are meant to provide tube patency, hydration, and medication flushing. No guidelines exist for how much water can be bolused into the jejunum. Texts suggest flushing with 20-100mL every 4 to 8 hours for continuous feedings, but do not specify gastric vs. jejunal. For intermittent or bolus feedings, flushes of 15-100mL are recommended (no frequency specified), along with patency flushes before and after feedings and medications.[9] However, there have been no prospective trials to support these guidelines.

The origin of the myth to not exceed 100mL water bolus at a time is unknown, but may have been propagated by a case report of an adult male with a 60% full thickness burn who expired after being given 400mL of distilled water every two (**2**) hours via a surgical J (total of 4800mL daily). He was found to have 4 liters of bilious abdominal fluid along with 3 duodenal perforations.[10] This was followed by a one (1) rat study that showed dissolution of epithelial cells and brush border with enlarged enterocytes when the small bowel was exteriorized and infused with distilled water. The report concluded that distilled **OR** tap water may cause bowel necrosis in jejunal feeding and "should not be infused into the small bowel." Our take-home message from this report was 4800mL of water is too much to put into any patient's GI tract in addition to the EN, and that distilled water – a fluid that no one uses for enteral flushes – should not be used. Furthermore, any patient with > 20% total burn surface area is at increased risk for developing gastric and duodenal ulcers,[11] and a 40-45% total burn surface area carries a significant increase in morbidity and mortality.[12]

Table 7. Calculating ¾ Strength Enteral Nutrition

1. Divide volume of can by 0.75:
   - Ex. 240mL can of TF product: 240 / 0.75 = 320mL
2. Subtract volume of can from value in step #1
   - Ex: 320 minus 240 = 80mL
3. Add value from step #2 to one can to make ¾-strength
   - Ex: add 80mL to 240mL TF to make it 3/4-strength
4. Remaining water for maintenance hydration can be divided over the day as med and/or water flushes

Before adding more than patency water flushes, first ensure EN tolerance and achievement of goal flow to meet nutrient requirements. IV fluids can provide adequate hydration if needed. Once at goal, clinical experience indicates that 200-300mL of water, 4-6x/day is reasonable – that is, unless your patient tells you otherwise. For nocturnal feedings, we often recommend 200mL before and after EN run, plus 200mL 3-4 times during the day when EN is off. In these cases, it is helpful to specify times, since RNs must give manual flushes. If patients require slower water flushes, consider using smaller syringes so it just takes longer to give the flush.

Do remember that ICU patients are different than floor patients. We typically use minimal water flushes and rely on our pulmonary critical care specialists to drive volume assessments, given current practice for judicious use of IV fluids and avoidance of fluid excess. Also bear in mind that hypernatremia (Na $\geq$ 150mEq/L) is a medical emergency and should *not* be treated with enterally delivered free water flushes.[13] Instead, IV fluids should be given to ensure that the patient actually

receives the correct volume of fluid needed, rather than relying on flushes that may be missed, lost from vomiting, etc.

Patients on home EN who have higher than normal fluid requirements can be advised to make ¾ strength to infuse some water with their formula as an alternative to increasing volume or frequency of flushes (see Table 7 for how to calculate). This method usually requires increasing the EN rate or run-time. In this circumstance, many patients benefit from an enteral backpack so that they can infuse on the go. Other patients may benefit from running their JF overnight and hanging a set volume of water to run during the day (e.g. 500mL via pump or gravity over 2-3 hours). Ask detailed questions about a patient's lifestyle and preferences so that an optimal regimen can be achieved; not doing so runs the risk of patients skipping their feedings or water flushes altogether.

Of note, the controversy over the use of sterile vs. tap water is beyond the scope of this paper, but a nice review is available elsewhere.[14]

Jejunostomy-Associated Small Bowel Necrosis

Although a multifactorial complication and rare (0.1-3.5%) occurrence, jejunostomy-associated necrosis following major gastrointestinal surgery has been reported in the literature. However, water boluses have not been implicated in these incidents.[15,16] It is also important to note that "tube feeding necrosis" (TFN), if that is in fact what it is, has only been reported retrospectively in patients with surgically placed feeding jejunostomies (not nasojejunal tubes or PEG-Js), and that risk factors for mesenteric ischemia are associated with the development of TFN.[15] Furthermore, heightened awareness, improved surgical practices, differences in anesthesia, antibiotics, and fluid resuscitation requirements have had a role in decreasing its incidence.

Additional Considerations

It is always a good idea to periodically assess for signs and symptoms of micronutrient deficiencies in long-term JF. Consider whether the goal volume of EN meets 100% of micronutrient needs, or whether a patient may need additional vitamin and mineral supplementation. Since the jejunum is the primary site for copper absorption, long-term JF may increase the risk for copper deficiency, especially in those who have a roux en y anastomosis. We recommend checking a serum copper level annually, unless lab indicators return within normal limits. Iron and selenium, both of which are absorbed proximally in the duodenum, also bear monitoring.

SUMMARY

In many cases, JF are a patient's only option other than parenteral nutrition or malnourishment. Yet, several myths around JF with the status of dogma among the healthcare community often render this type of EN ineffective. In the absence of any large, prospective trials, an understanding of the available data in the context of GI tract physiology with a healthy dose of experience remains an important, but often forgotten, guide on what is reasonable with respect to JF, namely that:

1. Polymeric EN can be infused and absorbed jejunally.
2. Isotonic formulas are rarely, if ever, necessary.
3. Diarrhea among patients on EN usually has an alternative cause.
4. JF can safely infuse at whatever rate the patient tolerates.
5. In stable patients, JF can be given via bolus, gravity drip, or high volume pump.
6. There is no need to check residuals from a JT.
7. Water flushes > 100mL do not cause necrotic bowel (although perhaps very large volumes of distilled water do, but who uses large volumes or distilled water to flush feeding tubes?).

Numerous small but important studies have demonstrated these principles. And let us not forget our most valuable resource in determining the proper EN regimen: the patient. Critical thinking and clinical judgment applied to the overall medical picture will ensure that JF are not held captive by dogma, but rather administered in a way that best meets our patient's needs. ■

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