Parenteral Nutrition

- What is PN and who gets it
- How is PN given
- How much PN should be given
- Complications/troubleshooting
- Case studies

Parenteral Nutrition (PN)

- Par-ental = not in or through the digestive system
- Commonly known as TPN (Total Parenteral Nutrition)
- Is the intravenous administration of protein, carbohydrate, fat and micronutrients
- Used successfully since the early 1960’s for those with non-functioning GIT’s

Disadvantages of PN

BUT
- More expensive than EN
- More infections
- Risk of other metabolic complications
- Requires more care with management
- Many medical staff still reluctant to use

Assessing the patient for PN

Multidisciplinary team
- various team members
- better outcomes eg. reduced infections, costs, HLOS
Consider
- pt appropriate for PN?
- access
- which solution and how much
- monitoring
- management of complications
- when to cease PN

When is PN appropriate?

- For those who can’t maintain adequate nutrition through the gastro-intestinal tract (GIT) e.g.
- GIT compromised or non-functioning
  - ileus, perforated bowel, extensive GIT surgery, disruption of blood supply to gut - need for bowel rest
- Gut obstruction
  - obstructive intestinal tumour or stricture
- Untreatable malabsorption or disordered motility
  - short gut syndrome, scleroderma
- Persistent poor tolerance of enteral nutrition
Other reasons for starting PN

- Severe mucositis which is expected to improve, but undesirable to have NGT in situ
- Enterocutaneous fistula
- Hyperemesis gravidarum
- Persistent refusal of enteral nutrition
- Chyloous ascites if very-low fat diet does not improve output
- If anticipated that a critically ill patient will be unable to meet nutrient requirements enterally for, say, 5-10 days
- At RNSH within 24-48hrs in ICU if not tolerating enteral

When is PN not appropriate?

- Functioning and accessible GIT
- When nutritional needs can be met through the oral/enteral route
- When patient has true allergy to any of components in the PN solution
- Ethical / end-of-life decisions

What’s in the PN

- Glucose (glucose or dextrose)
- Amino acid solution (derived from egg protein or egg/potato protein)
- Lipid (fat emulsion from soybean oil, soybean/olive oil mix, other oils)
- With electrolytes or electrolyte-free
- Trace elements
- Vitamin solution
- Individual solutions can be infused separately
- 2-in-1, or 3-in-1 pre-filled bags allow co-administration once stability data is established

Aseptic preparation

- 3-in-1 bag

How is PN administered?

- Central lines
  - Common in ICU
  - High blood flow
  - Increased flexibility in terms of solution choice
  - Good for long-term use
  - Watch for complications (sepsis, air embolism, thrombosis).

Peripheral and Central Lines

- Distal tip in superior vena cava
Peripheral lines
- suitable for short term use e.g. 2 weeks
- cheaper to use ($125 vs $370)
- all placed by one TPN CNC
- greater care with solution choice (lower osmolarity, pH, dextrose)
- line should be changed every 2-5 days (increased risk of thrombophlebitis)

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Macronutrients
- Energy substrates in PN - glucose, lipid, amino acids
- aa’s are the only source of N for protein synthesis
- Historically, concept of non-protein calories to N ratio has been used i.e.

<table>
<thead>
<tr>
<th>Catabolic state</th>
<th>Recommended non-protein calories to N ratio (kcal/gN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unstressed</td>
<td>135-185:1</td>
</tr>
<tr>
<td>Moderately Stressed</td>
<td>150:1</td>
</tr>
<tr>
<td>Severely Stressed</td>
<td>130:1</td>
</tr>
</tbody>
</table>

Calculating energy requirements
- The practice of artificially separating “protein-calories” from “non-protein calories” is now less common
- Current practice is to estimate total calorie requirement
  - e.g. Schofields, Harris Benedict, etc...
  - multiply by injury factor, activity factor
  - add on factor for weight gain if appropriate

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  - add on factor for weight gain if appropriate
Calculating energy requirements

| Indirect calorimetry studies measuring energy expenditure often present results in terms of kcal per kg or kJ per kg. This can be used as a 'rule of thumb' guide. | Calculating protein requirements

- **N requirements - related to the degree of physiological stress**
  - 1g N = 6.25g protein = 6.8g amino acids
  - 1g protein = 0.16g N
- **No stress**
  - 0.1 - 0.12g N/kg/day (0.6 - 0.75g protein/kg)
- **Mild Stress**
  - 0.12 - 0.15g N/kg/day (0.75 - 1.0g protein/kg)
- **Moderate Stress**
  - 0.15 - 0.22g N/kg/day (1.0 - 1.4g protein/kg)
- **Severe Stress**
  - 0.22-0.3g N/kg/day (1.4g - 1.88g protein/kg)

**Renal failure without dialysis**
- 0.8 - 1.0g/kg

Amino Acid Solutions

- Different AA solutions, vary according to concentration of aa’s or have specialised aa blend for a specific clinical purpose e.g.
  - Vamin 14 & Vamin 18EF
  - Synthamin 13 and Synthamin 17
  - Glamin
  - Aminosteril KE 10%, Aminosteril N-Hepa,
  - Intrafusin
  - Nephrosteril, Nephrotect

Carbohydrate

- **Glucose** (4 kcal per g)
- Solutions available range from 5-70% enabling nutritional needs of different patients to be met
  - Minimum glucose requirement to meet obligatory needs is 2.4 g/kg/day
  - Maximum glucose infusion 4.5mg/kg/min (or 7.2g/kg/day) to minimise risk of fatty liver, hyperglycaemia, hypercapnoea.
  - In a 50kg woman this is about 288-360g glucose a day.

Role of fat in PN

- **Source of essential fatty acids**
  - Linoleic acid, linolenic acid
- **Concentrated energy source**
  - 9kcal per g, so can use less glucose
- **Less glucose - more normalised insulin response**
  - Lowers risk of development of fatty liver
- **Less glucose - lower osmolality**
  - Enables PN to be given peripherally

Fat Source

- **Fat emulsions based on soybean oil**
  - E.g. Intralipid, Ivelip
  - Intralipid 10%, 20% & 30%
  - Caloric density of 1.1kcal/ml, 2kcal/ml, 3kcal/ml respectively
  - Lately more use of fat emulsions with different blends of oils
  - E.g. “Clinoleic” – soybean oil+olive oil
  - “SMOF” – soybean+MCT+olive+fish oil
Estimating fat requirement

• Minimum requirement 100-150g iv lipid/week to prevent essential fatty acid deficiency
• Excess fat can lead to hyperTGemia, liver impairment, cholestasis, high intake linoleic acid may contribute to impaired immune function
• Recommended fat intake 1-2.5g/kg
  • (0.5-1g/kg in critically ill?)

Micronutrients

Electrolytes

• Serum electrolyte & mineral requirements should be met to reap the maximum benefit from PN
• Daily individual monitoring & adjustments are required to maintain electrolyte & fluid balance

Table 3: Estimated daily requirements of electrolytes in parenteral nutrition

<table>
<thead>
<tr>
<th>Electrolyte</th>
<th>Estimated adult requirements for Parenteral Nutrition (mmol)</th>
<th>Amount in typical TPN solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>45-145</td>
<td>73</td>
</tr>
<tr>
<td>Potassium</td>
<td>30-60</td>
<td>60</td>
</tr>
<tr>
<td>Calcium</td>
<td>2-3.5</td>
<td>2.3</td>
</tr>
<tr>
<td>Magnesium</td>
<td>5-10</td>
<td>5</td>
</tr>
<tr>
<td>Chloride</td>
<td>Varies with acid-base balance</td>
<td>70</td>
</tr>
<tr>
<td>Phosphate</td>
<td>20-45</td>
<td>37.5</td>
</tr>
</tbody>
</table>

Table 3: Estimated daily requirements of electrolytes in parenteral nutrition

Vitamins, Minerals & Trace Elements

• Vitamins, minerals and trace elements are essential components of PN
• The AUSPEN Guidelines for intravenous Trace Elements & Vitamins have recommended daily requirements of water soluble & fat soluble vitamins and trace elements in PN, in line with international published literature (1999)
• Currently under review

Vitamins

Proprietary vitamin solutions exist for PN eg. Cernevit, Soluvit N

Vit K may be given as a weekly im or iv infusion.
Table 4: AUSPEN Recommended doses of water soluble & fat soluble vitamins for addition to PN (1999)

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>AUSPEN</th>
<th>Ceravevit (5ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>thiamine</td>
<td>100 mg</td>
<td>1.52</td>
</tr>
<tr>
<td>riboflavin</td>
<td>3.6 mg</td>
<td>8.74</td>
</tr>
<tr>
<td>niacin</td>
<td>40 mg</td>
<td>85</td>
</tr>
<tr>
<td>pyridoxine</td>
<td>4 mg</td>
<td>4.5</td>
</tr>
<tr>
<td>biotin</td>
<td>6 ug</td>
<td>6</td>
</tr>
<tr>
<td>pantothenic acid</td>
<td>16 mg</td>
<td>17.25</td>
</tr>
<tr>
<td>biotin</td>
<td>60 ug</td>
<td>6</td>
</tr>
<tr>
<td>folic acid</td>
<td>0.8 mg</td>
<td>614</td>
</tr>
<tr>
<td>d</td>
<td>1500 ug IU</td>
<td>1024</td>
</tr>
<tr>
<td>e</td>
<td>5 mg</td>
<td>5.5</td>
</tr>
<tr>
<td>k</td>
<td>10 mg</td>
<td>11.2</td>
</tr>
</tbody>
</table>

Trace Elements

Proprietary vitamin solutions exist for PN eg. Additrace, MTECC, MTEFE

Table 5: AUSPEN Recommended doses of trace elements for addition to PN

<table>
<thead>
<tr>
<th>Trace Element</th>
<th>AUSPEN 1999</th>
<th>MTEFE (10ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>iron(Fe)</td>
<td>20 umols</td>
<td>20</td>
</tr>
<tr>
<td>zinc(Zn)</td>
<td>50-100 umols</td>
<td>100</td>
</tr>
<tr>
<td>manganese (Mn)</td>
<td>4 umols</td>
<td>5</td>
</tr>
<tr>
<td>copper</td>
<td>0.2-0.4 umols</td>
<td>0.2</td>
</tr>
<tr>
<td>chromium</td>
<td>0.4 umols</td>
<td>0.2</td>
</tr>
<tr>
<td>molybdenum</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>iodide</td>
<td>1.0 umols</td>
<td>7.0</td>
</tr>
<tr>
<td>selenium</td>
<td>0.4-1.5 umols</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Managing the patient on TPN

Commencing and ceasing PN

- Start at low rate eg. 40-60ml/hr
- Do not use the line for any other solution
- Do not stop the TPN for showers, walks etc, only to change bag.
- Change 3-in-1 solution every 24hrs
- When ceasing TPN, halve rate for 1 hour then cease (to avoid rebound hypoglycaemia)
- Do not give insulin for at least 4 hours before ceasing TPN
- If TPN is ceased suddenly, give 1L iv dextrose if pt is not on oral/enteral diet

• Consider patients who have different requirements due to clinical condition
• e.g. burns patient will have higher Zn requirement
• e.g. pt with biliary obstruction will be retaining Cu and Mn
**PN monitoring**

- Daily review of each pt. (5-6 times/wk)
- Daily weigh, strict fluid balance
- Daily biochemistry
- Daily urinalysis - glucose and ketones
- Bag change each 24 hrs

**Complications**

- Technical - line problems
  - TPN nurse
- Septicemia
  - Aseptic techniques for line insertions and daily checking of lines, exclusive line use
- Refeeding syndrome eg Mg, K, PO₄
  - Daily review of biochemistry and supplementation as required

**Complications**

- Hyperglycaemia
  - Check mg glucose/kg/min, review other sources of glucose
  - Consider increasing calories from lipid
  - Check whether overfeeding calories
  - Endo review for insulin administration

- Hyperlipidemia
  - reduce lipid

**More complications**

**Elevated Liver Function Tests**
- need interpretation
  - Cyclic regimen e.g 12-16 hours of TPN (at higher rate) instead of 24hrs
  - Excess calories/glucose?
  - Try different fat emulsion with less PUFA?

- Biliary sludge (cholestasis)
  - If able to tolerate some enteral/oral intake may stimulate some gallbladder motility
  - check not overfeeding lipid

**Parenteral Nutrition - Summary**

- Use of TPN
- Peripheral and Central lines
- Calculating Requirements
- Protein, Carbohydrates, Lipids
- Electrolytes, Vitamins, Minerals and Trace Elements
- Complications
CASE STUDY

- 25yo girl admitted with 1-week history of watery painful diarrhoea (15-20x a day) due to Crohn's of terminal ileum and colon.
- Rehydrated and commenced on azathioprine, high-dose corticosteroids and low-lactose full-fluid diet.
- Diarrhoea continues. Trial of infliximab disappointing. Clear fluids only.
- After 8 days in hospital with little improvement in diarrhoea, plan for bowel rest and TPN.
- PICC line inserted by anaesthetic registrar

• Weight 53kg (usually 58kg)
• Ht 155cm (BMI 22)
• Bloods
  - EUC: Na⁺, K⁺, normal, Creat and Urea a bit low
  - Normal Ca, PO₄, Mg
  - BGLs 5-9 on corticosteroids
  - Alb 21 CRP 256
• Calculate requirements:
  - Energy (Schofields X AF 1.1 X IF 1.2)= 1673kcal
  - Protein (moderate stress + losses) 1.5g/kg or 0.24gN/kg = 80g protein or 12.7g N

'Adult standard' TPN solution to be given
- 0.93 kcal/ml
- 41.2 g protein/L = 6.6 g N/L
- 250 g glucose/2.5L = 100 g glucose/L
- 100 g lipid/2.5L = 40 g lipid/L
• Target rate to provide 75ml/hr over 24hrs
  - 1800ml
  - 1674kcal (31.6 kcal/kg)
  - 74g protein (1.4 g/kg)
  - 11.84g N (0.22g N/kg)
  - 180g glucose (2.36 mg/kg/min)
  - 72g lipid (1.36 g/kg)

Day 1
- Start at 40ml/hr at 6pm
Day 2
- Blood tests: electrolytes stable, transient rise in BGLs. Increase to 60ml/hr adult std
Day 3
- Drop in serum K⁺ and PO₄. Keep rate at 60ml/hr. Pharmacist adds K₂PO₄ to next bag to max allowed based on stability data. Team charts iv supplemental K₂PO₄ ASAP.

Day 4
- EUC, CMP improved. Increase to target rate 75ml/hr
Day 5
- Drop in K⁺ again, PO₄ stable. IV KCl 30mmol charted by team. BGLs high.
Day 6
- Pt tolerating TPN. BGLs still high. Endo consult: Actrapid commenced initially and eventually pt is placed on bd Protaphane.
Day 14
- Diarrhoea starts to settle and pt is allowed clear fluids

Day 15
- Progress to full fluids (low-lactose)

Day 16
- Still improving so for light diet and cease TPN. Endo reg is notified re need for R/V of insulin. Protaphane dose is dropped.
- TPN is decreased to 40ml/hr for 2 hours then ceased. BGLs stable.

Day 20
- Pt tolerates light diet and oral HP supps well. BGLs improve when corticosteroid dose decreased. PICC is removed
- Protaphane ceased. Pt goes home.
- LMO monitors HbA1c

- If patient had continued on TPN much longer, a cyclic regimen would have been considered (with adjustment of insulin) to allow pt some freedom from the pump and to minimise risk of liver impairment.
  e.g. 150ml/hr over 12 hours
- Serum vitamins and trace elements monitored regularly