Two-year-old lad suffers from mystery condition that means he can't eat or drink ANYTHING - including water

Little Liam Denner has to be fed intravenously but his mum Zoe says the tot is in a race aginst time for a diagnosis

BY STEPHEN WHITE
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NEWS

CHILD ABUSE

Twin baby girls found 'covered in faeces and crawling with maggots suffered worst abuse nurses had ever seen'


543

Total Parenteral Nutrition

Keynote Speaker:

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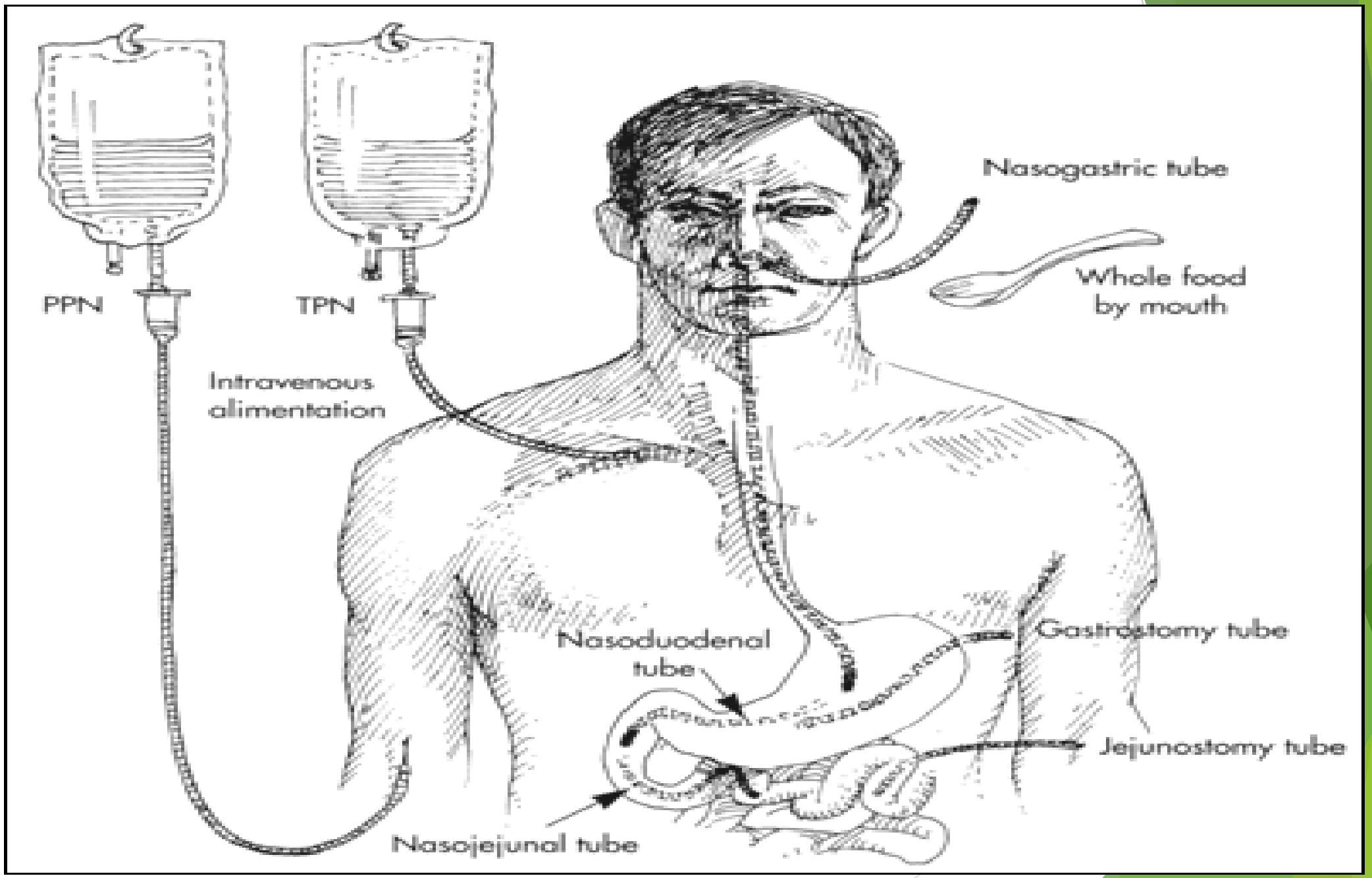
What is TPN?

- Parenteral nutrition: process of supplying nutrients via the intravenous route
  - Total parenteral nutrition (TPN)
  - Peripheral parenteral nutrition (PPN)
- TPN may reduce morbidity and mortality after major surgery, severe burns, and head trauma, especially in patients with sepsis.
- TPN is often used in hospital, long term care, and sub-acute care, and infrequently is used in the home care setting.


PPN
TPN
Intravenous alimentation
Nasogastric tube
Whole food by mouth
Nasoduodenal tube
Gastrostomy tube
Jejunostomy tube
Nasojejunal tube

Indication

- Inability to absorb nutrients via the GI tract because of one or more of the following:
  - Massive small bowel resection
  - Intractable vomiting when adequate EN is not expected for 7-14 days.
  - Severe diarrhea
  - Bowel obstruction
  - GI fistulae: PN is indicated for patients with prolonged inadequate nutritional intake longer than 5-7 days who are not candidates for EN.

- Cancer: antineoplastic therapy, radiation therapy, or HSCT
  - moderately to severely malnourished patients receiving active anticancer treatment who are not candidates for EN.
  - PN is unlikely to benefit patients with advanced cancer whose malignancy is unresponsive to treatment.
  - PN is appropriate for patients undergoing HSCT who are malnourished and who are anticipated to be unable to ingest and/or absorb adequate nutrients for 7-14 days.
- Pancreatitis: severe pancreatitis with prolonged inadequate nutritional intake longer than 5-7 days who are not candidates for EN. PN should be used when EN exacerbates abdominal pain, ascites, or fistula output.

- Critical care
  - whom EN is contraindicated or is unlikely to provide adequate nutritional requirements within 5-10 days.
  - Organ failure (liver, renal, or respiratory): moderate to severe catabolism when EN is contraindicated.
  - Burns: whom EN is contraindicated or is unlikely to provide adequate nutritional requirements within 4-5 days.
- Perioperative PN
  - Preoperative: for 7-14 days for patients with moderate to severe malnutrition who are undergoing major GI surgery, if the operation can be safely postponed.
  - Postoperative: for patients in whom EN is contraindicated or is unlikely to provide adequate nutritional requirements within 7-10 days.

- Eating disorders: anorexia nervosa and severe malnutrition who are unable or unwilling to ingest adequate nutrition.

- Adult PN therapy is not an emergent intervention and should not be initiated until the patient is hemodynamically stable.
- In general, adults who are not candidates for enteral nutrition should be considered candidates for PN after 7 to 14 days of suboptimal nutritional intake.

Patient Assessment

- ***Nutrition History***: malnutrition
- ***Weight History***
  - 5% of usual weight within 1 month, or 10% of usual weight within 6 months

$$\%\ \text{IBW} = \frac{\text{Current weight}}{\text{IBW}}\,(100) \qquad \%\ \text{Usual body weight} = \frac{\text{Current weight}}{\text{Usual body weight}}\,(100)$$

- ***Physical Examination***
- ***Anthropometry***
- ***Biochemical Assessment***

Visceral Proteins for Nutrition Assessment

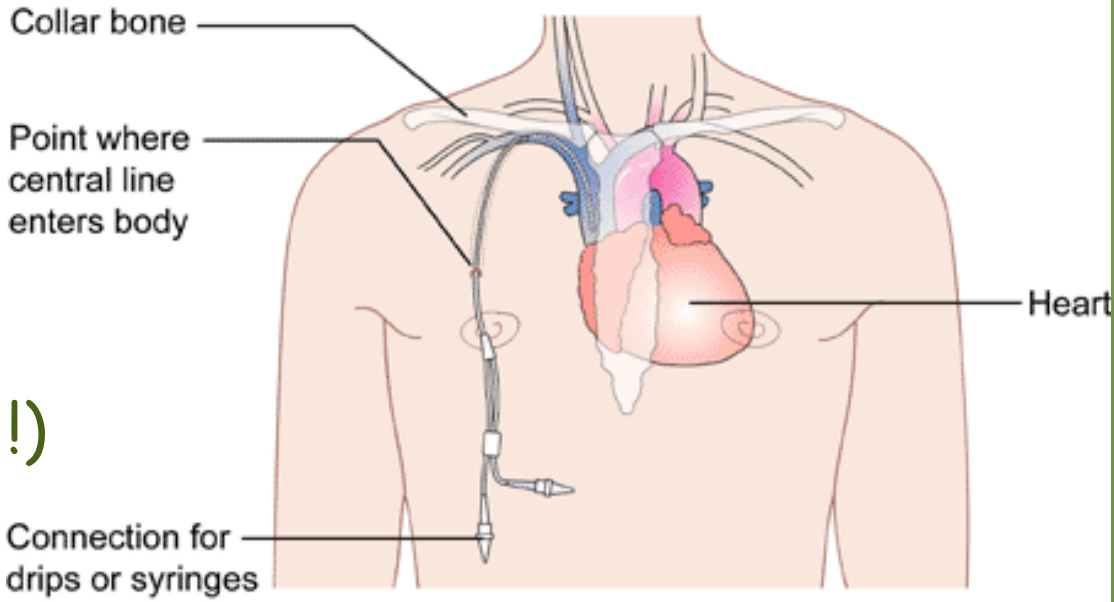
Visceral Protein	Half-Life (Days)	Normal Serum Concentration
Albumin	18–21	3.5–5 g/dL
Transferrin	8–10	250–300 mg/dL
Transthyretin (prealbumin)	2–3	15–40 mg/dL
Retinol-binding protein	0.5	2.5–7.5 mg/dL

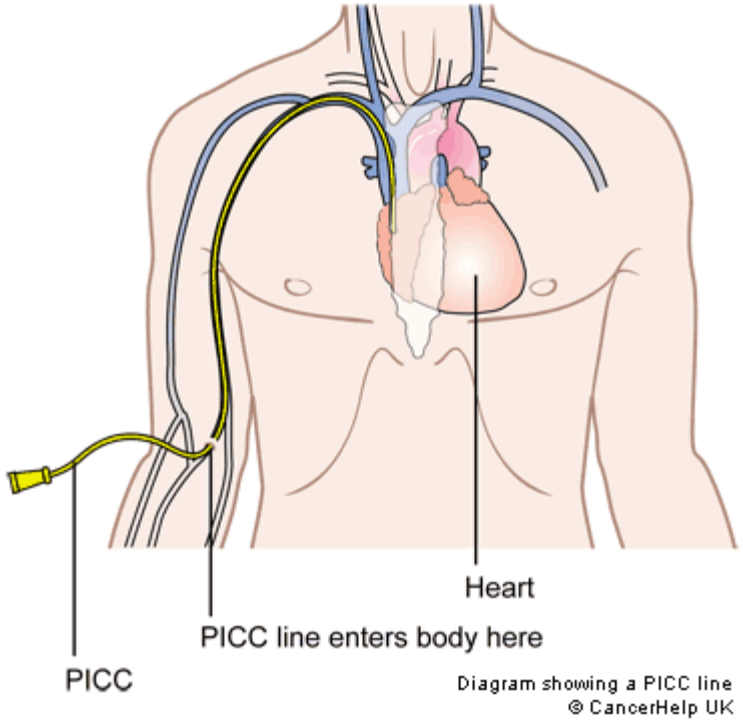
Subclavian

PICC

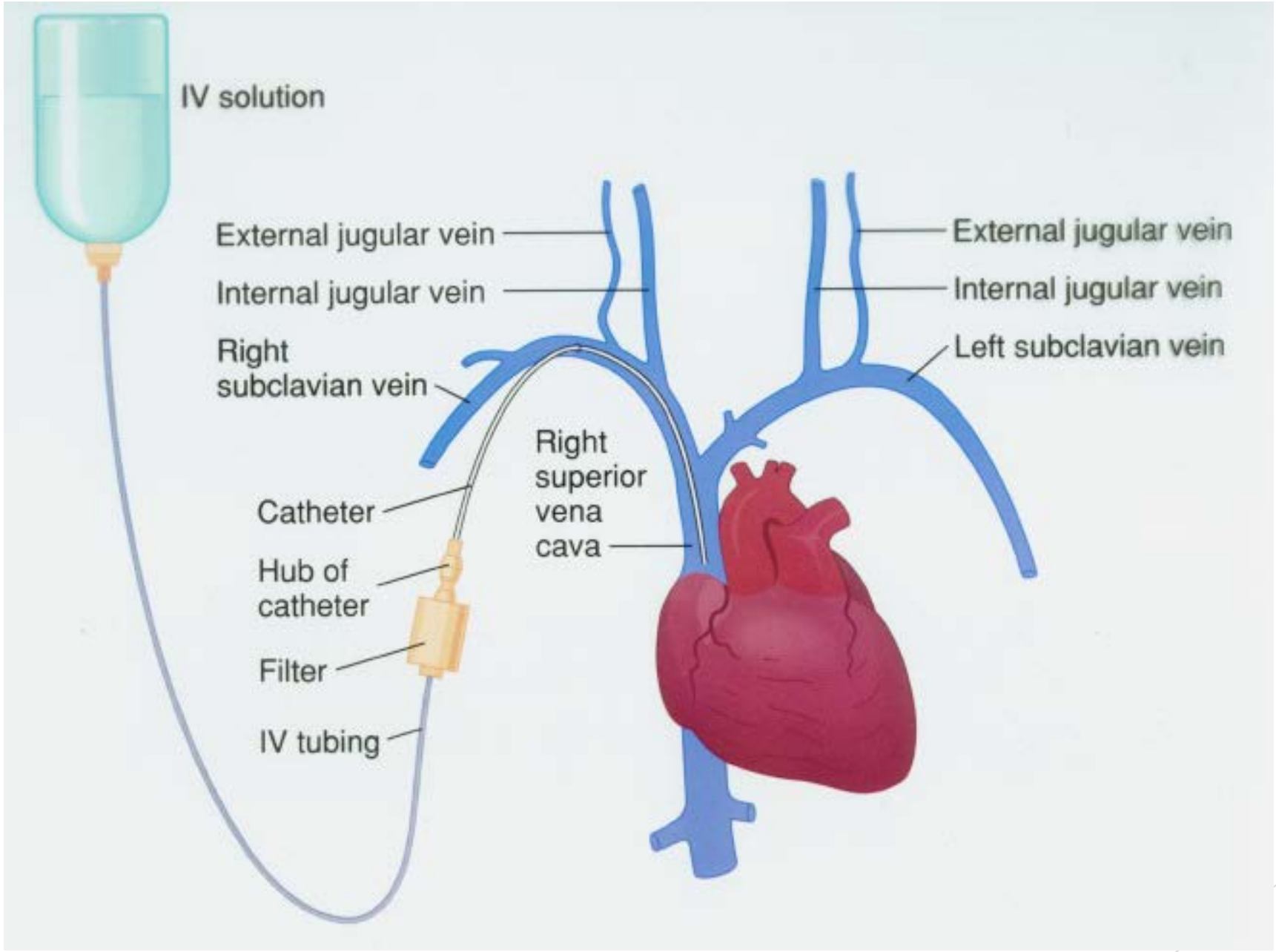
Jugular

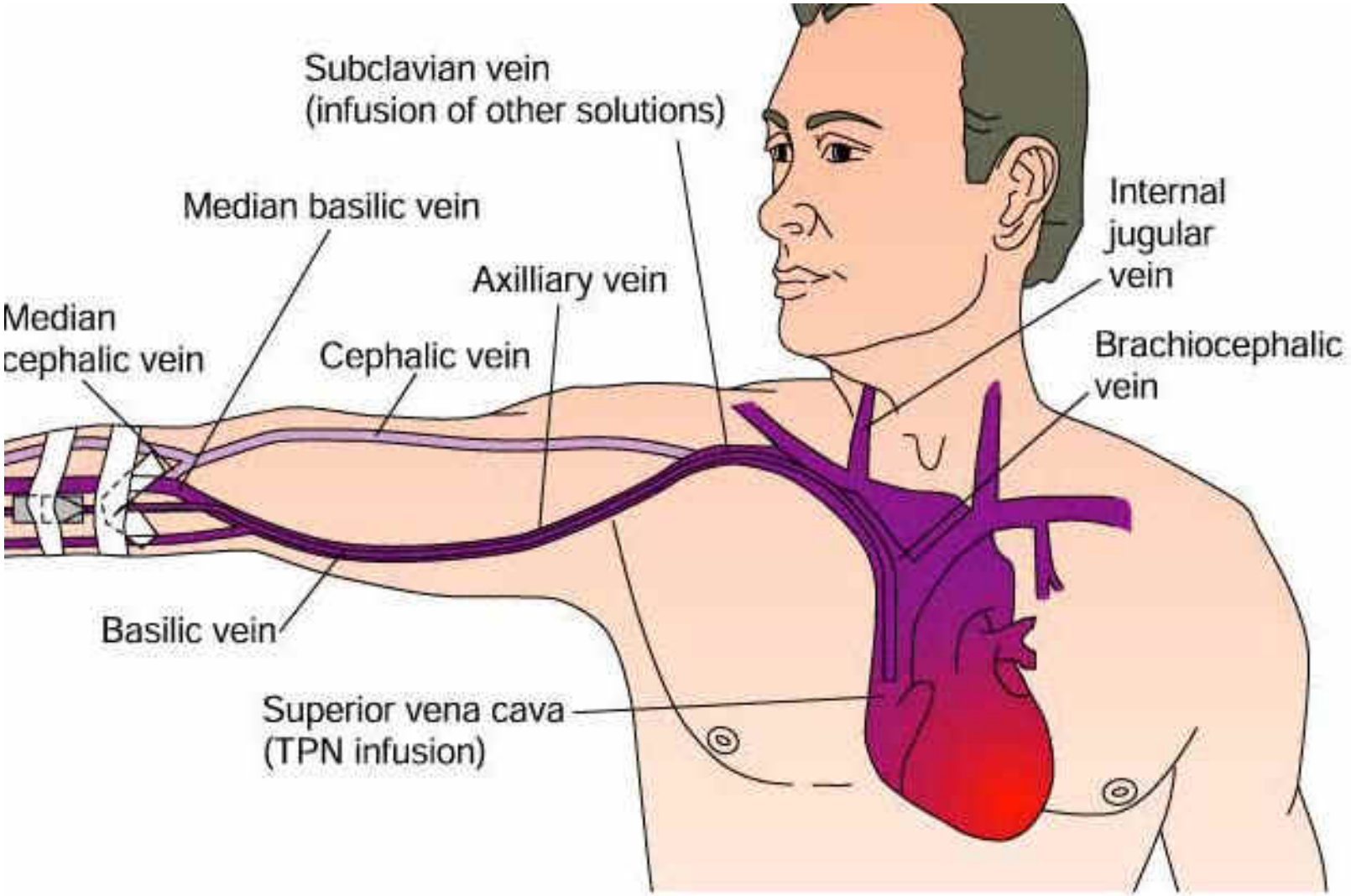
Femoral (more infection !)





PICC: Peripherally inserted central catheter


IV solution
External jugular vein
Internal jugular vein
Right subclavian vein
Catheter
Hub of catheter
Filter
IV tubing
Right superior vena cava
External jugular vein
Internal jugular vein
Left subclavian vein


Subclavian vein
(infusion of other solutions)
Median basilic vein
Axilliary vein
Internal
jugular
vein
Median
cephalic vein
Cephalic vein
Brachiocephalic
vein
Basilic vein
Superior vena cava
(TPN infusion)

Nutritional Content

- Water
  - 30 to 40 mL/kg/day
- Energy
  - 30 to 60 kcal/kg/day (depending on energy expenditure)
- Amino acids
  - 1 to 2.0 g/kg/day (depending on the degree of catabolism)
- Essential fatty acids
- Vitamins, and minerals
- Children who need TPN may have different fluid requirements and need more energy (120 kcal/kg/day) and amino acids (2.5 to 3.5 g/kg/day).

Basic TPN Solutions

- Prepared using sterile techniques
- Usually in liter batches according to standard formulas.
  - Normally, 2 L/day of the standard solution is needed.
- Solutions may be modified based on laboratory results, underlying disorders, hypermetabolism, or other factors.
- Commercially available lipid emulsions are often added to supply essential fatty acids and triglycerides
  - 20 to 30% of total calories traditionally have been supplied as lipids.
  - Withholding lipids and their calories may help obese patients mobilize endogenous fat stores, increasing their insulin sensitivity.

Special Considerations

- Patients who have renal insufficiency and are not receiving dialysis or who have liver failure require solutions with reduced protein content and a high percentage of essential amino acids.
- For patients with heart or kidney failure, volume (liquid) intake must be limited.
- For patients with respiratory failure, a lipid emulsion must provide most of non-protein calories to minimize CO_2 production by carbohydrate metabolism.
- Neonates require lower dextrose concentrations (17 to 18%).

Initiating TPN

- Vascular Access
  - Central venous access
    - Large vessels such as subclavian vein or internal jugular vein
    - Less incidence of extravasation
    - Solution with dextrose concentration greater than 10% must be delivered into the central venous system because of the hypertonicity of the solution
    - In-line filters are controversial and may not help.
- Started slowly at 50% of the calculated requirements, using 5% dextrose to make up the balance of fluid.

- Osmolarity limits
  - Peripheral: 600-900 mOsm/L
  - Central: > 1800 mOsm/L
    - Increased osmolarity limits allows for increased concentrations of dextrose and amino acids to be delivered
- Osmolarity of additivies (per 1% final concentrations)
  - Amino acids: 100 mOsm/L
  - Dextrose: 50 mOsm/L
  - Lipids: 1.7 mOsm/L
  - Electrolytes: 1-1.4 mOsm/meq

Preparing TPN Solutions

- Two Types of TPN:
  - Solutions with lipids (3-in-1)
  - Solutions without lipids (2-in-1)
- Advantages of (3-in-1)
  - Lower cost of preparation
  - Less administration time for nurses
  - Potentially reduced risk of sepsis

Preparing TPN Solutions

- Disadvantages to 3-in-1
  - Precipitants cannot be seen
  - Not stable as long as TPNs without lipids
- Expiration date for 2-in-1 is 21 days
- Expiration date for 3-in-1 is 7 days
  - Can remain at room temperature for 24 hours

Preparing TPN Solutions

- Carbohydrates
  - Dextrose: primary energy source (3.4 kcal/g)
  - Stock (manufactured) concentrations range from 5% dextrose to 70% dextrose
    - D70 most commonly used
  - Amount of carbohydrates in solution dependent upon caloric requirements and optimal balance of carbohydrates and fat for non-protein calories

Preparing TPN Solutions

- Amino Acids
  - Highest source of energy (4 kcal/g)
  - Standard solutions provide essential, semi-essential and non-essential amino acids
  - Special formulas are available for patients with renal and hepatic dysfunction
  - Amino acids have high osmolarity which limits their use in PPN

Preparing TPN Solutions

- Lipids
  - Concetrated source of calories
    - 10% solution provides 1 kcal/mL
    - 20% solution provides 2 kcal/mL
  - Provides essential fatty acids (linoleic and linolenic acid)
    - <10 % of daily caloric intake consisting of lipids may deplete essentiial acids
  - Optimal lipid intake is 20-40% of total daily calories
  - Lipids infused via PPN may provide protection from phlebitis

Mixing TPN

- Phosphates injected first
- Then add amino acids, dextrose, lipids, and water
- Then add the other electrolytes
  - Phosphate must be separated from calcium and magnesium
- TPN must be inspected after mixing to look for precipitates

Common Additions to TPNs

Electrolytes	Daily Adult Dose
calcium	5 to 15 mEq
chloride	100 to 150 mEq
magnesium	8 to 30 mEq
phosphorus	15 to 45 mMol
acetate	50 to 100 mEq
potassium	60 to 100 mEq
sodium	100 to 150 mEq

Recommended Trace Element Additions for TPN

- chromium
- copper
- manganese
- Zinc
- Selenium

Discussion

Which two additives must not be added together and why?

Answer: Calcium and phosphate (phosphate 1st and calcium last) due to risk of precipitants

Glycemic Control

- Insulin
  - Added to prevent hyperglycemia induced by high CHO load
  - Up to 10% of insulin added to PN solution may adsorb to the IV bag
- Advantages
  - Tight control of blood glucose improves outcomes and reduces infection
  - Prevents consumption of protein as energy source

Study Name: To determine the effect of total parenteral nutrition (TPN)-induced hyperglycemia on hospital outcome.

- **RESEARCH DESIGN AND METHODS-** The study determined whether blood glucose values before, within 24 h, and during days 2–10 of TPN are predictive of hospital complications and mortality.
- **CONCLUSION-** Hyperglycemia is associated with increased hospital complications and mortality in patients receiving TPN.

- Calorie/Protein Yields
  - 1 Gm protein = 4 kcals
  - 1 Gm fat = 9 kcals
  - 1 Gm dextrose = 3.4 kcals
  - 1 Gm nitrogen = 6.25gm protein

- Adult Energy Requirements
  - --Steps:
  - 1. Calculate BEE
  - 2. Determine activity/injury factors
  - 3. Calculate TDE

- Basal Energy Expenditure (BEE)
  - Harris Benedict equation:
  - BEE for females = 66.67+(13.75*kg)+(58*cm)-(6.76*y)
  - BEE for males = 66.51+(9.56*kg)+(1.85*cm)-(4.68*y)

- Activity factors:
  - Confined to bed 1.2
  - Out of bed 1.3

- Injury factors
  - Major surgery 1.1-1.2
  - Severe infection 1.4-1.8
  - Skeletal trauma 1.2-1.4
  - Burns 2.2

- **Total Daily Energy Expenditure**
  TDE=(BEE)*[(activity factor)+(injury factor)]

CALCULATIONS

- 1. Calculate total kcal needs for patient per 24 hours.
  - These normally fall in the 15-30 kcal/kg range.
  - Burn patients will require more depending on burned surface area.
  - The hospital nutrition support team will be able to give advice on kcal needs for burn or other special needs patients.
- 2. Next, figure protein requirements.
  - These are usually 0.8-2.5 g/kg/actual or dry body weight.
  - Some diseases such as acute renal failure without dialysis and hepatic encephalopathy may require 0.5-0.6 g/kg/body weight.
    - Special amino acids preparations are sometimes available for these patients. Check with the hospital pharmacy.

CALCULATIONS

- 3. Determine grams of amino acids necessary to meet protein requirements.
  - Order as grams per day or as % of total volume of solution depending on order form.
- 4. Times the grams of protein by 4 kcal per gram to get the number of kcal provided by protein.
- 5. Subtract protein kcal from total kcal required by patient.

CALCULATIONS

- 6. Decide number of kcal to be provided by lipid.
  - This can be up to 60% of non-protein kcal.
  - Normal is 30-50%.
  - Minimum is 5% of total kcal.
  - Maximum is 1g/kg per day.
  - 20% lipids will supply 2 kcal per ml.
  - 10% lipids will supply 1.1 kcal per ml.
  - Order per directions on hospital form.

CALCULATIONS

- 7. Subtract lipid kcal from non-protein kcal
  - The remaining kcal will be given as dextrose.
  - Divide kcal needed by 3.4 to calculate grams of dextrose.
  - Order as grams per day or as % of total volume depending on form.
  - Up to 80% of total kcal can be given as dextrose in stressed patients.
  - Minimum requirement is 100g/day.
  - Maximum rate of oxidation is 5 mg/kg body weight/min.
  - Most ICU patients are not be fed at the maximum rate in order to lessen the stress of metabolism.
  - Patients with Diabetes Mellitus or glucose intolerance, or those with pulmonary disease that results in excess CO2 production, need special consideration.

CALCULATIONS

- 8. Solutions with osmolarity greater than 900 mOsm/liter will require central venous access.
- 9. Routine hospital parenteral forms include options for standard or modified electrolytes, vitamins, minerals, and certain compatible medications.

Monitoring

- Weight, CBC, electrolytes, and BUN should be monitored often (daily for inpatients).
- Blood glucose should be monitored q 6 h until stable.
- Fluid intake and output should be monitored continuously.
- When the patient becomes stable, blood tests can be done much less often.
- Liver function tests should be done.
- serum albumin; prothrombin time; plasma and urine osmolality; and Ca, Mg, and phosphate (not during glucose infusion) should be measured twice/wk.
- Full nutritional assessment (including BMI calculation and anthropometric measurements should be repeated at 2-wk intervals.

Complications

- Less than 5%.
- **Central venous catheter**
  - Pneumothorax
  - Infection
  - Arterial puncture
- **Glucose abnormalities** are common.
  - Hyperglycemia can be avoided by monitoring blood glucose often, adjusting the insulin dose in the TPN solution and giving subcutaneous insulin
  - Hypoglycemia can be precipitated by suddenly discontinuing constant concentrated dextrose infusions.
    - Treatment, depending on the degree of hypoglycemia, may consist of 50% dextrose IV or infusion of 5 or 10% dextrose for 24 h before resuming TPN via the central venous catheter.

Complications

- **Adverse reactions to lipid emulsions**
  - dyspnea, cutaneous allergic reactions, nausea, headache, back pain, sweating, dizziness
  - uncommon but may occur early, particularly if lipids are given at > 1.0 kcal/ kg/h.
  - Temporary hyperlipidemia may occur, particularly in patients with kidney or liver failure
    - treatment is usually not required.
  - Delayed adverse reactions to lipid emulsions include hepatomegaly, mild elevation of liver enzymes, splenomegaly, thrombocytopenia, leukopenia, and, especially in premature infants with respiratory distress syndrome, pulmonary function abnormalities.
    - Temporarily or permanently slowing or stopping lipid emulsion infusion may prevent or minimize these adverse reactions.

Complications

- **Abnormalities of serum electrolytes and minerals**
  - should be corrected by modifying subsequent infusions or, if correction is urgently required, by beginning appropriate peripheral vein infusions.
  - Vitamin and mineral deficiencies are rare if solutions are given correctly. E
  - elevated BUN may reflect dehydration, which can be corrected by giving free water as 5% dextrose via a peripheral vein.

Complications

- **Volume overload** (suggested by > 1 kg/day weight gain)
  - may occur when high daily energy requirements require large fluid volumes.
- **Metabolic bone disease,** or bone demineralization (osteoporosis or osteomalacia),
  - develops in some patients receiving TPN for > 3 mo.
  - Mechanism is unknown.
  - Advanced disease can cause severe periarticular, lower extremity, and back pain.
  - Temporarily or permanently discontinuing TPN is the only known treatment.

Complications

- **Hepatic complications**
  - liver dysfunction
  - painful hepatomegaly
  - hyperammonemia.
  - Transient liver dysfunction, evidenced by increased transaminases, bilirubin, and alkaline phosphatase, is common with the initiation of TPN.
  - Delayed or persistent elevations may result from excess quantities of amino acids.
  - Contributing factors probably include cholestasis and inflammation.
  - Progressive fibrosis occasionally develops.
    - Reducing protein delivery may help.
  - Painful hepatomegaly suggests fat accumulation; carbohydrate delivery should be reduced.
  - Hyperammonemia can develop in infants.
    - Signs include lethargy, twitching, and generalized seizures. Correction consists of arginine supplementation at 0.5 to 1.0 mmol/kg/day.
    - For infants who develop any hepatic complication, limiting amino acids to 1.0 g/kg/day may be necessary.

- **Gallbladder complications**
  - include cholelithiasis, gallbladder sludge, and cholecystitis.
  - These complications can be caused or worsened by prolonged gallbladder stasis.
  - Stimulating contraction by providing about 20 to 30% of calories as fat and stopping glucose infusion several hours a day is helpful.
  - Oral or enteral intake also helps.
  - Treatment with metronidazole, ursodeoxycholic acid, phenobarbital, or cholecystokinin helps some patients with cholestasis.

Administration

Parenteral Nutrition

Central Nutrition

- Subclavian line
- Long period
- Hyperosmolar solution
- Full requirement
- Minimum volume
- Expensive
- More side effect

Peripheral nutrition

- Peripheral line
- Short period < 14days
- Low osmolality
  < 900 mOsm/L
- Min. requirement
- Large volume
- Thrombophlebitis

Routes of TPN

Central TPN

(usual osmolarity = 2000 mosmol/L)

Advantages:

- Can provide full nutritional support (No
- limits in concentration of dextrose and amino acids)
- No risk of thrombophlebitis, No pain.

Disadvantages:

- Requires surgery
- More risk of sepsis than peripheral TPN
- High risk of mechanical complications

Routes of TPN

Peripheral TPN

maximum osmolarity;

neonates = 1100/L, Pediatrics = 1000/L, Adults = 900/L

Advantages:

- Does not require surgery
- Less risk of sepsis than central TPN
- No risk of mechanical complications

Disadvantages:

- High risk of thrombophlebitis
- Painful
- Does not provide full nutrition support. Needs more
- fluids to provide more nutrition. (maximum dextrose
- = 7.5% and AA = 2.5%).

Note

PPN can infuse through central line but central TPN can NOT infuse through the peripheral line

Thank you