ABSTRACT: Parenteral nutrition (PN) has been successfully initiated in the home since the early 1990s. The American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) Standards for Specialized Nutrition Support: Home Care Patients, Safe Practices for Parenteral Nutrition, and Guidelines for the Use of Parenteral and Enteral Nutrition in Adult and Pediatric Patients do not contain specific information on the initiation of home PN (HPN). Peer-reviewed, published guidelines are necessary to provide safe and appropriate initiation of HPN. Certain patients should not have PN initiated in the home, such as those with organ failure, uncontrolled diabetes, or uncor- rectable electrolyte abnormalities. Excellent candidates for initiation of HPN include patients who have failed enteral feedings, have gastrointestinal (GI) diseases without excessive GI losses, or those with an oncology diagnosis and inability to tube feed. One concern of initiation of HPN is the potential for refeeding syndrome. Refeeding syndrome can be prevented when patients are properly evaluated and managed before initiation of PN. Refeeding syndrome can be avoided by rehydration with fluid and electrolytes before initiation of HPN to normalize blood chemistry when necessary and by starting with a moderate-volume, low-carbohydrate HPN solution compounded with optimal potassium, phosphorus, and magnesium content, and slowly advanced to goal. The “start low and go slow” motto of nutrition support should continue to be followed, but more specific guidelines are needed to assist nutrition support clinicians with safe and appropriate initiation of HPN.

My view you know is that the ultimate destination is the nursing of the sick in their own homes . . . . I look to the abolition of all hospitals and workhouse infirmaries. But it is no use to talk about the year 2000.

—Florence Nightingale, from letter to Henry Boham Carter, 1867

Initiation of Intravenous (IV) Therapies in the Home

Increasing healthcare costs and concerns with improving patient quality of life have resulted in the movement of many hospital-based therapies to the outpatient or home setting. 1 This includes surgical therapies such as inguinal hernia repair and cholecystectomy where previous multiple-day admissions for surgery and postoperative care have evolved into same-day surgical procedures, with the majority of postoperative recuperation occurring in the home. 2 Several IV therapies, including chemotherapy, antibiotics, pain medication, and parenteral nutrition (PN), once relegated to delivery only in the hospital, now are common home-based IV therapies in appropriately selected patients. 3

The initiation of PN in the home is a natural extension of the movement of hospital-based therapies to the home. Some experts claim that PN can be reliably and safely initiated in the home, whereas other experts state that the risk for complications and the associated healthcare costs of these complications outweigh any potential healthcare benefit. 4,5 As with many other home- vs hospital-based medical therapies, there is little published evidence-based literature to draw reasonable conclusions. The American Society for Parenteral and Enteral Nutrition’s (A.S.P.E.N.’s) “Safe Practices for Parenteral Nutrition” does not contain information to guide providers on the safe initiation of PN in the home setting. 6 In addition, the A.S.P.E.N. “Guidelines for the Use of Parenteral and Enteral Nutrition in Adult and Pediatric Patients” do not contain information on home initiation of PN in either adult or pediatric patients. 7,8

Home Parenteral Nutrition (HPN) Standards

A.S.P.E.N. has published practice standards for the provision of HPN therapy. 9 In it, Standard 7.4 briefly addresses the initiation of PN therapy at home. It states that, “initiation of PN in the home setting shall only be considered in patients who are clinically stable, have an appropriate indication for PN, are able to be evaluated in the home, and are capable of safe administration of the therapy. Initiating therapy at home shall be considered only when assessment confirms that benefits greatly outweigh
the risks.” However, no specific information is available to describe the mechanistic details of an appropriate initiation of PN therapy at home. There are no peer-reviewed, published guidelines regarding the operational details of the initiation of PN in the home. What is clear is that for the safe and effective initiation of HPN therapy in the home, an operational system is required, with strict policies and procedures that define what is an appropriate patient population, identify responsible personnel and their roles, provide a thorough education process for patients and their care partners, establish a standardized clinical monitoring program, and implement a series of checks and balances to ensure positive clinical outcomes, maximize healthcare resources, and improve patient quality of life. This organized process requires the leadership of an outpatient home infusion nutrition support team, working in conjunction with the responsible physician and, if available, the inpatient hospital-based nutrition support team.

Advantages and Disadvantages of Home Initiation of PN

The advantages and disadvantages to initiation of PN in the home setting can be described according to clinical practice experiences. Advantages include hospital avoidance, reduction of exposure to hospital-borne pathogens, ability to continue to work and perform daily activities, HPN education in a familiar setting from the start of therapy, and reduced overall expenses in comparison with hospitalization. Additional advantages may include improved quality of life and reduced insurance expenditure of lifetime maximum benefits for certain commercial policies. Normalization of blood chemistries with fluid and electrolytes before PN initiation and flexible infusion times may also be accomplished during hospitalization but may be more cost-effective and convenient at home (eg, infuse after work, use ambulatory infusion pump with carrying case). Management and monitoring of HPN tolerance by the home nutrition support team (HNST) may be available and influential in the decision-making process of whether to initiate PN in the home or hospital.

Potential disadvantages of home initiation of PN include the possibility of inadequate education of the patient and the care partner if the provider lacks a protocol-driven education process, dehydration and possible rehospitalization (if not adequately managed), noncompliance by the patient to infuse HPN as prescribed, lack of immediate access to healthcare personnel (nurse, pharmacist, dietitian, physician) at all times, dependence upon the home infusion provider or nursing agency, and possible delay in obtaining blood chemistry results.

Potential problems associated with the initiation of PN in both the hospital and home include refeeding syndrome. Refeeding syndrome is characterized by derangements of serum levels of glucose, phosphorus, potassium, and magnesium, as well as cardiac function and fluid status. Overaggressive carbohydrate infusion (“hyperalimentation”) to a person in a starvation state causes the potassium, phosphorus, and magnesium to shift intracellularly for anabolism. Excess carbohydrate infusion can also cause hyperglycemia, in addition to fluid and sodium retention. Physical symptoms of refeeding syndrome include muscle weakness, spasms, confusion, dizziness, shortness of breath, and edema. Additional potential PN problems include mechanical complications (with catheter, pump, tubing, additives, site dressing); metabolic complications, including fluid and electrolyte imbalance; lack of management of gastrointestinal fluid losses; hyperglycemia due to excessive carbohydrate or inadequate insulin coverage in the diabetic patient; and infectious complications (line infection or catheter-related bloodstream infection).

Appropriate Patient Population

Who can safely start receiving PN in the home? Crocker et al note that, “Not all patients are suitable for the initiation of PN in the home.” Attempting to initiate PN at home in patients who have uncontrolled diabetes, hemodynamic instability, severe malnutrition in which they may be at risk for refeeding syndrome, major organ failure, inadequate venous access, history of noncompliance, or recent substance abuse would not be ideal. The clinician must carefully consider what is safe and appropriate for the patient. In order to make a decision of the appropriateness of home initiation of PN, a systematic approach to evaluation should be followed. This includes a thorough medical and social history. Descriptions of which patients are suitable for initiation of PN at home are included in Table 1. A checklist for the provider’s use in determining the appropriateness of HPN initiation is included in Table 2. The physician or outpatient clinician may encounter the patient in the outpatient setting and determine that HPN is required. The option of home PN initiation should be offered to the patient when appropriate, including discussion with the home care provider and a review of payer benefits. Patients determined to have risk factors associated with refeeding syndrome (such as severe cachexia, chronic malnutrition, significant gastrointestinal fluid losses, postbariatric surgery, history of alcoholism) should be evaluated carefully. Baseline blood chemistry results should be normal or corrected to normal with fluid and electrolyte infusion (especially potassium, phosphorus, magnesium, and glucose) before PN initiation. Table 3 lists recommended adult electrolyte ranges for PN solutions. Patients with normal baseline blood chemistries are still at risk for refeeding syndrome if they are given excess carbohydrate and inadequate potassium, phosphorus, and magnesium. The general rule of thumb for PN initiation is to “start low and go slow”; begin with only 25%–50% of nutrition therapy goals and proceed grad-
Table 1
Description of possible candidates for initiation of home parenteral nutrition (HPN)

<table>
<thead>
<tr>
<th>HPN can be initiated in the home for the following patients or conditions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failed enteral tube feeding</td>
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<tr>
<td>Gastrointestinal diseases</td>
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<tr>
<td>Oncology diagnosis with malabsorption</td>
</tr>
<tr>
<td>HIV or AIDS with malabsorption</td>
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<tr>
<td>Hyperemesis gravidarum with normal blood chemistry results</td>
</tr>
<tr>
<td>Serum laboratory values are normal, especially potassium, phosphorus, magnesium, glucose</td>
</tr>
<tr>
<td>Physician available for PN-order adjustments and patient management</td>
</tr>
<tr>
<td>History of previous good tolerance to PN</td>
</tr>
<tr>
<td>Care partner available (preferred)</td>
</tr>
<tr>
<td>Adequate central venous access</td>
</tr>
</tbody>
</table>

HPN should not be initiated in the home for the following:

- Organ failure (liver, cardiac, renal)
- Uncontrolled diabetes (insulin or oral medication)
- Severe or chronic malnutrition with risk of refeeding syndrome
- Abnormally low serum levels of potassium, phosphorus, and/or magnesium despite rehydration and electrolyte replacement
- Unsafe home environment
- Pediatric patients with no history of PN
- Young or elderly (chronic illness with any of above)
- No venous access
- >1 L nonurinary fluid losses daily
- Tolerance to enteral tube feeding
- Physician unavailable for PN order adjustments and patient management

PN, parenteral nutrition.

Table 2
Checklist of considerations before initiation of home parenteral nutrition (HPN)

- Age, weight, usual weight, ideal weight, and height
- Diagnosis
- No evidence of malnutrition
- No history of recent alcohol or substance abuse
- Nonurinary losses <1 L/day (if >1 L/day, discuss with physician)
- Patient seen in previous week by prescribing physician and physician available for order adjustments
- No organ failure (liver, kidney, cardiac)
- Good glucose control (80–140 mg/dL at all times)
- Enteral feedings not tolerated or not possible
- Patient has nonfunctioning GI tract
- Current blood chemistry results are normal or correctable, especially potassium, phosphorus, magnesium, glucose
- No fever or untreated infection
- Patient and/or care partner willing and able to become independent with all aspects of HPN administration
- Environmental assessment adequate (electricity, running water, working telephone, working refrigerator, no safety concerns)
- Patient’s abnormal vascular volume status can be corrected with hydration before PN initiation
- History of good tolerance to PN (recommended for pediatrics)
- Central venous access confirmed

GI, gastrointestinal; PN, parenteral nutrition.

Example of Home Initiation PN Formulas With Infusion and Monitoring Guidelines

Through use of the algorithm depicted in Figure 1, the nutrition support clinician can determine whether a patient is a candidate for home initiation of PN and hospital avoidance. In general, a conservative approach is followed to minimize or prevent complications. Abnormal laboratory values may be normalized with fluid and electrolyte replacement before PN initiation; this can be done in the home or outpatient setting if necessary. Table 3 lists the generally accepted PN electrolyte dosage ranges for healthy adults.\(^6\) PN dosage ranges for pediatric electrolytes can be found in A.S.P.E.N.’s “Safe Practices for Parenteral Nutrition,” by Mirtallo et al.\(^6\) Table 4 guides the clinician through development of an initial HPN solution for patients at possible risk for refeeding syndrome, and Table 5 can be used as a guide for patients not at risk for refeeding syndrome.

Total nutrient admixtures (TNA) or “3-in-1” PN solutions that contain IV fat emulsion (IVFE), carbohydrate, and amino acids all in 1 bag are often preferred for home infusion.\(^14\) Electrolyte guidelines for HPN formulation must be followed to ensure physical compatibility.

Glucose Monitoring for HPN

Glucose control and monitoring during HPN are just as important at home as in the hospital. Ensure

Table 3
Adult daily parenteral electrolyte additives

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Standard requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>10–15 mEq</td>
</tr>
<tr>
<td>Magnesium</td>
<td>8–20 mEq</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>20–40 mmol</td>
</tr>
<tr>
<td>Sodium</td>
<td>1–2 mEq/kg</td>
</tr>
<tr>
<td>Potassium</td>
<td>1–2 mEq/kg</td>
</tr>
<tr>
<td>Acetate</td>
<td>As needed for acid-base balance</td>
</tr>
<tr>
<td>Chloride</td>
<td>As needed for acid-base balance</td>
</tr>
</tbody>
</table>

that all patients starting to receive HPN use glucose monitoring devices and test strips. Due to the ambulatory pump program of a 1-hour taper up and down, patients are instructed to check fingerstick glucose levels 2 hours into HPN infusion and 30–60 minutes after HPN infusion to maintain a blood glucose level between 80 and 140 mg/dL. During pregnancy, the blood glucose goal is 80–120 mg/dL. The carbohydrate content is not advanced and the infusion time is not compressed unless the blood glucose is within the desired range. After desired HPN nutrient and infusion rate goals are achieved, fingerstick glucose monitoring is not required for nondiabetic patients, unless desired for particular patients, such as during pregnancy or if a patient is symptomatic. If hyperglycemia occurs, discuss with the patient’s physician and evaluate for possible infection and treat as required. Speak with the physician if it is determined that a decrease in carbohydrate content and an increased infusion rate may be necessary to normalize blood glucose (may need to resume previously tolerated formulation). Ambulatory infusion pumps used in the home can be reprogrammed for a 2-hour taper up and down mode, which may prevent hyper/hypoglycemia. Oral intake is encouraged when possible after HPN infusion to avoid hypoglycemia. Additional injections to the HPN bag by the patient are generally discouraged; a reduction in carbohydrate content, if necessary, can be made through the ambulatory infusion pump.
Table 4
Sample recommendations for adult home parenteral nutrition (HPN) initiation at home for patient at possible risk for refeeding syndrome

1. Check baseline serum chemistry, including magnesium, calcium, phosphorus, electrolytes, glucose, blood urea nitrogen (BUN), and creatinine. Normalize blood electrolytes and minerals with IV infusion before initiation of HPN when necessary. Limit volume as necessary.
2. Evaluate for medications which may affect tolerance to PN.
3. Initiate PN with limited-volume, 1000-mL total nutrient admixture (TNA; “3-in-1”) or “2-in-1” HPN infusion over 24 h, with a 1-h infusion taper at the beginning and end of the infusion if desired. Initial base contains 50% of carbohydrate goal, 50%–75% amino acids goal, and 50%–75% IV fat emulsion (IVFE) goal. Example: 1000 mL TNA: 100 g carbohydrate, 50 g amino acids, and 200 mL 20% IVFE. A concentrated amino acid solution may be necessary, and base component percentages may vary due to 1000-mL volume restriction.
4. Add electrolytes and minerals according to generally accepted concentrations (Table 3), with adjustments made to meet clinical requirements. Maximize the potassium, phosphorus, and magnesium that are soluble and stable in the 1000-mL HPN formulation according to physical compatibility guidelines for TNA formulation.
5. Standard multivitamin dose injected into HPN by patient or care partner daily; consider adding thiamine 100 mg/day for first 3 days if patient has had minimal oral intake for >2 weeks or history of alcoholism.
6. Add histamine-2 blocker if patient is symptomatic or unable to absorb proton-pump inhibitor.
7. Educate the patient and care partner about HPN administration, catheter care, HPN complications, and self-monitoring of temperature, weight change, edema, and fluid balance. Vital signs, including heart rate, blood pressure, and respiratory rate, should be evaluated daily by the RN during the first 3 days of therapy and weekly thereafter.
8. Fingerstick glucose levels should be monitored with a glucometer during initial HPN infusion and subsequent increases in carbohydrate and decreases in infusion time to assure glucose remains 80–140 mg/dL or 80–120 mg/dL during pregnancy.
9. RN observation of patient tolerance to IVFE (as test dose) during initial 30-minute infusion.
10. Deliver 3 bags of initial HPN formula to infuse daily for 3 days as tolerated.
11. Collect blood chemistry results 24 h after infusion initiated, including magnesium, phosphorous, calcium, electrolytes, BUN, creatinine, glucose, and triglyceride. If laboratory results are normal and HPN volume is tolerated, continue to infuse remaining TNA formulation bags each over 24 h. Remix HPN if an electrolyte adjustment is required.
12. Recheck blood chemistry, including magnesium, phosphorus, calcium, electrolytes, BUN, creatinine, and glucose 72 h after PN initiation (by day 3). Increase HPN volume, amino acids, IVFE, and carbohydrate by 25% for next PN formulation and adjust electrolytes, ensuring potassium, phosphorus, magnesium increased as TNA volume allows, to achieve individual needs. Note: if serum magnesium, phosphorus, or potassium levels are below normal levels or hyperglycemia occurs, do not increase carbohydrate and adjust electrolytes in HPN formula or administer separate infusions as needed. Check laboratory results to assess tolerance during progression to goal.
13. Obtain blood chemistry results after newly formulated HPN infused for 2–3 days (around days 5–6), including levels of magnesium, phosphorus, calcium, electrolytes, BUN, creatinine, and glucose.
14. Continue to advance carbohydrate, IVFE, protein, and volume gradually to achieve nutrient and fluid goals; adjust electrolytes as needed. Fingerstick glucose levels should be checked by a glucometer after each increase in carbohydrate, and glucose maintained at 80–140 mg/dL.
15. Once nutrient and fluid goals are achieved, gradually decrease infusion time by 2–4 h daily to cycle to typically a 12-h overnight infusion with a 1-h taper up and down. Continue fingerstick glucose checks during cycling process. Increase to 2-h taper up and down if hyper/hypoglycemia occurs.
16. Weekly blood chemistry should include magnesium, phosphorus, calcium, electrolytes, BUN, creatinine, and glucose.

A 45-year-old woman was only able to consume 500 kcal of clear liquids daily due to development of an ileostoma after surgery for cervical cancer. She presented to the physician with generalized weakness. Her height was 173 cm and her weight was 93 kg. The physician called the home care provider from the oncology clinic, with a referral for initiation of HPN, with the request from the patient that she miss as little work as possible. The patient was scheduled for central line placement and radiology confirmation at an outpatient center the next day. Results of baseline blood chemistry, including potassium, phosphorus, and magnesium, were normal. HPN was initiated that same evening (Thursday) at home. The initial TNA formulation was 1500 mL and contained 150 g carbohydrate, 75 g amino acids, 200 mL 20% IVFE, multivitamins, trace minerals, and electrolytes. The HPN solution was infused over 18 hours, with a 1-hour taper at the beginning and end of the infusion. Five bags were delivered for the daily infusions. Follow-up blood chemistry results
were normal. The patient returned to work on Monday (day 5). The carbohydrate content was increased to goal, 300 g, by day 6. The TNA volume increased to 2000 mL, amino acids to 100 g, and IVFE to 225 mL. Her fingerstick glucose remained 80–140 mg/dL during and after the infusion. The TNA infusion time was compressed to 12 hours over the next few days. The patient missed only 2 days of work (Thursday and Friday) due to the excellent coordination of care. She continued to work and kept receiving HPN for 16 weeks.

### Survey of Patients Initiated on HPN

There is currently very little published information regarding the outcomes of patients who begin receiving PN in the home setting. From 2003 to 2005, data were voluntarily collected from clinicians working at 36 branch locations of a national home infusion provider (Coram Inc). The data collected were a representative sample of patients initiated at home on PN, but did not represent all patients initiated at home from the provider base of 72 branches. The data collected included age, sex, diagnosis, vascular access, determination of risk of refeeding syndrome according to an internal checklist, baseline laboratory values (pre-HPN), follow-up laboratory results, and days to achieve HPN goal. Data from 119 of 125 patients were analyzed. Table 6 describes the demographics of the patients initiated receiving PN in the home setting; the patients either had a gastrointestinal or oncology diagnosis. The majority of these patients had either a Port-a-

### Table 6

Demographics of 119 patients starting home parenteral nutrition (HPN), average age 48 y (range, 4–89)

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Diagnoses</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Digestive diseases</td>
</tr>
<tr>
<td>Males</td>
<td>41</td>
<td>67%</td>
</tr>
<tr>
<td>Females</td>
<td>78</td>
<td>56%</td>
</tr>
</tbody>
</table>

Digestive diseases include malabsorption, hyperemesis gravidarum, pancreatitis, Crohn's disease, fistulas, motility disorders. Oncology includes head, neck and esophageal; peritoneal; gastrointestinal; lung; ovarian; sarcoma; brain; renal; lymphoma.
in 1 patient with severe muscle weakness and muscle cramping. It was reported that the patient fell down at home 3 times. Laboratory results revealed a serum phosphorus level of 1.0 mg/dL and a serum magnesium level of 1.1 mg/dL. There were no cases of respiratory or cardiac decompensation reported.

The survey of 119 patients demonstrated that PN therapy can be initiated in the home safely. It also demonstrated that refeeding syndrome can be prevented when patients are properly evaluated and managed before the home initiation of PN. Patients with baseline laboratory results indicating low serum levels of potassium, phosphorus, or magnesium should be rehydrated and blood levels normalized before HPN. All 119 patients evaluated avoided hospitalization in order to receive HPN. According to constructed cost models at Coram Inc, a cost savings of $4500 per patient, or a total of $535,500 for 119 patients, was achieved by prevention of 3 $1500-per-day hospital days to start and cycle PN therapy before discharge. The potential complications associated with rapid progression to PN goal in the hospital may be prevented in the home setting by “starting low and going slow,” taking the time necessary to achieve individual nutrient and infusion rate goals in the comfort of home.

Conclusion

A skilled HNST, recognized as essential for optimal management of long-term HPN patients, can also facilitate successful HPN initiation with:

- Evaluation of baseline pre-HPN laboratory results, especially serum levels of potassium, phosphorus, magnesium, and glucose
- A comprehensive review of medical history, including nutrition status, diabetes, and gastrointestinal losses, and evaluation of risk of refeeding syndrome
- Correction of fluid and electrolyte imbalance before initiation of HPN
- An initial infusion of a low-carbohydrate HPN solution, compounded with adequate amounts of magnesium, phosphorus, and potassium, according to individual requirements and risk of refeeding syndrome
- Close monitoring of HPN tolerance, with laboratory results evaluated at least weekly and HPN solution adjusted as required until nutri-
ent and infusion goal is achieved and laboratory values are consistently within normal limits
- Close communication and contact with the physician, patient, and care partner
- Excellent nursing education, assessment, and monitoring to enable the patient to be independent and successful with the HPN infusion therapy
- Recognition of opportunity for appropriate transition from HPN to enteral nutrition

Established guidelines for initiation of HPN are necessary, along with experienced HNST clinicians. Adherence to the established guidelines, in addition to patient compliance with self-monitoring, is essential in preventing the occurrence of refeeding syndrome and other potential HPN complications. Home initiation of PN can achieve significant cost-savings and patient satisfaction in the comfort of familiar surroundings, and should be considered whenever hospitalization is neither desired nor required.

Acknowledgments

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References