

The When, Where and Why of Permissive Underfeeding

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Introduction

- The importance of providing patients with sufficient energy and protein to achieve the desired nutrition and clinical outcome is always paramount.
- Whether the nutrition goal is promoting weight gain or minimizing weight loss, the importance of providing adequate calories has been emphasized.
- Underfeeding can have deleterious effects.
- Overfeeding can also be detrimental. Patients who are provided with nutrients in excess of desired nutrition and clinical goals are prone to, among other effects, hyperglycemia, azotemia, immunosuppression and hepatic steatosis (1, 2, 3).

Historical background of energy delivery

- Early use of parenteral nutrition (PN) was characterized by the provision of high caloric intake with it not uncommon for patients to receive 3500 – 5000 kcals/day (4).
- Reports began to appear in the literature documenting significant respiratory complications related to this practice (5-7). Increased minute ventilation, excessive carbon dioxide retention and failure to wean from mechanical ventilation were noted in patients who received significantly high caloric intakes (4-7).
- More modest energy intake recommendations were made for PN along with suggestions to provide regimens with a balance of both carbohydrate and lipid versus the use of carbohydrate as the primary non-protein energy source (8-9).

Rationale for the use of hypocaloric feeding

- Based in part on the complications observed with nutrient overfeeding, the concept of permissive underfeeding was introduced. Overfeeding is known to be detrimental with potential clinical and metabolic deleterious effects. These include ventilatory effects such as respiratory failure, increased work of breathing and failure to wean from mechanical ventilation (10). Other effects include hyperglycemia, hepatic steatosis, uremia, and impairment of immune function (11-13)
- Restricting nutrient intake, specifically in critically ill patients, over a short term time period is based on the theory of “hormesis”, a theoretical concept defined as “a beneficial or stimulatory effect obtained when an agent is provided at a low dose whereas a detrimental or toxic dose is obtained at higher doses (3).
- Permissive underfeeding is based on research indicating that provision of 100% of estimated nutrient requirements may stimulate detrimental effects including inflammation, cytokine release, oxidant production and damage (3).

- Strategy is based on the premise that the short term restriction of nutrient intake may limit the pathologic processes that occur in critical illness while minimally impairing organ function (3).
- In the obese patient population, the attractiveness of this concept is due known detrimental effects of overfeeding the obese patient and to the continued increase in obesity rates nationwide. The intent is to provide a reduced caloric intake combined with high protein that will minimize metabolic complications, preserve lean body mass and promote gradual loss of adipose tissue (14).

Animal studies

- Berg and colleagues compared a restricted and unrestricted enteral diet in rats and noted those receiving the restricted intake lived 20% longer (15).
- Alexander and colleagues provided 20% fewer enteral calories to animals with induced infection. Approximately 67% of the underfed animals survived compared to 37% who were provided with a higher caloric intake (16).
- A study of infected animals by Peck and colleagues identified that mice provided with an energy restriction of 50% had significant lower mortality compared to the group without energy restriction (17).

Evidence supporting the use of hypocaloric or permissive underfeeding

Parenteral nutrition

- Studies examining permissive underfeeding with PN in the non obese population are limited.
- Patino (1999) and colleagues retrospectively reviewed data from 107 critically ill patients who received a hypocaloric PN regimen (18).
 - Patients were grouped by when they received the hypocaloric regimen; Group I 1987-1988 and Group II 1988-1992. Energy intakes ranged from 22 to 24 kcals/kg /day IBW and protein intakes ranged from 1.7 to 1.9 gm/kg/day of IBW.
 - Small sample size and heterogeneity study characteristics prevented statistical analysis.
 - Average nitrogen balance in the groups was -8.46 g in Group I and -9.7 g in Group II. Blood glucose levels of 122 mg/dl in Group I and 135 mg/dl in Group II were observed and no insulin was required during the PN course.
 - The authors noted that this is in marked contrast to that observed when hypercaloric PN regimens are utilized and concluded from their review, that the use of a hypocaloric and high protein PN regimen in the first few days of illness is more in accordance with the inflammatory mediator milieu and should be considered.
 - Difficult to assess this data in relation to current practice as study was conducted 15-20 years ago and patient care practices have changed significantly in that time period.
- McGowan and colleagues (2000) prospectively compared a hypocaloric and a eucaloric PN regimen in acutely ill hospitalized patients (19).

- Patients were randomly assigned to receive either a 1000 kcal/day PN regimen or a regimen providing 20 – 25 kcals/kg/day of body weight.
- Average caloric intake was significantly lower in the hypocaloric group (913 ± 90 vs 1192 ± 212 kcals/day). Average protein intake was 1.1 gm/kg/day in the hypocaloric group and 1.3 g/kg/day in the eucaloric group. Nitrogen balance was more negative in the hypocaloric group.
- Average blood glucose levels, rate of hyperglycemia and infection rates were not significantly different between the two groups.
- A significant reason why differences may not have been observed is that the PN advancement regimens were strictly managed such that advancement to goal formula was delayed if hyperglycemia was present. This practice was not controlled thereby limiting the usefulness of the results.
- Authors concluded that in their institution, limiting patients to 1000 kcals/day with 70 gm of protein is not much different than their standard practice and in those settings where higher a higher caloric PN regimen is used, consideration toward a lower energy intake should be made.
- High quality prospective studies evaluating the use of permissive underfeeding in parenterally fed patients is very limited making it difficult to render conclusive recommendations. Clearly research in this area is needed.

Enteral nutrition

- Primary research evaluating the use of hypocaloric or permissive underfeeding in enterally fed patients is limited. Review of studies evaluating various levels of enteral intake and their relationship to outcomes lends support for hypocaloric feedings.
- Ibrahim and colleagues (2002) (20) randomly compared feeding patients 100% of their estimated total nutrient requirements starting on Day One of ventilatory support compared with feeding patients 20% of their requirements for the first four days.
 - Actual daily calories delivered in the first five days of ventilator support were 2370 ± 2000 kcals in the early group versus 629 ± 575 kcals in the late group (p<0.001). Patients in the early feeding group developed more ventilator assisted pneumonia (p=0.02), had a longer ICU length of stay (p=0.04) and required more days of antibiotic therapy (p<0.001) compared to the late feeding group. Hospital mortality was not different between the feeding groups.
- Krishnan and colleagues (2003) (21) prospectively compared nutrition support practices with energy intake guidelines set forth by the American College of Chest Physicians (ACCP) for ICU patients. Actual calorie intake as a percentage of ACCP recommendations for included patients was divided into tertiles; 0 – 32% = Tertile 1, 33 – 65% = Tertile II and ≥ 66% = Tertile III. The average caloric intake among all participants (n=187) was 50.6% of the ACCP.
 - Actual caloric intake in Tertile II was associated with significantly higher likelihood of hospital discharge alive compared to Tertile I whereas Tertile III caloric intake was associated with a significantly lower likelihood of being alive at hospital discharge.

- A criticism of this study is that PN therapy was provided in 2.2% to 39% of study patients, with the potential confounding effect of glycemic control not controlled.
- In 2005 Ash and colleagues (22) retrospectively evaluated enterally fed non obese trauma patients (n=128).
 - Average daily caloric intakes for the first seven days of feeding were divided into quartiles based on kcals/kg/day; Quartile I = 10.1 ± 2.5 , Quartile II = 15.8 ± 1.4 , Quartile III 19.6 ± 1 and Quartile IV = 26.2 ± 4.4 . Patients in Quartile IV had a significantly longer hospital length of stay and experienced greater number of days with cardiovascular and central nervous system failure compared to those fed less calories.
- Hise and colleagues (2007) (23) reported results of their prospective evaluation of energy intake in severely ill ICU (medical and surgical) patients.
 - Daily energy intake from all sources was determined with a mean percent of goal energy intake per ICU day calculated.
 - Percent of energy goal intake of > 82% was associated with a mean ICU length of stay (LOS) of 24 days compared to 12 days if percent of energy goal intake was < 82%.
 - In the SICU population, a percent goal intake of >67% was associated with a longer hospital and ICU LOS.
 - The authors concluded that severely ill patients may not benefit from delivery of full energy goal intake with energy delivery limited to 80% of goal caloric intake during severe critical illness.

Does Permissive Underfeeding Occur with Enteral Nutrition?

- Do the commonly observed challenges in enteral nutrition delivery actually result in permissive underfeeding?
- McClave, et al, in 1999 evaluated MICU and CCU patients receiving nasogastric enteral feedings. 78% of ordered feedings were actually delivered with a range of 11% - 102% during the study period. The two most common reasons for feeding interruption were elevated gastric residual volumes and procedures.
- Petros in 2006 observed ICU patients who received at least seven days of enteral feedings. Each patient's energy expenditure was assessed via indirect calorimetry (MEE) and compared with actual energy intake. Enteral feedings were interrupted in 32% of feeding days. Mean energy intake was 39.2% on Day 1 and 83.1% on Day 6. The authors concluded that caloric delivery was much less than MEE.
- Marshall also in 2006 conducted a descriptive survey of enteral feeding practices with 376 critical care nurses (response rate = 50.5%). Reasons to delay feedings included elevated gastric residual volume measurement (65.4%), patient positioning (21%) and tube placement issues (25%). Overall enteral feeding intakes were decreased.

Recommendations

- The American Dietetic Association's Evidence Analysis Library recommends an actual EN delivery of 14 – 18 kcals/kg/day representing 60% to 70% of EN feeding goal within the first week of ICU admission.
 - This level of intake is associated with improved hospital LOS, reduced time on ventilator support and fewer infectious complications (29).
- The Canadian Clinical Practice Guidelines have recommended consideration of low dose PN in critically ill patients who are not malnourished or when PN is indicated for short term use (30)
 - They conclude that research is lacking with respect to permissive underfeeding and PN in those from whom a longer duration is required.

Conclusion

- It is evident that permissive underfeeding is a strategy that should be considered in ICU patient.
- Employing such an approach appears to offer clinical benefit.
- Permissive underfeeding in enterally fed patients is often already occurring and therefore should not be a routine strategy but should be evaluated in conjunction with overall nutrient intakes.
- Further prospective randomized controlled trials are needed to help answer questions regarding what calorie level is associated with improved outcomes and how long this method should be utilized.

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