This article provides a review of TPN therapy, encompassing the rationale for its use, physiological changes produced, and metabolic problems. For the times when the anesthetist may be required to monitor a patient undergoing such therapy, this background data should prove beneficial.

New techniques widen the anesthetist’s scope and understanding, while placing a new perspective on total anesthesia care and management. Here is one such technique that bears consideration.

Total parenteral nutrition (TPN) is the continuous intravenous injection of hypertonic solutions of dextrose, protein (as crystalline amino acid or hydro-salate), vitamins and trace elements. It maintains the status quo in patients unable to utilize nutrients by achieving a positive nitrogen balance, weight gain and normal wound healing. It is used in treatment or prevention of malnutrition from varying causes: surgical, pathological and psychological. These include:

1. Preoperative preparation of the malnourished patient.
2. Prolonged postoperative surgical complications (such as, postbowel resection).
3. Inflammatory bowel disease (such as, ulcerative colitis).
4. Inadequate oral intake.
5. Hypercatabolic states (such as, burns and fever).
6. Psychiatric problems (such as, anorexia nervosa).

Total parenteral nutrition is prescribed by the physician in relation to each particular patient’s needs.

TPN administration

A central venous catheter is threaded into the superior vena cava above the heart. The use of a large vein permits the rapid dilution of hypertonic solutions and lessens the occurrence of rapid osmotic pressure changes and phlebitis.¹

Short-term isotonic infusions are successfully given in the peripheral veins. In this instance, nutrients are limited and are carefully selected for the patient’s specific needs. Unlike central venous lines, blood, blood products, medications and supplemental intravenous solutions may be given via peripheral TPN lines. No additives are given through central venous TPN lines to prevent sepsis.

A TPN infusion is administered at a slow, constant rate with gradual increases up to the patient’s limit of tolerance. With this protocol, most patients can tolerate large amounts of TPN solution. A malnourished patient may receive up to 3 liters per day of hypertonic solution, or 2,500 calories. Accurate titration is aided by the use of an intravenous (IV) pump.

TPN solutions are discontinued slowly so as to avoid the patient having an insulin reaction caused by continued endogenous insulin secretion.
TPN solutions

TPN solutions vary in content and concentration. Here is an example of a typical solution:

- 50% dextrose is diluted with an equal amount of crystalline amino acid solution, providing a 25% dextrose solution or 550 calories per liter. To this are added electrolytes, vitamins, and sometimes lipids.
- The average dose of sodium added to the TPN solution is 100 milliequivalents per day, plus additional amounts to replace losses via the nasogastic tube, or from wound drainage.
- Potassium, vital to body efficiency, is lost in large amounts following surgery, trauma, large nitrogen losses and in dextrose metabolism.
- Frequent potassium level assessment is required, and replacement of its loss is essential. The average potassium requirement is 60-80 milliequivalents per day, but doses up to 250 meq. per day have been needed for some patients on a 3-liter per day regimen.
- Insulin is added to TPN solutions if the patient's ability to metabolize glucose is inadequate. The average dose is 15 units per liter.

Metabolism

Understanding the mechanism of metabolism can serve to illustrate the useful effect of TPN therapy.

Starvation is intensified by injury or disease: the body's metabolic rate is frequently increased, causing a demand for more energy, and thus, the accelerated use of adipose tissue results. This in turn accelerates the wasting of body protein; for example, burn patients have a 100% increase in metabolic rate, requiring 40-60 calories per kilogram per day. (The normal rate is 25-30 cals/kg/day.)

Protein supplies amino acids and nitrogen to maintain a constant level of body protein. Estimation of protein levels is calculated as nitrogen intake and output. Each gram of excreted nitrogen in excess of intake represents the depletion of 6.25 grams of protein, that is, a negative nitrogen balance.

Inadequate carbohydrate and lipid (or more rarely protein) intake results in catabolism.

TPN replacement protein consists of amino acids, both essential and non-essential, or protein hydrosalates.

Lipids are hydrolyzed, absorbed and then resynthesized to triglycerides for long-term energy reserve. Immediate energy is supplied by lipids from the burning of free fatty acids in the Kreb's cycle. The greater the reliance on lipids for energy, the greater the incidence of ketosis and acidosis from incomplete metabolism. Nevertheless, essential fatty acid deficiency has been observed in patients who receive long-term TPN therapy devoid of lipids.

Lipids offer the highest concentrated source of calories—9 kilocalories per gram. Lipids offer an ideal supplement to peripheral TPN therapy, as a 20% fat emulsion is not considered hypertonic; therefore no diuresis or phlebitis occurs. Plus, there are the additional benefits of vitamins A and D.

Carbohydrates, following hydrolysis, may be oxidized for immediate energy reserve by conversion to glycogen, or for storage in the liver or muscle. For long-term energy supply, carbohydrates may be converted to fatty acids and stored as neutral fat.

Possible complications

Complications that result from TPN therapy are either metabolic or technical. Both are of concern to the anesthetist. Surgical patients presented for anesthesia may have functioning TPN lines, requiring the anesthetist to have an awareness of the metabolic side effects and/or drug interactions.

Technical problems may require the aid of anesthesia personnel in maintaining vital support systems, while surgical intervention and corrections occur. These problems would generally concern the pleural space, neck or mediastinum.
The following complications are important to note.

Symptoms of dyspnea, cyanosis and shock can be caused by:

1. *Hydrothorax*, where the central venous line has been threaded into the pleural cavity. The aspirate will contain TPN fluid.

2. *Pneumothorax* can occur and a chest tube is required if more than 20% of the lung has collapsed.

3. *Mediastinal haematoma* can obstruct the superior vena cava. Evacuation of the haematoma has to be done promptly in the operating room.

Symptoms of all, or some of the following: dyspnea, tachypnea, tachycardia, cyanosis, central venous pressure (CVP) elevation, disorientation, shock or cardiac arrest are indicative of the infrequent case of air embolism. This can be shown by EKG readings, arterial blood gas (ABG) readings, and the characteristic sound of precordial mill wheel churning. Treatment consists of quickly venting the CVP catheter and tilting the patient in the head-down position.

Cardiac tamponade with dyspnea, chest pain, tachycardia, tachypnea, cyanosis, CVP elevation, disorientation, shock, or cardiac arrest may be due to myocardial perforation resulting from the infusion of TPN fluid into the myocardium.2

Dysrhythmias are frequently caused by myocardial irritation from the catheter, and is cured by pulling the catheter back.

Pericardial effusion with tamponade, dyspnea, chest pain, tachycardia, tachypnea, cyanosis and shock indicate that the CVP catheter is blocking the coronary sinus and obstructing venous flow from the heart. To solve the problem, the catheter is withdrawn.2

Thrombi are sometimes found at cannula puncture sites or at the point where the tip of the catheter abrades the vessel wall. Also, the fibrin sleeve can mobilize even a few days after catheter withdrawal—this too, can cause a thrombus. The danger is that all thrombi can embolize to the lungs.

Accidental arterial puncture which, when it occurs, requires pressure for a few minutes.2

Lymphatic leak is usually found on the left side with lymph drainage from the puncture site. Treatment consists of removing the catheter and applying a pressure dressing.2

Shoulder pain can result from trauma to the brachial plexus, paralysis of the left circumflex axillary or suprACLavicular nerves. This pain clears spontaneously with time.

Infection, a major long-term complication, is prevented by strict aseptic techniques, including no additives to the central TPN line.3 Peripheral lines may have drugs, blood or blood products infused along with the TPN solution.

**Metabolic complications**

The following metabolic complications may occur in patients undergoing TPN therapy.

Glucose intolerance occurs when the pancreas is unable to adapt to the new demands of increased glucose metabolism. It is most frequently seen in diabetic and severely debilitated patients.

The infusion of crystalline amino acids can cause a hyperchloremic metabolic acidosis due to the release of hydrochloric acid during the metabolism of the amino acids. This condition is less likely to occur if the acetate base of the sodium and potassium salts are used, thereby decreasing the number of hydrogen and chlorine ions.2

Hypophosphatemia can be precipitated by TPN infusions or inadequate TPN levels.2 In these cases, the patient often complains of parathesias, lethargy, or mental confusion, and red blood count function can decrease. The addition of phosphate to the infusion reverses the situation. If the hypophosphatemia is acute, dilute potassium phosphate is given via a peripheral line. Calcium has to be given simultaneously to prevent rebound hypocalcemia.

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Cardiac arrhythmias and muscular weakness with the characteristic flattened T-wave on the EKG may be due to potassium loss from the gastrointestinal tract. Hypercalemia may also cause myocardial irritability.

Sodium deficiency is associated with lethargy and confusion; the treatment is to replace the sodium. If the low serum sodium is due to water intoxication, then simultaneous sodium salts are given while the patient’s fluid intake is restricted. Conversely, in hypernatremia, the patient complains of thirst, skin turgor is decreased, and the temperature is elevated.

Hepatic dysfunction and urea cycle amino acid deficiency sometimes produces untoward elevated ammonia levels in patients receiving TPN therapy.\(^2\) The infusion has to be decreased or discontinued. This condition is more frequently found in infants.

Any condition producing renal dysfunction or impairment contradicts the use of TPN therapy.

Osmotic diuresis (osmotic dehydration) occurs when the patient’s renal threshold for glucose is exceeded and large amounts of glucose spill into the urine.\(^2\) The treatment of hyperosmolar hyperglycemic, nonketotic coma is to stop the TPN therapy and administer a solution of 2.5% glucose with 0.45% sodium chloride intravenously in large amounts. Coma is due to a low insulin level from pancreatic exhaustion, and small doses of crystalline zinc insulin bring elevated blood sugar levels back to normal.\(^2\)

Folic acid, vitamin B\(_{12}\) and vitamin K are supplemental vitamins necessary to prevent anemia. Iron is given intramuscularly.\(^2\) Vitamin D toxicity possibly causes hypercalemia.

TPN infusions must be discontinued gradually to prevent rebound hypoglycemia.\(^4\)

Patients require care in stabilization of biochemical and physiological levels by precise titration of TPN infusion rates. When the infusion rate is equilibrated with the patient’s needs and the TPN rate remains constant, then the minimal monitoring requirements found in the accompanying table are applied. These parameters can be helpful for the preanesthetic review and the evaluation of the patient’s condition.

### Biochemical Monitoring

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Frequency</th>
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</thead>
<tbody>
<tr>
<td>Urine</td>
<td>Q6H</td>
</tr>
<tr>
<td>Urinary glucose</td>
<td>Daily, until stable, then bi-weekly</td>
</tr>
<tr>
<td>Serum glucose</td>
<td>Daily, until stable, then bi-weekly</td>
</tr>
<tr>
<td>Serum electrolytes</td>
<td>Daily, until stable, then bi-weekly</td>
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<td>Daily</td>
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<tr>
<td>N(_2) balance</td>
<td>Daily</td>
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<tr>
<td>Ca., Phos., Mg.</td>
<td>Weekly</td>
</tr>
<tr>
<td>Pro time</td>
<td>Weekly</td>
</tr>
<tr>
<td>Blood ammonia</td>
<td>Weekly</td>
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<tr>
<td>Vital signs</td>
<td>Daily</td>
</tr>
<tr>
<td>Temperature</td>
<td>q.i.d.</td>
</tr>
</tbody>
</table>

**REFERENCES**


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