Guidelines for Management of Home Parenteral Support in Adult Chronic Intestinal Failure Patients

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Management of home parenteral support in adult benign but chronic intestinal failure patients requires a nutrition support team using disease-specific pathways. Education of patients to ensure they self manage home parenteral nutrition (HPN) is cornerstone to obtain minimal rate of technical complications and improvement in quality of life. Nutritive mixtures, compounded by pharmacists in single "all-in-one" bags, must be tailored according to the nutritional and intestinal status of individual patients with definition of macronutrients and water-electrolyte needs, respectively. Each PN cycle should be complete in essential nutrients to be nutritionally efficient and should have sufficient amounts of amino acids, dextrose, water, minerals, and micronutrients to avoid deficiency. When the nutritional goal is achieved, a minimum number of PN cycles per week should be implemented, guided ideally by digestive balance(s) (*In-Out*) of macronutrients and minerals of individual patients. Indeed, HPN is, in most cases, a complementary nonexclusive mode of nutritional support. In short gut patients—who represent 75% of chronic intestinal failure patients—encouraging enteral feeding decrease PN delivery and the risk of metabolic liver disease associated with HPN. In short gut patients with no severe renal impairment, blood citrulline dosage, in association with the remnant anatomy, is a tool to delineate transiant from permanent intestinal failure. The latter group includes candidates for trophic gut factors and rehabilitative or reconstructive surgery, including intestinal transplantation. Thus, outcome improvement for intestinal failure patients needs intestinal failure teams having expertise in all medical and surgical aspects of this field.

Home parenteral nutrition (HPN) is the gold standard of therapy that has been applied to the recent concept of chronic intestinal failure.[1] HPN for chronic intestinal failure is comparable with dialysis treatment for chronic renal failure. The recognized definition of chronic intestinal failure is a nonfunctioning small bowel either removed after severe disease leading to very short bowel syndrome, or present but impossible to use by enteral support even accessed through jejunostomy (eg, chronic intestinal pseudo-obstruction or extensive villous atrophy diseases).[2] HPN should be administered to patients if nutritional requirements cannot be met by enteral nutrition feeding.[3] This article recalls some aspects of published guidelines for the use of HPN[3] and focuses on specific points of management of adult HPN patients in a tertiary care center in the setting of chronic intestinal failure, excluding most cancer patients. Metabolic HPN complications are not reviewed.[4–8]

HPN Guidelines

Nutrition Support Team and Patient Education

The American Society for Parenteral and Enteral Nutrition recently has issued a *Journal of Parenteral and Enteral Nutrition* supplement for the use of home artificial nutrition in adult and pediatric patients.[3] These published guidelines should be known and followed. They are summarized for HPN adults in Tables 1–3.[9–55] HPN usually is managed by a nutrition support team that includes a specialized nurse, dietician, pharmacist, physician, and a surgeon that ideally is trained in both nutrition and gastroenterology, plus a social worker, caregiver, and general practitioner, with the patient and their family being at the center of the medical sphere. The nutritional support team has to identify appropriate candidates, develop a nutritional plan of care agreeable to the patient and caregiver, provide a prescription appropriate for the home setting, and properly train the patient/caregiver.[56] According to the American Society for Parenteral and Enteral Nutrition the standard of minimally required care for home artificial nutrition patients is a standardized method for ordering and monitoring home artificial nutrition support. This is necessary because physicians with different academic training may order home artificial nutrition support. It also is highly

Abbreviations used in this paper: AHRQ, Agency for Healthcare Research and Quality; HPN, home parenteral nutrition; NST, nutrition support team.

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Table 1. Practice Guidelines (A.S.P.E.N.): Parenteral Access

PN should be delivered through a catheter located with its distal tip in the superior vena cava or right atrium	A
A chest x-ray should be obtained after catheter insertion unless internal jugular or upper extremity IV access is obtained by interventional radiology techniques	B
Full-barrier precautions should be used during the insertion of central lines	B
Skin preparation before catheter insertion should be performed using chlorhexidine	B
Catheter hubs and sampling ports should be disinfected before access for medication administration and blood drawing	C
Central catheters should not be exchanged routinely over guidewires	A
Low dose anticoagulation therapy should be used in patients requiring long-term catheterization	B
Specialized nursing teams should care for venous access devices in patients receiving PN	B

NOTE. The authors used the Agency for Healthcare Research and Quality (AHRQ) criteria to classify the strength of the evidence supporting each guideline statement. The evidence supporting each statement is classified as follows:[9,38]
A, There is good research-based evidence to support the guideline (prospective, randomized trials).
B, There is fair research-based evidence to support the guideline (well-designed studies without randomization).
C, The guideline is based on expert opinion and editorial consensus.

recommended to use disease-specific pathways for obtaining laboratory values and patient visits and to organize formal communication between the home care staff and the involved general practitioner.[57]

In our opinion, education of HPN patients always should be implemented in benign but chronic patients.[58,59] At our institution a dedicated nurse who is part of the hospital nursing staff educates patients until they are able to self-manage HPN. The educational module on learning how to disconnect the line from the catheter is minimum knowledge for patients before they go home. In case of complications occurring during intravenous infusion, the patient then can take the appropriate measure immediately (eg, immediate line disconnection in case of fever or immediate closure of the catheter in case of leakage).

Table 2. Practice Guidelines (A.S.P.E.N.): Monitoring Efficacy

Nutrition and outcome goals should be stated in the nutrition assessment prior to the initiation of Specialized Nutrition Support (SNS)	C
Nutritional and outcome parameters should be measured serially during SNS therapy	B
Periodic comparison of nutritional and outcome measures with SNS goals should occur to monitor efficacy of therapy	C

NOTE. The authors used the AHRQ criteria to classify the strength of the evidence supporting each guideline statement. The evidence supporting each statement is classified as follows:[39,45]
A, There is good research-based evidence to support the guideline (prospective, randomized trials).
B, There is fair research-based evidence to support the guideline (well-designed studies without randomization).
C, The guideline is based on expert opinion and editorial consensus.

Table 3. Practice Guidelines (A.S.P.E.N.): Monitoring for Complications

Malnourished patients at risk for refeeding syndrome should have serum phosphorus, magnesium, potassium, and glucose levels monitored closely at initiation of SNS	B
In patients with diabetes or risk factors for glucose intolerance, SNS should be initiated with a low dextrose infusion rate and blood and urine glucose monitored closely	C
Blood glucose should be monitored frequently upon initiation of SNS, after any change in insulin dose, and until measurements are stable	B
Serum electrolytes (sodium, potassium, chloride, and bicarbonate) should be monitored frequently upon initiation of SNS until measurements are stable	B
Patients receiving intravenous fat emulsion should have serum triglyceride levels monitored until stable and when changes are made in the amount of fat administered	C
Liver function tests should be monitored periodically in patients receiving PN	A
Bone densitometry should be performed upon initiation of long-term SNS and periodically thereafter	C

NOTE. The authors used the AHRQ criteria to classify the strength of the evidence supporting each guideline statement. The evidence supporting each statement is classified as follows:[46,55]
A, There is good research-based evidence to support the guideline (prospective, randomized trials).
B, There is fair research-based evidence to support the guideline (well-designed studies without randomization).
C, The guideline is based on expert opinion and editorial consensus.

In our center, complete training takes 15 sessions (5 sessions/wk for 3 consecutive weeks). An expected duration of HPN lasting more than 3 months and benign but chronic intestinal failure are acceptable indications for complete education. Education requires at least 3 conditions: (1) a patient who understands the need for HPN treatment, (2) a stable and controlled somatic condition for which the patient is able to cope, and (3) emotional control.[60,61] All staff members provide full support to achieve the goal of patient self-management. Complete self-management in line and pump connection and disconnection from all-in-one nutritive bags provides important advantages to the patient: confidence and compliance in HPN treatment, greater freedom in daily living at home, and better ability to cope with family and community living. Indeed, self-management improves the quality of care.[62]

In the 1990s, we showed that the occurrence of a first related catheter sepsis was decreased in 79 HPN (53 benign, 14 cancer, and 12 human immunodeficiency virus patients; $P = .09$) self-managed patients (n = 44)

in comparison with non–self-managed patients (n = 35).[63] HPN funds can be linked to a managed clinical network.[64] Recent HPN surveys have indicated that self-management is lower (nearly 50% of patients) than in previous pioneering reports.[65–68] This increase in non–self-management probably is explained by hospital cost restrictions, some degree of expertise loss because of the dispersion of cases in nonapproved nontertiary care centers, and the increasing percentage of cancer patients who receive HPN for a short-term period. Indeed, an HPN survey in the 1980s in French-approved HPN centers showed a significant increase in the probability of survival according to the date of inclusion, with the number of deaths being higher during a 3-year run-in period than during the 2 subsequent 3-year periods.[69] Nutrition support team(s) that specialize in chronic intestinal failure are a prerequisite for running such HPN programs. This learning-curve observation that shows long-term health outcome improvement in HPN pleads now for intestinal failure units to cover and integrate expertise in all medical and surgical aspects of chronic intestinal failure treatment.[5]

Nutritive Mixtures

Nutritive mixtures, apyrogenic and sterile, are compounded by pharmacists in single bags called *all-in-one*, or sometimes *bipartite* (the second compartment for a lipid emulsion is opened and mixed with other compounds before use). Bags are made of phthalate-free multilayered ethyl vinyl acetate plastic. Total (H)PN should be complete therapy including adequate amounts of amino acids and glucose, a maximum of a third of total energy being furnished as triacyl-glycerol, of which a variable amount of polyunsaturated essential fatty acids is present.[70] In our opinion, furnishing more than 1 g/kg/day of 20% n-6 rich lipid emulsion(s) is a strong significant contributor to intrahepatic cholestasis, leading to extensive fibrosis and cirrhosis-associated HPN disease.[71] Complete PN also must include the 35 essential nutrients (electrolytes, minerals, vitamins, and trace metals) and amounts should be tailored according to the clinical and intestinal status of individual patients. All of these nutrients, of which it is important to avoid an excess or deficit, play a major role in nutritional efficiency and, along with energy, in nitrogen retention of PN. A separate sheet for PN prescription should be used to avoid omission.

When nutritive mixtures performed by pharmaceutical companies are used in PN, especially at home, there is a risk for deficiencies (vitamins usually are absent from these mixtures) and imbalances (eg, electrolytes, minerals, and excess fat/glucose ratio) if additives are not added according to the patient's requirements. Administering these necessary intravenous supplement(s) at home by nurse, caregiver, or patients themselves[72] instead of doing it under laminar hood flow creates, despite using aseptic techniques, an additional risk for infection. The stability of the mixture also might be compromised by inappropriate supplementation. Optimized HPN care still sometimes is not fully applied despite 35 years experience in long-term HPN.[66,67,73]

Technical Aspects

The placement of long-life silicone catheters at the superior vena cava–right atrium junction requires expertise with either underskin cuff externalized catheters or catheters with under-the-skin chambers. The advantages and disadvantages of both types of devices have to be explained to the patient before he can choose a device, but patients who have experience with both types of catheters usually prefer the under-the-skin chamber.[74] A reluctance to puncture the skin, a higher frequency of weekly nocturnal PN cycles, and more than 1 previous catheter-related infection are arguments for an externalized catheter, whereas patients who like water such as long showers and baths and those who are concerned with their body image will prefer an under-the-skin chamber. Furthermore, if catheter-related sepsis (nonlocal, nonvirulent bacterial, nonfungal sepsis) on an externalized catheter can be treated successfully (without removal of the catheter) with several types of antibiotic treatment (ie, systemic and/or local), the antibiotic lock technique leads to control in 90% of cases,[75–77] and sepsis is more difficult to eradicate with the under-the-skin chambers. Catheter-related blood stream infections should induce urgent catheter removal in patients with a hemodynamically unstable condition and in those with chambers or exit site infections involving the underskin cuff of tunneled catheters. Indeed, removal of the port is needed in more than 50% of patients.[59] One of the advantages of a subcutaneous tunnel on the anterior thoracic wall is to provide direct vision of the cutaneous entry of the catheter, which greatly facilitates self-line care.

The catheter-related sepsis rate is a way of measuring the quality of care and it can be as low as .13 episodes per year of catheter life.[59] It is not related to the type of material used (ie, chambers vs externalized catheters)[74] but it decreases with the use of strict aseptic techniques both at the site of skin entry of the catheter and at the connectors at the 2 ends of the line (ie, bag and catheter).[36,78,79] In cohorts of HPN patients a subset of approximately 20% of patients represents approximately 75% of the total number of cases of catheter-related

sepsis. It remains to be seen, as in non-HPN patients, if this increased risk is in part linked to the bacterial skin and/or nasal ecosystem.[80] In HPN patients having more than 1 catheter-sepsis episode, with no (sub)cutaneous catheter entry point infection and without evidence for breaking the aseptic technique at the connectors, several secondary prophylactic measures have been proposed such as adding antiseptic (taurolidine, not available in the United States) to the nutritive mixtures[81] or using the antibiotic lock technique[75] between the infusion PN cycles (personal positive results, unpublished data). The antibiotic-/antiseptic-coated catheters have not been used in HPN patients because the short duration of action in these catheters would not be of benefit.[36,38,76,82]

A strong policy for prevention of vein thrombosis must be used in HPN patients to decrease the rate of subclavian, jugular, and superior vena cava thrombosis.[3,83] Endogenous systemic thrombophilic factors, either primary or secondary, must be recognized and positive-risk patients must be treated with anticoagulant treatment. For example, HPN cancer patients benefit from preventive oral anticoagulation with 1 mg/day of oral warfarin, with more than a 50% decrease in catheter-related thrombosis vs the control group.[37] Exogenous localized catheter trauma or sepsis also increases the risk for venous thrombosis. A prevalence rate of 20% for vein thrombosis was found in cases of catheter-related sepsis.[84] This catheter-related risk is decreased by (1) the placement of the catheter by an experienced physician with the endovascular extremity located at the junction of the superior vena cava and the right atrium,[3,36] and (2) the use, in our practice, of prophylactic anticoagulation by either warfarin 1 mg/day or low heparin weight in every case of catheter-related sepsis, starting as soon as possible for a minimum duration of 3 days. In cases of superior vena cava thrombosis, the lower vena cava can be catheterized through the femoral vein, with a thigh or abdominal subcutaneous tunnel that significantly decreases the sepsis rate vs no tunnel,[85] the endovascular catheter tip being located upper to the renal–vena cava junction to prevent thrombosis.

When a venous thrombosis occurs, regular anticoagulant treatment (low molecular weight heparin, anti–vitamin K) is indicated for at least a 6-month period. To remove or not to remove the catheter depends on the patency of the vein flow: if intravenous infusion is impossible or induces pain or swelling then the nonfunctioning catheter has to be removed; if vein flow is normal down to the catheter tip then it is possible to keep the catheter because it has been shown that its life span is not reduced under ongoing anticoagulant treatment.[84]

Protocols to treat catheter blockade either blood clot, lipidic, or mineral during HPN recently have been published.[7,86]

Intestinal Failure and HPN Management

Definition of Intestinal Failure

The initial definition of intestinal failure is "reduction in functioning gut mass below the minimal amount necessary for adequate digestion and absorption of nutrients."[1] Three variables (2 clinical and 1 biochemical) have been shown to be able to delineate transient from permanent, or indefinite, intestinal failure in short-bowel syndrome (SBS) adult patients[87–91]; SBS represents nearly 80% of long-term HPN patients.[5,58,92] First, weaning from HPN can be achieved, according to different remaining lengths of small bowel depending on the 3 main anatomic types of SBS[87,89]: in end-jejunostomy (type I, no colon in continuity), in jejunocolonic (type II, some part of the colon is in continuity), and in jejuno-ileal (type III, the full colon is in continuity), the minimal lengths of a normal small bowel are 100 cm, 60 cm, and 35 cm, respectively.[87,89] For types II and III, 100 cm is required to wean patients off of HPN if the remaining bowel is abnormal but without stenoses. Second, the probability of weaning patients off HPN became less than 10% if weaning was not obtained during the first 2 years of HPN.[88,89] Third, a plasma level of postabsorptive citrulline, a nonessential amino acid not incorporated into peptides or proteins, lower than 20 μmol/L (half the normal value in controls) is associated significantly with permanent intestinal failure past the adaptive 2-year period after the re-establishment of bowel continuity after extensive small-bowel resection.[91] This biochemical marker cannot be used in renal insufficiency. It is correlated highly to remnant small-bowel length and absorptive capacity; it is more predictive of permanent intestinal failure (negative and positive predictive values of 86% and 95%, respectively) than remnant length of small bowel within the 3 anatomic types of SBS. In fact, citrulline seems to reflect the absorptive function of the remaining short gut because its level was significantly higher in 10 hyperphagic patients than in 10 normophagic patients paired with the same length of remnant small bowel.[91] It is interesting to note that in children with SBS, a similar citrulline threshold (19 μmol/L) recently was found for both length of remnant small bowel and development of enteral tolerance with comparable high negative (100%) and positive (87%) predictive values when observing weaning patients off HPN.[93] Length of the remnant bowel plus the citrulline

level offer the advantage of better defining appropriate HPN candidates for either complementary (pharmacologic trophic gut factors or reconstructive surgery) or alternative treatments for permanent intestinal failure.[5]

PN Dependence

It is important to set up a minimum level of PN dependence during HPN management. PN dependence can be viewed as minimal input of water, minerals, protein, and energy for patient's equilibrium.[94,95] It certainly is useful to try to define further the degree of PN dependence (from 0% to 100%) by comparing patient's net absorption, expressed as a percentage of oral autonomy (3-day balance study), and PN water, protein, and energy delivery (7-day intravenous infusion), expressed as a percentage of nutritional needs. This probably will provide information to help set the PN delivery closer to the effective PN dependence level. For example, an important discrepancy may exist in a patient's potential for achieving oral autonomy with diet alone (ie, the rate of absorption for energy/protein and/or water/salt indicate positive balance), while their HPN prescription still is important (ie, $\geq$3 infusions/wk).[94] Indeed, initial overuse of PN on entry into a study of diet, growth hormone, and glutamine therapy may explain, in part, the long-term success at weaning from PN over time with modified diet and glutamine alone, long after a short course of growth hormone was completed.[96] Notably, a parallel 3-arm study that compared PN-dependent SBS patients given either an individualized modified diet and oral glutamine (control), an individualized modified diet with growth hormone alone, or a modified diet with growth hormone and oral glutamine showed that a significant decrease in PN needs occurred in the control group during a 1-month treatment period, although this was significantly less than achieved in the 2 other arms.[97] Insufficient oral intake or oral failure, not directly dependent on the intestinal condition, is another caveat that compromises oral autonomy and also may induce a higher-than-needed PN delivery. In that circumstance, apart from psychologic evaluation, one may decide on a period of nasogastric tube feeding to evaluate the absorptive capacity of the remnant gut properly. This type of management may be justified because a high degree of PN dependence with intravenous hyperalimentation may accelerate, as shown in the past, the occurrence of metabolic complications (ie, liver failure).[98]

Patient Management

Two principles apply to obtain the minimum required level of PN dependence in a patient: to avoid exclusive or total intravenous feeding as much as possible and to implement enteral feeding as much as possible. Indeed, the prognosis of HPN patients was shown to be significantly better in patients with no bowel obstruction than in patients with chronic obstruction (eg, Crohn's or radiation enteritis patients). Therefore, the lesson drawn from this observation is that it is better to have a functioning and accessed short gut rather than a longer but nonfunctioning gut.[69] In our tertiary care center we therefore discuss every case to re-establish colonic continuity in SBS patients, whatever the age of the patient or the percentage of remaining colon (if $>$30% of a full colon[99] or the rectosigmoid alone provided a normal anatomy and function after treatment with short-chain fatty acid enemas[100]). In these patients, hydromineral and energy balance improve[101] and the number of PN cycles per week decrease. We also perform bowel resections in patients with multifocal obstructive disease (eg, in radiation enteritis plus a left colostomy if the anorectum is involved by the disease). These patients may recover normal fluid intake and again enjoy as large a food intake as possible, with the benefit of reduced PN dependence.

We later extended this concept in selected severe (medically resistant nonreversible) primary pseudo-obstruction syndrome patients. In these few patients, extensive small-bowel resection with a jejunocecal anastomosis was realized that allowed unrestricted oral intake without vomiting, a decrease in the degree of PN dependence, and a better quality of life.[102] Indeed, the macronutrient absorption of a very short remnant bowel is never negligible and the net balance increases with increased intake of free oral solid foods as large as 3-fold the patient's resting energy expenditure.[94,101,103,104] The behavior of hyperphagia should be encouraged with no futile solid food restriction because it promotes physiologic adaptive intestinal processes[101] and gives some patients with borderline remnant gut full oral nutritional autonomy. The latter lesson is derived from our large experience with balance studies on Western free solid-food feeding to determine net intestinal absorption (*In-Out*), *In* measured either with dietary inquiry or with duplicated diets and *Out* measured by 3-day stool collections.[94,101] In this regard our HPN management in a patient with chronic intestinal failure is a 2-stage process: (1) first, with the goal of restoring a low normal body mass index in underweight patients, we implement a 6-cycle PN regimen per week with a PN-free day, water electrolytes only if necessary, each cycle being no more than 1.3-fold the resting energy expenditure,[71] together with a free solid oral feeding permitted by a nonoccluded gut; (2) second, with the goal of main-

taining a near-normal body composition, we tried to reach, step by step, a minimum number of cycles per week[89]; water electrolyte needs being dissociated from energy-protein needs, especially in SBS type I patients, in whom the fluid balance is more difficult to achieve than the energy balance. Indeed, it was shown that 20% of these patients require only a water-electrolyte supply.[90]

In conclusion, management of HPN must be an integrated part of the management of the disease that has led to intestinal failure. We have new tools that permit better delineation in short bowel patients of transient from permanent (ie, irreversible intestinal failure). A better prognosis is observed in HPN patients having a short but functioning gut than in patients with a longer but nonfunctioning gut. Along with medical therapy, dietary management[94,101,103,104] of intestinal failure as a result of very short bowel is a crucial point that may reduce the PN dependence at its lower level, therefore decreasing the risk for technical and metabolic complications associated with long-term HPN.[104] Therefore, HPN in the management of intestinal failure must not be viewed as hyperalimentation but rather complete nutrition support for each PN cycle with a minimum number of PN cycles per week. This number obviously is reduced in patients in whom hyperphagia takes place. In most patients in our tertiary care center, HPN is a complementary nonexclusive mode of nutritional support.

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