Nutritional Support in Intensive Care Unit (ICU) Patients

Topic 18

Module 18.4

Routes of Nutrition in ICU

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Learning Objectives

- To describe the techniques, the indications and contraindications of enteral and parenteral nutrition therapy;
- To describe the access routes for enteral and parenteral infusion, to describe their advantages and disadvantages.

Contents

Key Messages

- Enteral support is always preferable to parenteral nutrition;
- Enteral access is available via nasogastric, gastrostomy or post-pyloric tube;
- Significant risks of enteral feeding include aspiration, pneumonia and motility disorders;
- Parenteral nutrition is associated with catheter-related and metabolic complications.

1. Enteral nutrition

As a general rule, administration of nutritional support is required to critically ill patients to limit the negative energy and protein balance observed in these patients (Fig. 1).
Enteral nutrition is always preferable to parenteral nutrition, for a variety of reasons outlined previously (module 18.3, Fig. 2).
Briefly, the absence of nutrients in the gastrointestinal tract has 3 consequences (Fig. 2) (13-14):

- lack of fuel source for enterocytes
- lack of mechanical stimulation
- abnormal hormonal pattern

Therefore, the absence of nutrients has been proposed as a trigger for the translocation process of endotoxins, bacterias and fungi from the gastrointestinal tract (GIT) (15) lumen into the blood stream despite liver filter, inducing metabolic response, and a body response to a second "hit" that may induce systemic inflammatory response to stress and multi organ failure(16).
Early enteral feeding (17) and even a small amount of nutrients in the gastointestinal tract may prevent this translocation process, even though others discuss this evidence (18).
Enteral nutrition is often feasible, as the gastrointestinal tract function is usually normal, but some precautions, however, must be taken before initiating enteral feeding.

1.1 Contraindications

Absolute contraindications (Fig. 3) for enteral access include:
• Complete bowel obstruction
• Severe malabsorption
• Severe diarrhea

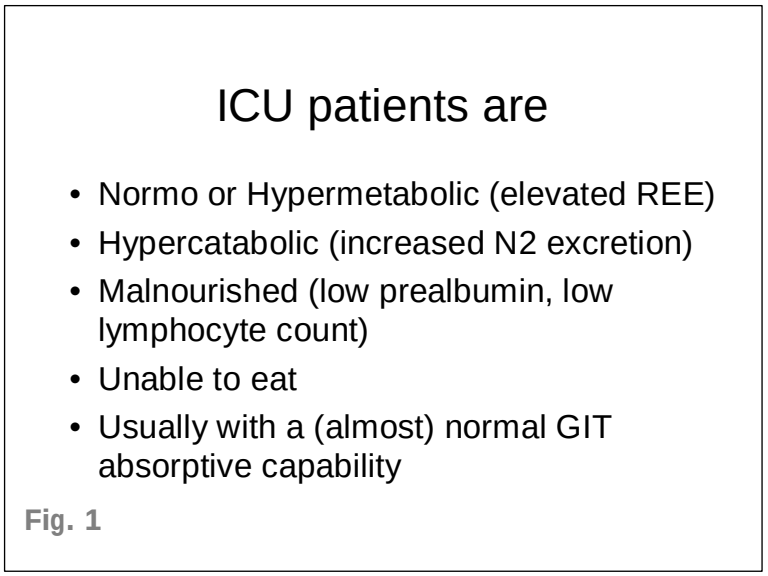


Fig. 1

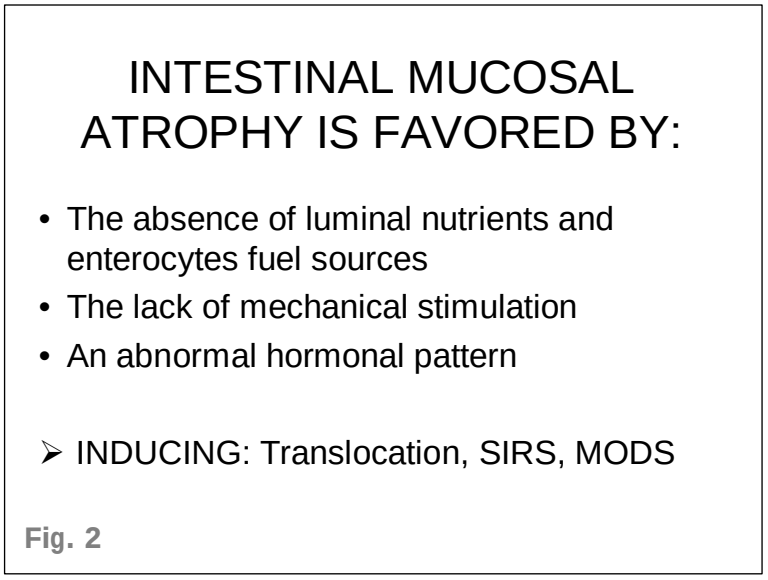


Fig. 2

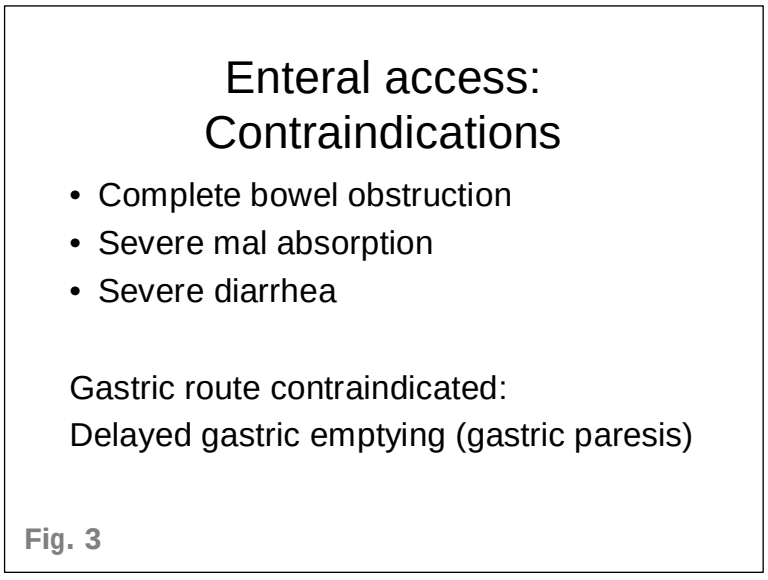


Fig. 3

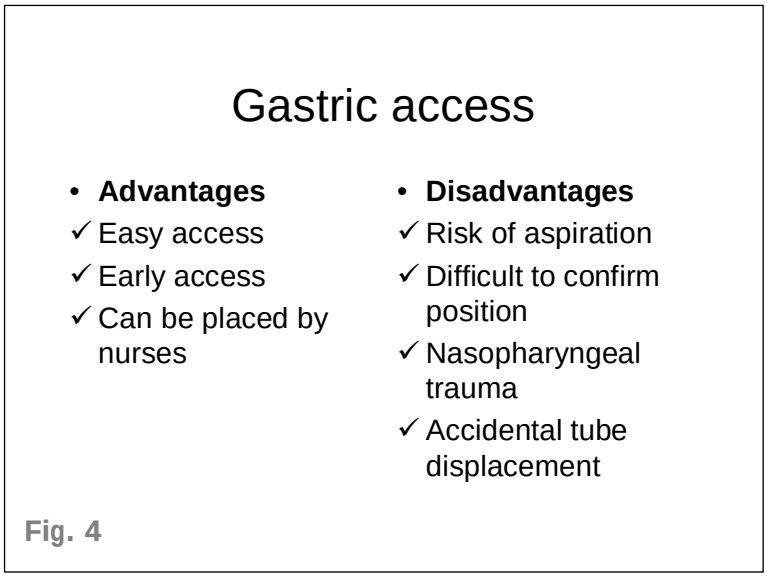


Fig. 4

1.2 Advantages and disadvantages

The gastric access (Fig. 4) has many advantages:
- easy access
- early access
- access preformed by nurses

Therefore this access should always been proposed in any case where GIT is functioning and available.
The disadvantages are not negligible and include the risk of inhalation of gastric content, because of supine position, gastroesophageal reflux and impaired gastrointestinal peristaltism (19).

This aspiration complication can induce pneumonia, one of the leading causes of respirator related pneumonias observed in the ICU patient (20) and nasopharyngeal trauma that induces profuse bleeding can be encountered in ICU patients and should be prevented by gentle introduction through the nose of small bored nasogastric tube (21).
Accidental tube displacement should be continuously diagnosed since fixation may be removed and re-fixed and new positioning not reconfirmed by X ray.

1.3 Types of enteral feeding techniques

Enteral feeding techniques include:

Gastric Feeding (Fig. 5)

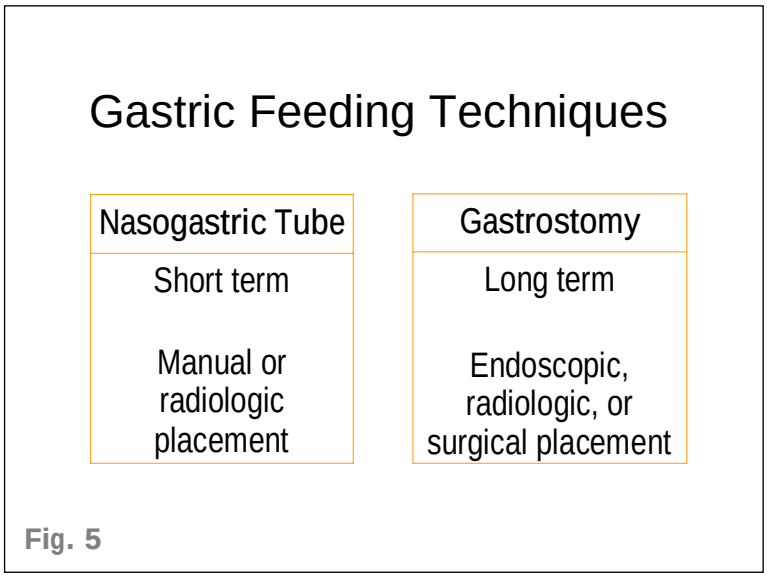


Fig. 5

- nasogastric tubes available for short time feeding process (less than 3-6 weeks), and achievable using an manual bedside placement that could be confirmed radiologically (not mandatory).
- gastrostomy available for long term feeding through the GIT tract, and achievable using the endoscopic, radiologic and a surgical placement (22, 23, 24)

Postpyloric feeding
- nasojejunal feeding tubes
- jejunostomy

1.3.1 Naso-gastric tubing and placement

Tubes used (Fig.6, Fig. 7) could be of polyvinyl (more rigid), silicone (more flexible) or of polyurethane (less traumatic)
Their diameter varies from 6 to 14 French. Their length can vary from 95, 105 up to 120 cm, according to the anatomy size of the patients and the extremity could be weighted, although a confirmation of the advantage of this technique is still awaited.
Recently, some techniques have developed to improve the rate of success of introducing a nasogastric tube (Fig. 8).
If the purpose is to introduce the tube in the duodenal tube, a 10-10-10 technique has been proposed (25). This technique proposes to administer metoclopramide (10 mg), to wait 10 min and then to introduce a 10 Fr duodenal tube, achieving around 70% of success. Other techniques have reached similar results and bedside introduction of gastric or duodenal tube have been widely proposed, even in pregnant women suffering from hyperemesis gravidarum (26-28)
The right placement of the tube must always be checked before starting enteral feeding (Fig.9).
Coughing, vomiting or nasotracheal suctioning, as well as extubation of the endotracheal tube can induce dislodgement of the nasogastric or the nasoduodenal tube. Therefore, position of the tube should be checked regularly by nurses during their shift. In case of undetermined position, x-ray should be ordered (29).

Routes of administration

- Enteral route: through naso gastric or jejunal tubes
- Polyvinyl (rigid), silicone (Ch 6 to 14), or polyurethane (less traumatic)
- Length 90, 105 or 120 cm, can be with weight.

Fig. 6

Nasogastric Tubes

Fig. 7

Precautions in introducing the tube

- Insufflate air, aspirate, Xray control in doubt of intra alveolar placement
- Intraduodenal tube can be placed using the 10 10 10 rule: 10 mg metaclopramide -10 min wait - 10 Ch tube. About 70% success
- Wait for 24 hours for help of peristaltism.
- Prevent obstruction by flushing and using low viscosity formulas

Fig. 8

Verifying placement of small-bore feeding tubes

- Danger of silent dislogement during coughing, vomiting or nasotracheal suctioning, extubation of NTT
- Radiography?
- 15% of small-bore NGT, 27% of weighted and 50% of unweighted NI tubes were not located at their intended position
- Aspiration of Gastric content
- pH testing, auscultation of insufflated air

Fig. 9

Percutaneous Endoscopic Gastrostomy: Advantages

Rigid

- No surgery
- Bedside
- Minimal sedation
- Short procedure
- Low costs

Flexible

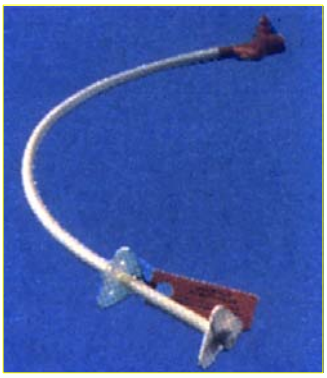


Fig. 10

Minard G. *Nutr Clin Prac* 1994;9:172-182

PEG versus NGT in ICU

Angus et al, Am J Gastro 2003;98:272-7

- PEG vs small-bore feeding tubes: NGT can provide adequate nutritional support, are cost-effective and safe for 8 weeks
- Fay, Poplausky: Long term enteral feeding: a retrospective comparison of delivery via PEG and nasoenteric tubes. Am J Gastroenterol 1991; 86:1604-9
- Major complication: aspiration is **not** decreased by PEG
- PEG is not beneficial in comparison with NGT in patients with anticipated need less than 6-8 weeks
- PEG should be considered in the agitated patient requiring enteral feeding for more than 2 weeks, and in severe head trauma, Persistent vegetative state, long term ICU stay

Fig. 11

According to (30), 15% of small-bore nasogastric tubes, 27% of weighted tubes and 50% of unweighted nasointestinal tubes were not located at their intended position.
An easy test of position may be the pH analysis of aspirated juice, remembering that gastric juice pH is more close to 2-3, and duodenal pH is closer to 6-7, although biliary reflux may represent a confounding factor.
Auscultation of insufflated air is frequently used but of low accuracy.

1.3.2 Gastrostomy

Percutaneous Endoscopic Gastrostomy (32) has many advantages: no need for surgery, performed at bedside, minimal sedations, short procedure and low costs (Fig. 10).
Versus a nasogastric tube, PEG should be suggested if enteral feeding is planned for more than 8 to 12 weeks. Aspiration is not decreased by PEG. But if the patient is agitated, pulling out his tube many times and is in vegetative state, PEG should be recommended (Fig. 11).
The procedure is simple and the complication rate is even lower than the surgical gastrostomy. It is even cost effective. Immediate feeding has been tested in comparison with feeding the next day and in none of the parameters, any difference has been found.
Some patients require surgical procedures because of the abdominal condition and an expected prolonged stay in the hospital and in rehabilitation centres.

The surgical techniques recommended in case the patient is undergoing laparotomy should be performed according to the surgeon experience, the abdominal status and the related risks of the procedure.
Complications of the operative gastrostomy tube placement are hemorrhagic in rare cases (less than 1%). Improper lodgement of the tube, or dislodgement in the anterior part of the stomach can be found. The site leak is more frequent. Wound infection can occur in 2-8% of the cases. (Fig. 12, Fig. 13, Fig. 14)

Feasibility, Efficacy, Safety

Van Natta, Ann Surg 1998; 227:618-26
Akkersdijk et al: Injury 1998; 29:11-4

- 129 PEGs from 16,417 trauma admissions: in closed head trauma and agitated patients
- Complication rate: 1.5% vs jejunostomy 18%
- 2 leaks from the gastrostomy (1 MOF)

- Efficient: 24 trauma patients ISS 44 with mean hospital stay of 71 days. Eight patients were discharged with PEG, 1 aspirated and died, 2 had leak, 12 were weaned from PEG

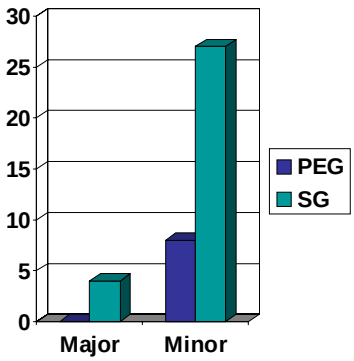
Fig. 12

Complications of operative gastrostomy tube placement

- Hemorrhage: fewer than 1%
- Improper placement of the tube
- Dislodgment of the stomach from the anterior abdominal wall
- Site leakage is frequent
- Wound infection (2-8% of the cases)

Fig. 13

Complications PEG vs SG in trauma
Dwyer et al: J Trauma 2002; 52:26



- 95 PEG vs 63 SG in 4 years

- Charges for PEG: 1271 $
- Charges for SG: 2761 $ (P<0.001)

Fig. 14

Nasojejunal tubes….

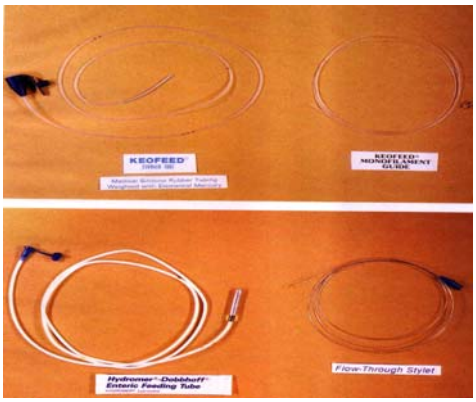


Fig. 15

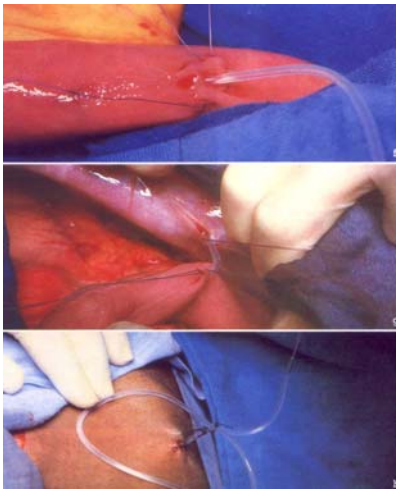
1.3.3 Postpyloric feeding

Surgical techniques

- Witzel jejunostomy
- Needle catheter jejunostomy
- Transgastric jejunostomy
- Roux en Y jejunostomy
- Operatively placed nasojejunal feeding tube
- Gastrostomy surgical or PEG

Fig. 16

Jejunostomy if surgery is planned



Complications of postpyloric feeding

- 1-2% have serious complications
- Mechanical complications: dislodgement, intraperitoneal migration, occlusion, volvulus
- Diarrhea: 22 to 50% of the patients
- Cramping, abdominal distension
- 13% never tolerate and convert to TPN
- Bowel necrosis

Fig. 17

1.4 Initiation of enteral feeding

A list of potential concerns and queries have to be solved before the initiation of enteral feeding, in order to prevent and avoid complications. The systematic use of a checklist and of standard settings, as shown in the (Fig. 19), can be useful to start and to optimise enteral feeding.

Initiation of enteral feeding

Significant gastrointestinal dysfunction?	Is the gastric residual volume >250 ml?
Suspicion of ileus?	Infuse enteral feeding (30 ml/h) and check gastric residual volume 4–6 h later
Initial settings?	Pump-driven, continuous, 30–60 ml/h
Position of the feeding tube?	Naso- or oro-gastric. Distal end in fundus or antrum.
Catheter type?	PVC
Patient position?	> 45°
Which formula?	Polymeric, isoenergetic in most cases (see Chapter 5)

Fig. 18

1.5 Prevention and management of current problems of enteral feeding

Once enteral nutrition has been initiated, several adverse events commonly occur, sometimes discouraging or impeding adequate delivery of enteral feeds.

Some of the frequently asked questions are shown below. Suggested solutions are also shown (Table 1), although standardization is lacking in this area. Although the guidelines listed in this chapter are not evidence-based and are open to debate, they reflect current practice in several ICUs in Europe and, with minor alterations, could realistically be adopted by most ICUs worldwide (33, 34).

Table 1 Management of current problems of enteral feeding

Problem	Suggested solution
High gastric residual volume	Decrease infusion rate by half and give prokinetics
Prevention of inhalation pneumonia	Constant infusion Flush the catheter after administration of drugs, to prevent occlusion Elevate: keep the patient in semi-recumbent position
Prevention of sinusitis/nasal erosions	Frequent mouth washing Use small tubes, preferentially in silicon
Diarrhoea	Exclude infectious diarrhoea Decrease infusion rate by half and give loperamide Replace by a fibre-enriched solution and add *Saccharomyces boulardii*
Constipation	Replace by a fibre-enriched solution
Oral drug administration	Avoid long-acting medications, use liquid formulas in preference Crunch and mix pills, rinse the tube with water after administration
Keeping a naso-gastric catheter in place when oesophageal erosions have been seen by an endoscopist	Unless responsible for significant bleeding, a small-calibre feeding catheter can be left in place.
Is stress ulcer prophylaxis useful during enteral nutrition?	Although intragastric administration of enteral nutrition partially prevents the occurrence of mucosal erosions and gastrointestinal bleeding, the efficacy of enteral nutrition alone as stress ulcer prophylaxis is not proven. At present, pharmacological stress ulcer prophylaxis should be independent of enteral nutrition

Administration techniques

- Drip feeding or bolus (500 mL per bolus and no more than 30 mL/min)
- Requires nursing, gastric residue every 4 to 8 hours, no more than 3 L/24 hours
- Continuous enteral feeding: decreases intestinal secretions and transit time through pumps (volumetric)
- Keep cold and give by fractions

Fig. 19

Practical recommendations

- Elevated head 30oC during enteral feeding
- Check gastric residue every 8 hours at least
- Always prefer gastric if possible,
- Start with 50 mL/h and 1 kcal/cc and increase to 75 – 100 mL/h if isoosmotic
- If jejunal tube: increase more progressively from 25 mL/h

Fig. 20

How to increase administration

	GASTRIC	JEJUNAL
START flow concentration	**50 mL/h 0.25 to 0.50 kcal/mL**	**25 mL/h and 0.25 kcal/mL**
Daily Progress	**Increase concentration by 25% and then the flow by 25 mL/h**	**Increase the flow by 25 mL/h and then the concentration by 25%**
If polymeric	**50 mL/h at 1 kcal/cc & increase to 100 ml/h**	

Fig. 21

1.6 Administration technique

Drip feeding is preferred to bolus feeding (no more that 500 mL per bolus or 30 mL/min). This technique requires nurse intensive observation and gastric residue analysis every 4 to 8 hours (Fig. 20).

Continuous enteral feeding decreases the GIT secretion and is achieved using volumetric pumps. Not all the planned volume should be placed in the bag at the room air, but fractioned volumes should be taken from the refrigerated storage.

Practical recommendations include positioning the head in an elevated position of 30 degrees, introduction of nasogastric tube to start with, check residue and start with rates of 40-50 mL/h and a concentration rate of 1 kCal/cc. Increase to 75-100 mL/h after a few hours if the solution is isotonic (Fig. 21).

In case of failure in achieving gastric emptying, try prokinetic agents and in case of failure after hours of try, introduce a nasoduodenal tube. The administration rate of enteral feeding is slower, starting from 25 mL/h (Fig. 22). In case of low viscosity of the formula, or in case of obstruction risk, flushing should be a technique to prevent obstruction.

1.7 Complications

The complications most encountered (35) are clogging, aspiration pneumonia, vomiting and esophagitis. Abdominal pain and diarrhea are also encountered. In case of use of hypertonic enteral solutions, hyperosmolality and dehydration can occur. Increase in glucose load can induce glucose intolerance and hepatic steatosis with an increase in alkaline phosphatase, Gamma-glutaryl transferase and sometimes total and direct bilirubin.

In ventilated patients, the gastric motility is decreased. This is even more decreased when morpine or norepinephrine are used. The duodenal activity fronts persist and therefore, duodenal tube should be inserted very early.

1.7.1 Gastroduodenal dysfunction

A common concern during enteral feeding is delayed gastric emptying (24, 25). This condition is defined by an increased gastric residue more than 150 mL/h or more than the double of the previous administration in the last hour (20) or more than 600 mL for the last 24 hours.
Studies have shown that this gastric residue was not enough reliable for gastric emptying evaluation. Other tests as the sophisticated isotope technique (21) or the paracetamol test have been proposed to evaluate bedside gastric evaluation. However, if gastric paresis is observed, it should be inducing evaluation of the gastric emptying function (22).

Although there is no clear consensus on the management of gastro-duodenal dysfunction, one should remember that the infusion of enteral feeding is beneficial for the gut mucosa, even at a low rate. Therefore, enteral infusion should not be discontinued, and pro-kinetic drugs should be used when the patient cannot tolerate "a low delivery rate" of enteral feeding. Importantly, once the gastric residual volume is below the cut-off value, the administration rate should be restored to a higher value. An example of algorithm is shown.

Check gastric residual volume

Head trauma patients are suffering from impaired gastric emptying. Ott et al (Fig. 23) developed a diagram for patients suffering from head injury and requiring nutritional support.

According to this diagram, if the Glasgow coma Scale is above 12, a nasogastric tube will be recommended. If the GCS is below 12, nasogastric tube, duodenal tube, PEG, PEJ or parenteral nutrition will be recommended in function of the clinical status and the expected stay of the patient.

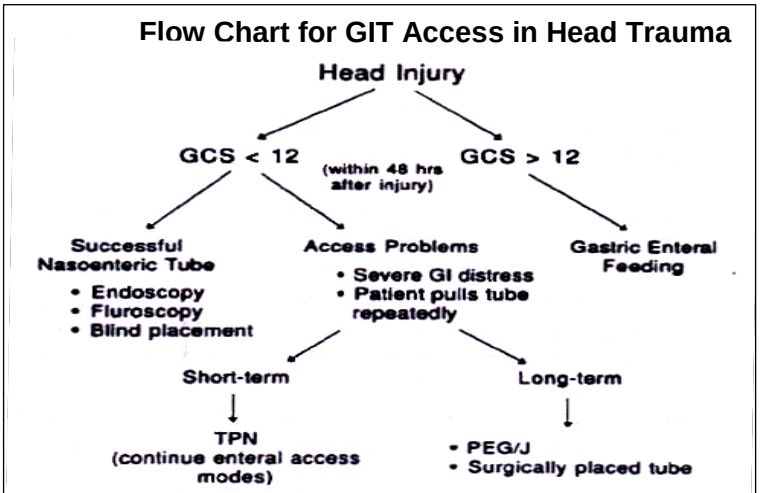


Fig.22 Flow chart for the most effective means of administering nutrients to patients with severe head injury.
Ott et al. J Neurotrauma 1999; 16: 233

Many studies have tested the use of metoclopramide 10 to 20 mg, or erythromycin previous to tube placement in medical, surgical or mixed populations. The rate of success was significantly better in 3 out of the 6 studies included (rates of success of 61% up to 96%).

High gastric residue is not always a sign of poor gastric peristaltism. Cohen et al (36) demonstrated that half of the patients with gastric residue larger than 200 mL had normal gastric emptying demonstrated by paracetamol test. This easy to achieve bedside test can be proposed to decide of continuing enteral feeding admininstration, to propose nasojejunal tube, or to think about endoscopic or radiologic positioning.
If the patient is receiving enteral feeding for more than 3-6 weeks and will require longer enteral support, percutaneous endoscopic gastrostomy should be considered. If the patient is undergoing abdominal surgery, indication for jejunostomy should be weighted.

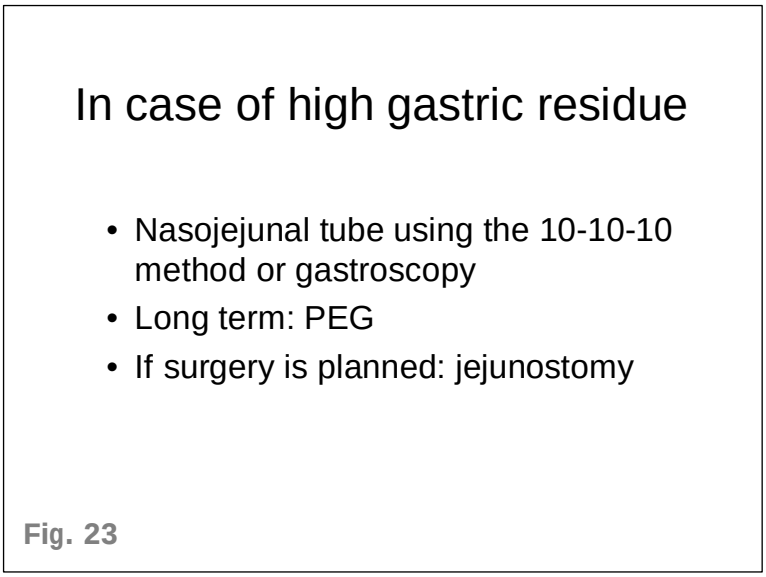


Fig. 23

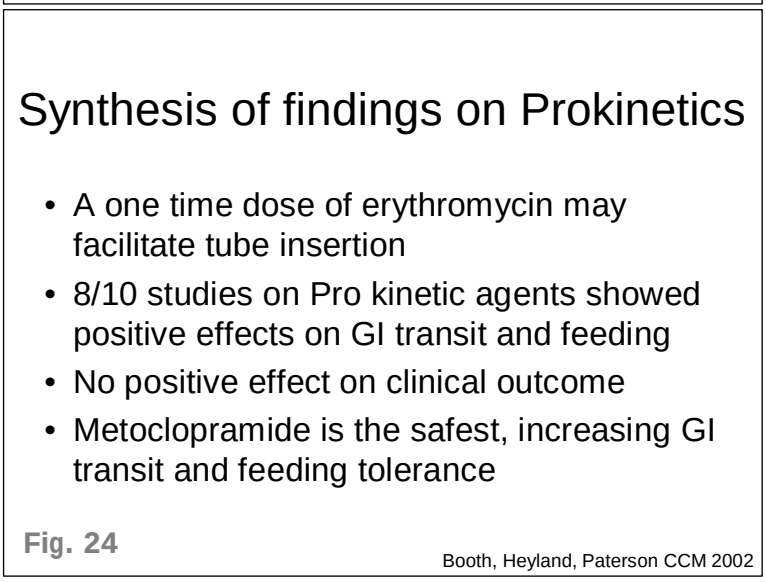


Fig. 24

Booth, Heyland, Paterson CCM 2002

Additional help can be reached using prokinetic agents that increase gastric peristaltism and gastric emptying.
Heyland's team (34) summarized the different studies in this field. In case of difficult insertion of a nasoduodenal tube, erythromycin as a one time dose may be proposed and facilitate the tube insertion (Fig. 24**,** Fig. 25).
Prokinetic agents have shown positive effects on the gastrointestinal transit and feeding in most of the studies, but without showing positive effect on clinical outcome.
When comparing between erythromycin, metoclopramide and cisapride, metoclopramide has been found to be the safest, increasing the gastrointestinal transit and the feeding tolerance. Erythromycin arised the question of bacterial resistance and cisapride was reported to increase QT and induce cardiac toxicity in children.

1.7.2 Diarrhoea

Diarrhoea is another common complication of enteral feeding and is actually the most current cause of interruption of enteral feeding.
When diarrhoea is defined as the emission of three or more liquid stools per day, its incidence in critically ill patients ranges from 20% to 50%. In most cases, the continuation of enteral nutrition can often be achieved by using a systematic and standardized approach. The causes of diarrhoea during enteral feeding can be divided into two broad categories: infectious and non-infectious. Standard treatments for infectious diarrhoea associated with Clostridium difficile include oral metronidazole and vancomycin.

1.7.3 Constipation

Although frequent in patients fed enterally, constipation is not a typical feeding-related complication, but is probably related to a prolonged period in the supine position. However, if untreated, constipation can cause ileus, increase abdominal pressure and ultimately impair respiratory function and weaning from the ventilator. Fibre-enriched solutions are usually recommended in cases of constipation.

2. Parenteral nutrition

Parenteral nutrition (Fig. 26, Fig. 27, Fig. 28, Fig. 29) is recommended if enteral nutrition is contraindicated or if enteral nutrition does not reach energy requirements.

Access is described in the slide and subclavian access is preferred because it is associated with lowest rates of complications.

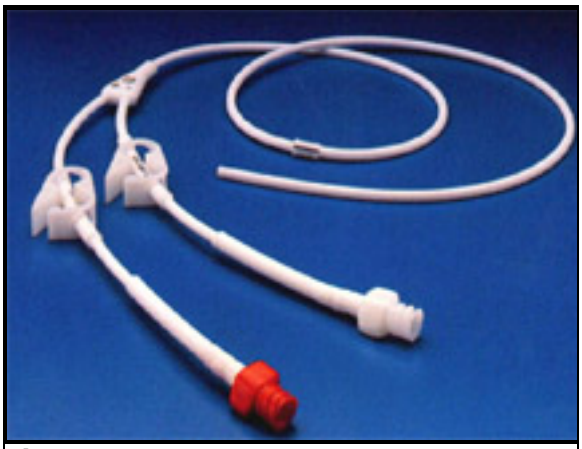


Fig. 25 **Catheter with Cuff**

Fig. 26 **Peripheral Central Venous Catheter**

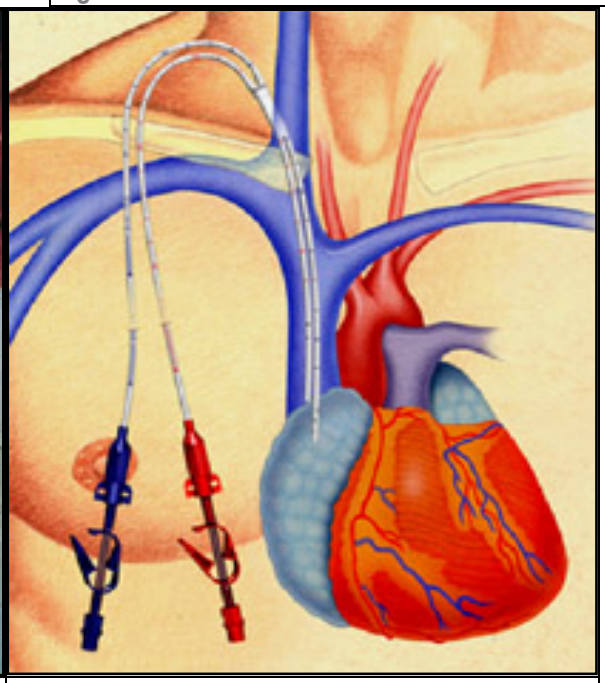


Fig. 27 **Parenteral Access**

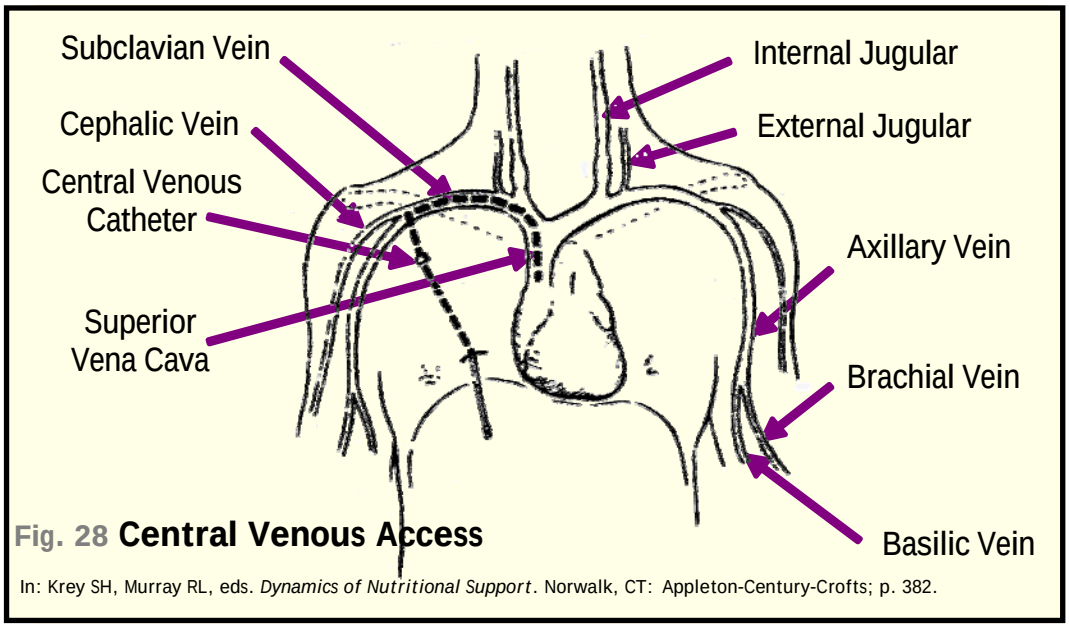


Fig. 28 **Central Venous Access**

In: Krey SH, Murray RL, eds. *Dynamics of Nutritional Support*. Norwalk, CT: Appleton-Century-Crofts; p. 382.

2.1 Complications

vention	Treatment

Complications

- **Insertion** (pneumothorax, arterial puncture)
- **Mechanical:** Rupture, occlusion, embolus, thrombosis, poor placement
- **Infection:** Catheter site, subcatenous tunnel, colonization, bacteremia, sepsis
- **Metabolic:** Hyperglycemia, electrolyte inbalance, refeeding syndrome
- **Liver function disorder**

Fig. 29

Fig. 30 **Subclavian Catheter Dressing**

Complications (Fig. 30) are related to:
a) **Insertion** (pneumothorax, arterial, venous or nerve puncture)
b) **Infection**: the infection can be located at the catheter site, the subcutaneous tunnel, the catheter extremity, or in the blood. CRS (catheter related sepsis) is frequent cause of sepsis in critically ill patients and requires blood and hub cultures and replacement of the catheter in case of fever and high suspicion of CRS. New catheters impregnated with antiseptic products have been proposed to reduce the prevalence of catheter related sepsis (Fig. 31)
c) **Metabolic complications**: Hyper or hypoglycemia are the most frequent metabolic disturbances encountered. Tight glucose control has become a recommended therapy in critically ill patients. Electrolyte disturbance is diagnosed easily by regular laboratory tests. Hepatic function test disturbances can be found in up to 55% of the patients receiving TPN. A reduction in lipid emulsion load is usually enough step to improve the liver blood tests.
d) **Thrombosis**: mostly encoutered in PVC catheters, the venous thrombosis or the catheter occlusion are also associated with catheter misplacement and hyperosmolar solutions use. The diagnosis is suspected when no reflux is obtained and confirmed by Pulsed doppler. Catheter fibirnolysis, catheter removal and /or systemic anticoagulant therapy are usually indicated. The use of polyurethan or silicon catheters can prevent these complications

The appropriate management of TPN should aim to detect and treat all of the complications associated with this type of feeding. The frequent complications (catheter-related or metabolic/hepato-biliary) and the specific managements are listed in the following tables. When enteral feeding cannot meet > 50% of the energy and nitrogen requirements for more than 5 days, TPN is used as a complement calculated to match the difference between the amount on enteral feeds and the actual requirements.

Table 2 Complications

Catheter-related	Metabolic and hepato-biliary
Pneumothorax/hemothorax Catheter misplacement or torsion Thrombosis or occlusion Infection	Hyper-/hypoglycaemia Hypertriglyceridaemia/macrophage activation syndrome Electrolytic disturbances Steatosis Cholostasis Acalculous cholecystitis

Pneumothorax Hemothorax	Sub-clavian puncture	Chest X-ray		Insert thoracic drain
Catheter misplacement or torsion	Internal jugular puncture	Chest X-ray		Remove the catheter
Venous thrombosis Catheter occlusion	PVC catheters Catheter misplacement Hyperosmolar solutions	Inflammation and/or swelling (local/homolateral arm) No reflux Pulsed Doppler	Use polyurethane or silicon catheters Transparent dressings Use 0.22 microm filters	Remove the catheter Systemic anticoagulant therapy or catheter fibrinolysis
Catheter infection	Femoral access	Local inflammation Fever Systemic inflammation Positive culture of the catheter	Surgical preparation Line solely dedicated to TPN Aseptic manipulations Sterile handling of the solutions Removal of unnecessary lines	Remove the catheter Antibiotic therapy in case of signs of sepsis (and not if isolated local inflammation) Antibiotic lock in case of long-term subcutaneous chamber

Table 3 Catheter-related complications

Type	Risk factors	Prevention	Treatment	Complication
Hyperglycaemia	Rate of glucose infusion > 4 mg/kg.min	Provide calories as a dextrose + lipids mixture Check glycaemia every 4 hours	Reduce glucose supply (2–4 mg/kg.min) Intensive insulin therapy	
Hypoglycaemia	Abrupt withdrawal of dextrose administration Excessive insulin therapy	Check glycaemia every 4 hours	Re-infuse dextrose solution	Coma
Hyper triglyceridaemia	Excessive lipid supply (>4–6 g/kg.day)	Check plasma triglycerides 1–2 times /week		Macrophage activation syndrome
Cholestasis	Absence of oral alimentation Sepsis	Check liver tests 2–3 times/week	Interrupt TPN Re-start oral nutrition as soon as possible	
Steatosis	High caloric supply	Avoid excessive caloric supply. Check liver tests 2–3 times/week	Interrupt TPN	Hepatic failure
Acalculous cholecystitis	Fasting Intraluminal microbial overgrowth	Check liver tests 2–3 times/week		

Table 4 Metabolic and hepato-billary complications

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