PARENTERAL NUTRITION

PRACTICE GUIDELINE ©

DOCUMENT SUMMARY/KEY POINTS

- Guideline developed to give information for staff providing clinical care to inpatients requiring parenteral nutrition and patients requiring home parenteral nutrition within the Sydney Children's Hospitals Network.
- This guideline is to be read in conjunction with the following:
  - Central Venous Access Device (CVAD) Practice Guideline
  - Aseptic Non Touch Technique
  - Intravenous Fluid Management - CHW
  - Intravenous Fluid and Electrolyte Therapy - SCH

Approved by:	SCHN Policy, Procedure and Guideline Committee	
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CHANGE SUMMARY

- Light protective intravenous infusion lines for patients < 5kg and those on long-term PN or home PN are recommended to be used where possible.
- Changes to CHW blood collection protocol.
- Updated potential complications of PN.
- Changes to CHW vascular access pathway.
- **4/03/2022**: Minor review:
  - Additional information added in Table 4: Composition of the standard paediatric PN solutions available at the SCHN. No changes to standard solution composition.
  - Amended Section 6.1 - CHW PICU and GCNC to continue charting Paediatric PN using the paper forms.

26/05/23: Minor review. Amended Section 7 – clarification of the scope of practice of enrolled nurses in PN management.

READ ACKNOWLEDGEMENT

- The following staff should read and acknowledge they understand the contents of this document:
  - Pharmacists, dietitians, nursing and medical staff caring for patients receiving PN.
  - Department Heads and all other medical and nursing staff working in clinical areas administering PN should be aware of this document.

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1 Indications for the Use of Parenteral Nutrition

1.1 Parenteral nutrition

Parenteral nutrition (PN) involves delivery of macronutrients, fluid and electrolytes intravenously. It is a form of nutritional support for patients with short, medium or long-term intestinal failure (IF) when they are unable to receive adequate nutrition via the gastrointestinal tract or their nutritional requirements exceed what is able to be provided orally or enterally. Providing nutrients intravenously is complex and is associated with the risk of causing patient harm when not administered correctly or for the right indication. If there is a functioning gastrointestinal system, oral and enteral nutrition should be optimised to reduce the morbidity risk to the patient (7, 8).

1.2 General indications for PN

PN is indicated for patients with acute or chronic IF and some medical and surgical conditions where nutrition is severely compromised. IF is a reduction of gut function to below the minimum requirement for the absorption of macronutrients, fluid and electrolytes (7, 8).

Functional classification of IF is comprised of (8, 9):

Short term: Self-limiting IF lasting from several days which is usually associated with post gastrointestinal surgical complications such as post-operative ileus, excessive burns/trauma as well as post radiation and cytotoxic treatments. The need for PN should be assessed on an individual basis.

Medium term: (>28 days). Significant and prolonged PN support usually associated with persistent GI surgery complications, prolonged post-operative ileus, severe inflammatory bowel disease or radiation/cytotoxic therapy.

Long term: (>3 months). Chronic IF associated with short bowel syndrome, chronic motility disorders and/or enteropathies.

Refusal of a nasogastric tube is not an indication for PN

2 Information for Patients and Families/Carers

The treating team should inform the parent/carer of the indication for starting PN and the likely duration of treatment as well as the associated risks and complications that may occur. There is a factsheet on parenteral nutrition available on the SCHN intranet for patients and families.

3 Initial Assessment

3.1 Parenteral nutrition team consultation

A prescription for PN should only be considered after consultation with the attending physician or surgeon. The PN team (SCH) or Gastroenterology team (CHW) should be contacted for an initial consult. PN will be prescribed for the primary medical team with the exception of Intensive Care Units and Oncology/BMT patients who will be reviewed by their own teams and dietitians and referred to the PN team as required.

The PN team is a multi-professional team consisting of a gastroenterologist, pharmacist, dietitian and clinical nurse consultant who are all specialised in providing and managing PN. The PN team will remain involved in the patient's care for the administration of PN until its cessation.

3.2 Initial nutritional assessment

A referral to a dietitian must be placed before commencing a patient on PN. The dietitian will complete a comprehensive nutrition assessment including growth assessment and development of appropriate nutrition goals (energy, protein, carbohydrate and fat requirements) for the patient whilst they are on PN. The dietitian will also assess the patient for the risk of refeeding syndrome.

Height and weight must be measured and recorded in the patient's growth chart.

Head circumference should also be measured in patients <2 years of age.

3.3 Venous access

PN solutions should ideally be delivered via a central venous access device (CVAD) or peripherally inserted central catheter (PICC) to minimise risk of thrombophlebitis and extravasation (5).

- It is strongly recommended that additional securement devices such as GripLok or StatLock are applied for all non-tunnelled or uncuffed CVADs to reduce risk of dislodgement and extravasation (1).
- Non-tunnelled CVADs (excluding femoral lines) and/or PICC lines may be used for PN administration in all wards depending on the child's age, cognitive status and duration of therapy. This may need to be assessed on a case-by-case basis. Any deviations from the vascular access pathways recommended below should be well documented in the patient's progress notes.

  Please refer to the relevant Venous Access Decision Pathway:

  a. Randwick Venous Access Decision Pathway (Appendix 3)
  b. CHW Venous Access Decision Pathway for Parenteral Nutrition (Appendix 4)

- CVAD tip position must be confirmed with imaging prior to using the device for PN infusion (1).
- Peripheral PN is **only** permitted in the following areas and the glucose concentration must not exceed 10% when given peripherally or via midline:
  - GCNC and ICU at CHW and
  - SCH Randwick.
- Lipid emulsions are isotonic and may be administered peripherally (1).
- If it is expected that a patient will require PN support for longer than 14 days, a long-term venous access device should be inserted for ongoing PN administration (1). Please refer to the venous access decision pathways for SCH (Appendix 3) and CHW (Appendix 4).
- When inserting a CVAD, consider using a device with the minimal number of lumens required to reduce complications, such as infection, occlusion (5, 10). Not all IV solutions are compatible with PN and/or lipids and a device with multiple lumens or alternative venous access may need to be considered.

3.4 Baseline investigations

The following blood tests should be performed before commencement of PN (Appendix 2) (10):

- Full blood count
- Electrolytes, urea and creatinine
- Calcium, magnesium and phosphate
- Blood glucose level
- Liver function tests
- Triglycerides

4 Prescribing Parenteral Nutrition

4.1 Fluid requirement

- Maintenance fluid requirements are based on age and body weight. See Intravenous Fluid Management Guideline for further information:
  a. Intravenous Fluid and Electrolyte Therapy SCH
  b. Intravenous Fluid Management CHW
- Fluid requirements increase with fever, gastrointestinal losses, presence of a hypermetabolic state and respiratory distress; and decrease with renal and congestive heart failure (11).

- Do not attempt to correct rapidly changing fluid losses with PN. If large fluid losses are present, these should be replaced with a separate IV infusion of fluid (11).
- Consider other intravenous medications, infusions and fluids, blood products and enteral intake being given to the patient when considering their total fluid requirement to avoid fluid overload.
- In children at risk of refeeding syndrome, PN may need to be started at reduced calories. Please seek dietitian advice.

4.2 Energy requirement

- The estimated energy requirements (EER) of healthy individuals are the sum of basal metabolic rate (BMR), diet induced thermogenesis, physical activity factor and growth (12).
- Energy requirements for patients receiving total PN has been estimated to be approximately 90% of that required when enteral feeding due to the thermogenic effect of food (12).
- Various factors, such as fever, inflammation, chronic diseases increase the energy requirements.
- Critically ill children in ICU may benefit from withholding PN while providing micronutrients during the first week of hospital admission (13).

4.3 Protein requirement

- The protein/amino acid requirement is lower in parenterally fed infants and children than in enterally fed infants because the supply bypasses the intestine (2).
- After the second month of life, a minimum amino acid intake of 1 g/kg/day is recommended to avoid a negative nitrogen balance (Table 1). For critically ill patients the advisable amino acid intake may differ (2, 14)
- Energy content of amino acid: 4 kcal/g.

Table 1: Amino acid requirements (g/kg/day) for administration via PN for stable patients (2, 14).

Age	g/kg/day
Preterm infants Day 1 Day 2 onwards	 1.5 – 2.5 2.5 – 3.5
Term infants	1.5 - 3.0
Infants 2 months – 3 years	1.5 - 2.5
Children 3 – 12 years	1.0 - 2.0
Adolescents > 12 years	1.0 - 2.0

4.4 Glucose requirement

- Rate of glucose oxidation is influenced by age, acute illness, nutritional state and drug administration. Hepatic glucose oxidation rates are highest in young infants (17.2 g/kg/day = 12 mg/kg/min).
- Excessive glucose administration during PN should be avoided as it may cause hyperglycaemia and if the glucose infusion rate (GIR) exceeds the oxidation rate, the excess is directed to lipogenesis promoting fat deposition, together with liver steatosis and enhanced production of VLDL triglycerides by the liver (15, 16). Glucose requirements for neonates, infants and children are shown in Table 2.

Table 2: Guidance for glucose administration via PN (16).

Glucose requirements for neonates in g/kg/day (mg/kg/min)		
	Day 1	Day 2 onwards
Preterm	5.8 - 11.5 (4 – 8)	Target 11.5 - 14.4 (8 – 10) Min 5.8 (4); max 17.3 (12)
Term	3.6 - 7.2 (2.5 – 5)	Target 7.2 - 14.4 (5 – 10) Min 3.6 (2.5); max 17.3 (12)
Glucose requirements for infants and children in g/kg/day (mg/kg/min)		
28 days – 10kg	8.6 – 14 (6 – 10)	Hepatic glucose oxidation rates are highest in young infants and excessive amounts should be avoided to prevent complications.
11 – 30kg	4.3 - 8.6 (3 – 6)	
31 – 45kg	4.3 - 5.8 (3 – 4)	
> 45kg	2.9 - 4.3 (2 – 3)	

4.5 Lipid Emulsions

- Lipid emulsions are a high source of energy delivered as an iso-osmolar solution in a low volume (20% emulsions = 2 kcal/ml; 10% emulsions = 1.1 kcal/ml given the higher content of glycerol).
- Lipid emulsions are isotonic solutions and can be given peripherally.
- Lipid emulsions should be introduced into the PN regime starting at 0.5 – 1 g/kg/day and gradually increased (Table 3). Starting at higher doses increase the risk of hyperlipidaemia (3, 17). Lipid emulsions should provide 25 – 40% of non-protein calories in fully parenterally fed patients.
- Lipid emulsions contain 80% of fluid which should be taken into consideration in fluid restricted patients.
- SMOF (20% lipid emulsion) containing 30% soybean oil, 30% medium chain triglycerides, 25% olive oil, 15% fish oil is the lipid of choice at SCHN.
- Omegaven (10% lipid emulsion) a fish oil emulsion rich in omega 3 is occasionally used as specific therapy for PN-related liver disease after consultation with the PN/Gastroenterology team. A Special Access Scheme (SAS) form is required.

- The use of lipid emulsions prevents the complications of using glucose as the sole non-protein energy source including hyperglycaemia, liver steatosis and essential fatty acids deficiency (3).
- The infusion rate should not exceed 0.15g/kg/hour. Rapid infusion of lipid emulsions can cause fat overload syndrome (Section 11 - Potential Complications)(17).

Lipid emulsion use in patients with known or suspected inborn errors of metabolism (metabolic disorders)

Lipid emulsion is used in a number of metabolic disorders to augment caloric intake with the aim of preventing catabolism.

In some inborn errors of metabolism it can be used to a support a modified ketogenic diet.

Lipid emulsion is **contraindicated** in some inborn errors of metabolism, specifically those known or suspected of having a disorder of fat metabolism.

Dosage for these patients may vary between 2-4g/kg/day, depending on their needs irrespective of age.

If further advice is required for this cohort of patients, please consult the Metabolic Team.

Table 3: Guidance for lipid administration via PN (3, 17).

Age	Maximum g/kg/day
Preterm	4
Term Infants	4
Children 3 – 12 years	3
Adolescents > 12 years	3
Adults	2.5

5 Parenteral Nutrition Solutions

5.1 Standard paediatric solutions

Standard paediatric solutions are used if the patient has normal fluid and electrolyte requirements. It is preferable to correct electrolytes with enteral replacements or via a separate intravenous (IV) infusion (18). Compositions of the standard PN solutions available at the SCHN are shown in Table 4.

Table 4: Composition of the standard paediatric PN solutions available at the SCHN.

PN solution	S2-10	S4-20	S4-25	S5-25 SCH Only
Amino Acid (%)	2	4	4	5
Glucose (%)	10	20	25	25
Sodium (mmol/100mL)	4	4	4.5	4.5
Potassium (mmol/100mL)	2.4	2.4	4	5
Calcium (mmol/100mL)	1	1	0.5	0.5
Magnesium (mmol/100mL)	0.4	0.5	0.5	0.5
Phosphate (mmol/100mL)	0.9	0.9	1	1
Chloride (mmol/100mL)	3.9	4.4	6	6.5
Total kcal (kcal/mL)	0.46	0.92	1.11	1.15
Peripheral	Yes only SCH + GCNC	No	No	No

5.2 Modifications to standard PN solutions

Modifications to standard PN solutions (e.g. glucose, electrolytes) incur additional compounding time and might also affect the stability and the shelf life of the PN solutions. Always consider other alternative strategies before requesting modified PN bags (18).

It is evidence-based practice to use standard parenteral nutrition solutions where possible and avoid modifications (18). Running an additional IV sideline to correct electrolytes minimises the need for PN modifications

Please contact the PN team and/or Pharmacy for further advice prior to ordering a modified PN solution.

5.3 Multivitamins

Multivitamin solutions used in SCHN are shown below and their composition is described in Appendix 1. Vitamins are light sensitive and reduce the shelf life of the PN solution (4).

- **Vitalipid N Infant**: Fat-soluble vitamin in 10% fat. Used for infants and children < 5 kg. Recommended dose: 4 mL/kg; maximum of 10 mL/day.
- **Soluvit**: Water-soluble vitamin. Used for infants and children < 5 kg. Recommended daily dose: 1 mL/kg; maximum of 10 mL/day.
- **Cernevit**: Combination of fat- and water-soluble vitamins (except for vitamin K). Used for children > 5 kg. Recommended daily dose: 0.5 mL/kg; maximum of 5 mL/day (4).

5.4 Trace elements

Baxter AusPEN Trace Elements are used at SCHN for both neonates and older children. Its composition is described in Appendix 1. Recommended daily dose: 1 mL/kg; maximum of 10 mL/day.

Patients on long-term PN may require parenteral or enteral iron supplementation as solution does not contain iron (19).

6 Ordering PN

6.1 Orders

PN will be prescribed by the PN team for the primary medical team, except in the Intensive Care and Oncology/BMT Units where it is prescribed by the relevant teams.

- Paediatric PN is ordered daily on the electronic inpatient **Paediatric PN Powerform** (except for CHW PICU and GCNC – these clinical areas chart PN using the paper form). This electronic form is found in the 'AdHoc' tab in PowerChart under General > Gastroenterology and Oncology/BMT folders. PN and lipid solutions and infusion rates must also be ordered electronically on the Medication Administration Record (MAR). Ensure that paper forms remain available in the downtime box in the event of EMR downtime.
- The Neonatal PN order paper form is used for infants < 3 months of age and the original form needs to be sent to pharmacy by 11am. No neonatal PN will be supplied without an order form accurately completed, written legibly, and signed by a medical officer. If the patient is on cycling PN, a weaning calculator is also required.
- PN and lipid orders for Saturdays and Sundays must be ordered on Fridays. A separate order is required for PN and lipid bags administered on Saturdays and Sundays as no vitamins or trace elements are added into these bags over the weekend for stability reasons.
- Standard paediatric PN solutions come in 1000 mL and 2000 mL volumes. Please consider these volumes when prescribing it.

- Lipid emulsion orders only (e.g. for metabolic patients) DO NOT require a PN Powerform order. Orders can be done directly from the MAR.
- Home PN bags are “2 in 1” (PN and lipids) solutions. These solutions should be ordered on the MAR under Parenteral Nutrition Solution (Home TPN). No Paediatric PN Powerform is required.
- PN orders must be completed daily by 11 am. Extra orders will be required in advance for weekends and public holidays. PN solutions and lipid emulsions are delivered to the wards usually before 5 pm on weekdays.
- When making changes to a PN prescription, you must create a new electronic order on the MAR and cancel any previous orders by entering a “stop date”. This will ensure that the current order will be applied until the change of PN in the evening and will be discontinued when the new order commences.
- Avoid printing and/or photocopying PN electronic or paper orders to minimise the risk of administration errors.
- Please notify Pharmacy as soon as possible of any changes or cancellations of PN orders to avoid wastage of solutions.
- After hours, S2-10 standard PN solution and SMOF are the only solutions available for use. If a patient requires a replacement bag (e.g. due to spillage, disconnection or the solution has expired) a medical officer must be contacted to prescribe S2-10 standard PN solution and SMOF or IV fluids with additional glucose. Consider additional glucose monitoring, particularly if there is a significant change in glucose provision.

6.2 Drug and PN compatibilities

- No drugs are to be added to the PN solution, bags or lines (1)
- IV medications should be administered via a separate lumen where possible. If IV access is limited, compatible medications can be administered via the same lumen as the PN/lipids, using a separate IV extension set and burette, connected to a multi-valve extension set. This line should then remain a closed circuit until the next line change is due.
- Refer to MicroMedex to check drug compatibility with PN solutions. Please seek advice from PN team or pharmacist for further advice.

6.3 Stability of solutions

- PN solutions containing vitamins have a maximum expiry date of three days when stored in the fridge and protected from light. Bags should always be kept in their light protective cover (1).
- All PN solutions should continue to be refrigerated even if they are not used on the date specified. The Pharmacy should be notified on the next working day if a bag is no longer required so that it can be collected.

- The expiry date for lipid emulsions not manipulated in Pharmacy is stated on the manufacturer's label.
- Please ensure PN solutions and lipids are protected light protected from daylight and artificial ambient light to prevent peroxidation and degradation of the solutions (1-4). This includes the bag and burette.

For all patients < 5kg or those requiring long-term and/or home PN, a light protective line is recommended to prevent peroxidation and to minimise the risk of IFALD (1-4).

7 Administration of Parenteral Nutrition

Registered nurses (RN) and enrolled nurses (EN) are permitted to check and administer PN solutions. An EN is only permitted to check PN solutions with an RN.

ENs are not permitted to check and/or administer high potassium containing fluids (please see Potassium Management practice guideline). PN solutions with a potassium concentration of greater than 40mmol/L must be checked and administered by an RN. This includes solutions that have been modified to include extra potassium above 40mmol/L and S5-25 solutions (SCH only).

Prior to undertaking PN management, the RN/EN must have successfully completed their CVAD accreditation and Aseptic Non Touch Technique (ANTT) accreditation.

Administration of PN carries an increased risk of catheter-related bloodstream infection. Diligence during setup, connection and disconnection is essential. Please refer to:

- Central Venous Access Device (CVAD) Practice Guideline
- Aseptic Non Touch Technique

7.1 Basic principles

7.1.1 General principles for changing the PN line and bag

- Standard ANTT is recommended for PN preparation, administration, bag change and PN disconnection procedures. Please see Appendix 5 for risk assessment. Surgical ANTT can be applied if deemed necessary based on individual/ward assessment using the ANTT risk assessment tool found in the ANTT Policy.
- Surgical ANTT is required for home PN preparation and administration when administered by trained parents/caregivers. Please refer to section 7.2 'Chronic Intestinal Failure – Home PN patients'.
- PN and lipid lines should remain a closed system. If a PN line is disconnected the PN solution must be discarded. If disconnection of PN/lipids/IVF lines occur, DO NOT reconnect. Contact AMO1 and Gastroenterology team for advice as line cultures may be requested.

- All in-patients receiving PN via CVAD should have an extension set with a bleed-able, luer-activated valve connected to each lumen.
- Additional, compatible IV infusions can be added to the multi-valve extension set on the PN lumen at any time during infusion. Blood can be withdrawn from the bleed-able valve if required. This is not considered “breaking the line” as the system remains closed. Please refer to **section 3.4** of the SCHN CVAD Practice Guideline for further guidance.
- Where possible, the PN line should be dedicated to PN use only and should not be used for administration of medications or for monitoring central venous pressure (5).
- In-line filters are required for PN administration to reduce the risk of microbial, precipitate, or particulate contamination. PN solutions are to be filtered using a 0.22-micron filter and lipid emulsions are to be filtered with a 1.2-micron filter (3, 5).

PN solutions should be out of refrigeration for at least 1 hour prior to commencement to reduce the effect of effervescing of the solution once its temperature rises. This can alleviate ongoing problems with IV pump alerts to “air in line”.

- All PN solutions and lipid emulsions must be changed every 24 hours (3, 16).
- PN and lipid administration should be altered between lumens if the child has a multiple lumen venous access device.
- Line changes (including the filter) for lipid emulsions are performed every 24 hrs (3, 16).
- Line changes (including the filter) for PN solutions are performed at least every 72 hours (3, 16). Daily line changes are required when the PN is not given continuously over 24 hours.
- Light protective lines are available for use and are recommended for use in all patients < 5kg and/or, patients on long-term PN or on home PN to prevent peroxidation and minimise risk of intestinal failure-associated liver disease (3, 16).

7.1.2 Procedure for setup and connection of PN

General principles of CVAD management are to be maintained when preparing and connecting the PN, using standard ANTT (refer to SCHN CVAD Practice Guidelines and ANTT Policy).

- Perform hand hygiene.
- Identify and gather equipment for procedure.
- Clean trolley/work surface and tray with surface wipes.
- Perform hand hygiene and don gloves.
- Prepare equipment: ensure all clamps are on (including roller clamps), connect burettes and filters to the lines and then to the multi-valve extension set. Please refer to the

Types of Add-On Devices in the SCHN CVAD policy for extension sets to be used. Ensure all valves on the multi-valve extension set have been primed.

Multi-valve extension sets are recommended for PN. When selecting a multi-valve extension set, select one with the minimum ports required.
The use of a multi-valve extension set with additional ports that are not required increases the risk of infection and adds significant weight to the line, increasing the risk of line disconnection and/or dislodgement.

- Using 2% chlorhexidine and 70% alcohol swabs, clean the rubber stopper on the lipid emulsion and allow it to dry, while maintaining aseptic technique and spike IV giving set.
- Using 2% chlorhexidine and 70% alcohol swabs clean the connection port of the PN bag, allow to dry, and while maintaining aseptic technique insert the spike of IV giving set.
- Prime the lines with PN and lipid solutions, ensuring all lines are free of air bubbles. It is important to maintain the sterility of the internal pathway of the line - keep the ends of the lines clean and capped and clear of contaminants by placing them back on the surgical field ready for connection.
- Remove gloves, perform hand hygiene and don new gloves.
- Proceed to accessing of CVAD and connecting PN as per SCHN CVAD Practice Guideline.
- Both lipid and PN bags and burettes should be covered with the light protective bag provided from Pharmacy for all patients.
- Clear the volume of the IV pump before starting to ensure accurate total fluid delivery.
- No "slow infusions" should be "caught up" - all discrepancies between flow rates and orders must be documented. If cessation is required, replace with a 10% glucose solution to avoid hypoglycaemia, ensure medical staff are notified and confirm with written fluid order. Monitor blood glucose level as required.

7.1.3 Blood collection and/or blood cultures

Peripheral blood collection is strongly recommended for all patients on PN to minimise risk of infection (5).

All patients receiving PN should have an extension set with a bleed-able, luer-activated valve connected to each lumen in accordance with the SCHN CVAD Practice Guideline. In the event that blood collection is required via the CVAD as per the treating team, the infusion should be paused for 10-15 minutes prior to collection. A discard of 3mls should be taken (as per SCHN CVAD Practice Guideline – **section 3.6**) to clear any contaminants.

For children that are at risk of developing sampling anaemia, twice the catheter volume may be an appropriate discard. The ‘deadspace’ volume is often documented in the CVAD insertion/removal form. Instructions on how to measure the catheter volume or ‘deadspace’ can be found here. This is at the discretion of the Gastroenterology/PN team and/or

Vascular Access CNS2. Individual instructions regarding sampling and line locking may be documented in “Management Plans” as a “Vascular Access Management Plan” in PowerChart.

If a child receiving PN spikes a fever ≥38°C, a catheter-related blood stream infection (CRBSI) must be considered and remain as the key source of infection until proven otherwise (1, 5, 6). If confirmed infection, complete an IMS+ report.

The following steps should be performed as per the SCHN CVAD Practice Guideline – **section 4.1.1**:

- The primary treating team and PN/Gastroenterology team should be notified. It is at the discretion of the PN/Gastroenterology team to determine if PN needs to be ceased or if it is safe to continue. If PN needs to be ceased, some IV fluids with 10% dextrose should be commenced to avoid hypoglycaemia.
- Take blood cultures from CVAD via bleedable valve from all lumens and label the blood cultures bottles accordingly. If at time of fever the lumen was locked with Taurolock, this should be withdrawn and discarded prior to collecting blood culture sample to avoid potentially false negative result. Take peripheral blood cultures where possible to assist in identifying colonisation of catheter vs. sepsis.
- Start empiric broad spectrum IV antibiotics to cover for positive and negative gram bacteria (1, 5, 6). Each IV antibiotic dose should be administered through alternate lumens of the CVAD. If patient remains on PN, compatibility of antibiotics can be discussed with Pharmacy if required.
- Suspected CRBSI should be treated with IV antibiotics for 48-72 hours or until blood culture results are available (1, 5, 6).
- If CVAD culture returns a positive result, consult with Infectious Diseases (ID) for further advice.

7.2 Chronic intestinal failure – Home PN patients

Parents/carers of patients receiving home PN have been extensively trained in the care of their child’s CVAD and the administration of PN. For all patients requiring long term home PN therapy, their CVAD is essential for their survival. Parents/carers are trained to apply surgical ANTT when attending all aspects of CVAD care. This is based on international guidelines and is recommended practice when caring for this cohort of children requiring PN (1, 5, 6, 20, 21). When caring for these patients as inpatients, CVAD and PN cares should be negotiated with the parents/carers. If further clarification is required, please contact the PN CNC.

The home PN bags, lines and pumps are different to what is used in the hospital setting. When these patients are admitted to the hospital, cares and management should be negotiated between nursing staff and parents/carers in consultation with ward managers (20). If a patient requires IV medications, it is recommended that IV infusions, including home PN solutions should be attended by the nursing staff. If further clarification of this management is required the PN CNC and/or Gastroenterology team is to be contacted. If the

patient is using their personal home PN pump, the parents must attend to all PN cares. This pump is programmed to self-wean and a weaning calculator is not required. If the home PN solution is being infused via hospital pump, a weaning calculator must be ordered on the MAR.

Home PN bags are “2 in 1” (PN and lipids) solutions which are activated by lying flat, removing the divider and gently mixing prior to spiking the bag. When administering this solution via hospital pump, a **1.2 micron (lipid filter)** should be used (1, 3, 21).

Taurolock is the recommended line lock for patients on home PN or patients requiring a long-term course of PN support (5, 22, 23).

8 Monitoring

The following guidelines are the minimal requirements for the commencement of PN (1). The monitoring regimes must be tailored to the patients.

- Strict fluid balance is to be maintained at all times, as over hydration and dehydration are possible complications of PN therapy.
- Vital observations every 4 hours. The child’s condition must always be considered and monitored and follow Recognition of the Deteriorating Child policy. Observations should meet the “Between the Flags”. A fever could indicate a CRBSI and the attending medical officer should be informed.
- All patients commenced on PN must have 8 hourly blood glucose levels (BGL) until established on PN, usually 24 - 48 hours. This at the discretion of the PN team.
- Daily urinalysis for glucose as glycosuria could be an indication of decreased glucose tolerance.[1] If positive, BGL should be measured (finger/heal prick) and the team informed. Specific gravity of urine should be tested to help determine hydration.
- Patients to be weighed at least twice a week, at the same time of day and on the same scales. Lengths/heights should be attended at a minimum monthly. Head circumferences should be measured in children < 3 years old. Some patients will require more frequent measurements, and this will be specified by the PN/Gastroenterology teams.

8.1 Blood monitoring

- Initial daily bloods (first 2-3 days while grading up) then twice a week: EUC, CMP, BGL, LFTs and triglycerides.
- Monthly: EUC, CMP, BGL, LFTs and triglycerides, FBC, iron studies, urine electrolytes.
- Patients at risk of refeeding may require more frequent blood monitoring when commenced on PN.
- Long-term PN patients: the frequency of monitoring depends upon the patient's age, clinical status, the duration of PN therapy and whether there are signs or symptoms of specific nutrient deficiencies. Guidelines for monitoring stable patients are shown in Appendix 2. (1, 21)

9 Refeeding Syndrome

Refeeding syndrome is a potentially fatal condition due to shifts in fluids and electrolytes, caused by aggressive nutritional support (whether enteral or parenteral) after a period of under nutrition (24, 25).

Re-introduction of enteral or parenteral feeding provide glucose load leading to insulin secretion and can precipitate electrolyte imbalance, especially hypophosphatemia, hypomagnesaemia and hypokalaemia. These metabolic disturbances can cause cardiac arrhythmias, seizures, amongst other life-threatening complications.

Awareness of refeeding syndrome and identification of patients at risk is paramount as the condition is preventable and the metabolic complications are avoidable. Patients at high risk include chronically undernourished patients and those who had little or no nutritional intake for a prolonged period. Dietitian advice should be sought.

For patients at significant risk of refeeding: (17, 24)

- PN should be started at approximately 50% of EER or less as per dietitian recommendations and graded up slowly over 4-7 days.
- Supplementation with thiamine (1-2 mg/kg PO/IV once daily; maximum 100 mg) should be commenced prior to starting PN and continue for 10 days.
- Patients should be carefully rehydrated and electrolytes supplemented and/or corrected:
    - Potassium 1-3 mmol/kg/day
    - Phosphate 0.3-0.6 mmol/kg/day
    - Magnesium 0.2 mmol/kg/day IV or 0.4 mmol/kg/day PO
- Monitor UEC and CMP 8-12 hourly, and BGLs 6 hourly for the first 24-48 hours, and then daily for the first 7 days. Amend treatment as appropriate.
- Strict fluid balance and daily weights. Cardiac monitoring should be considered in very malnourished patients or negligible intake for > 14 days due to the risk of cardiac arrhythmias.

10 Other Considerations

10.1 Cycling of PN

Children who require long term PN can benefit from a cycled regimen. Cycling of PN is an evidence based practice to prevent/limit PN-associated liver disease caused by continuous infusions of glucose, amino acids and lipids (1). The method of reducing the hours of administration of PN must be discussed with the PN/Gastroenterology team prior to commencement. Possible complications of cycling PN are mainly hyperglycaemia at the commencement of the infusion and hypoglycaemia at cessation.

- **At CHW** – PN is weaned in the last 2 hours of infusion and hourly infusion rates are calculated in the Paediatric PN Powerform weaning calculator. Weaning calculator rates must be checked by 2 nursing staff, one whom must be an RN.
- **At SCH** – PN is weaned in the last 1 hour of infusion and the rate is halved in this hour before ceasing. Infants are weaned over 2 hours, following a similar process as above.

When cycling PN it is recommended to check BGL one hour after cessation of PN. This should be performed whenever changes to PN hours are made. For ongoing management, the Medical Officer will review each case on an individual basis depending on the initial BGL performed.

10.2 Discontinuation of PN

The decision to discontinue PN is made by the Attending Medical Officer in conjunction with the PN/Gastroenterology team. A general recommendation is to wean the PN progressively as guided by the PN/Gastroenterology team to prevent complications such as hypoglycaemia. Optimal nutrition should be maintained whilst moving from PN to enteral nutrition, and dietitian advice if recommended. Please inform Pharmacy that the patient is stopping PN.

11 Potential Complications

11.1 Incident reporting

All incidents involving PN **MUST** be reported using the IMS+ reporting system. This includes events where harm has occurred to the patient, near-misses and situations with potential to cause harm. Reporting incidents that occur help the Gastroenterology/PN team to identify areas where practice improvement is needed.

Incidents should be escalated to the treating team at time of the incident as required for immediate management. If an incident involves faulty equipment, an IMS+ report is required. The faulty item should be kept and reported to local clinical product co-ordinator.

11.2 Potential PN complications

Complication	Findings	Considerations
PN-associated liver disease	Abnormal LFTs	• Trophic feeding to stimulate the entero-biliary axis • Cycle PN to reduce hyperinsulinaemia and liver steatosis • Limit glucose intake to reduce hepatic steatosis
Hyperglycaemia	Blood glucose level > 8mmol/L	• Ensure glucose supply is not excessive (<75% of non-protein calories). • Ensure the maximal rate of glucose infusion does not exceed the rate of glucose oxidation • Consider insulin infusion or referring to endocrine for review
Hypoglycaemia	Blood glucose level < 3 mmol/L	• Ensure adequate glucose supply while on PN • To reduce the risk of rebound hypoglycaemia after stopping PN, the rate of PN infusion should at least be halved for the last hour • Check blood glucose 1 hour after stopping PN to detect rebound hypoglycaemia
Hyperlipidaemia	Serum triglycerides > 2.5 mmol/L (infants) > 4.5 mmol/L (children)	• IV lipid infusion should not exceed 0.15 g/kg/h (See Section 4.5) • Reduce IV lipid prescription as required for tolerance • Case by case management - perform peripheral if questioning result, stop infusion for a period prior to testing
Glycosuria	Positive glucose in the urine	• To avoid osmotic diuresis, consider decreasing glucose provision.
Dehydration	Weight loss Negative fluid balance Low urine output Increased urea Increased haematocrit	• Refer to local fluid guidelines (26, 27) • Ensure adequate hydration and increase as required • Ensure strict fluid balance
Fluid overload	Increasing weight Positive fluid balance Polyuria Peripheral oedema Low serum urea Low serum haematocrit	• Refer to local fluid guidelines (26, 27) • Ensure adequate hydration and decrease as required • Ensure strict fluid balance
Hypernatraemia	Serum sodium >145mmol /L	• Often iatrogenic • Ensure adequate hydration, reassess fluid balance • Consider slowly decreasing sodium intake
Hyponatraemia	Serum sodium <135 mmol /L	• Consider water overload, reassess fluid balance chart and slowly correct • Consider performing urine sodium • Frequent in preterm infants < 34 weeks gestation
Hyperkalaemia	Serum potassium > 6 mmol /L	• Consider performing urine potassium • Reassess fluid balance and urine output • Severe hyperkalaemia (> 7 mmol/L) requires prompt intervention

Hypokalaemia	Serum potassium < 3.5 mmol /L	• Assess fluid balance • Check urine sodium and potassium (exclude secondary hyperaldosteronism) • Consider increasing potassium through enteral or parenteral supplies
Fat overload syndrome	Headaches Fever Jaundice Hepatosplenomegaly Respiratory distress Spontaneous haemorrhage	• Review lipid infusion rates for high doses or excessive rates • Repeat full blood count and coagulation profile
Refeeding syndrome	Electrolyte imbalance Hypophosphatemia, Hypomagnesaemia Hypokalaemia	• Please refer to Section 9
CVAD related complications	Fever Suspected CRBSI Line displacement or dislodgement Line breakage	• Please refer to the SCHN CVAD Practice Guideline for all CVAD related complications for advice and management (28) • Refer to ANTT Guideline for advice and prevention (29)

12 Key Performance Indicators

Identified KPI's include:

- Incidents documented on Safety Management Data Base (IMS+)
- Incidence of catheter-related bloodstream infections on patients on PN

13 References

1. Hartman C, Shamir R, Simchowitz V, Lohner S, Cai W, Decsi T, et al. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Complications. Clin Nutr. 2018;37(6 Pt B):2418-29.
2. van Goudoever JB, Carnielli V, Darmaun D, Sainz de Pipaon M, nutrition EEECwgopp. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Amino acids. Clin Nutr. 2018;37(6 Pt B):2315-23.
3. Lapillonne AM, N.F.; Goulet, O.; van den Akker, C.H.; Wu, J.; Koletzko, B. ESPGHAN/ESPEN/CSPEN guidelines on pediatric parenteral nutrition:lipids. Clin Nutr. 2018;37(6B):2324-36.
4. Bronsky J, Campoy C, Braegger C, nutrition EEECwgopp. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Vitamins. Clin Nutr. 2018;37(6 Pt B):2366-78.
5. Kolacek S, Puntis JWL, Hojsak I, nutrition EEECwgopp. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Venous access. Clin Nutr. 2018;37(6 Pt B):2379-91.
6. Wendel D, Mezoff EA, Raghu VK, Kinberg S, Soden J, Avitzur Y, et al. Management of Central Venous Access in Children With Intestinal Failure: A Position Paper From the NASPGHAN Intestinal Rehabilitation Special Interest Group. J Pediatr Gastroenterol Nutr. 2021;72(3):474-86.
7. Worthington P, Balint J, Bechtold M, Bingham A, Chan LN, Durfee S, et al. When Is Parenteral Nutrition Appropriate? JPEN J Parenter Enteral Nutr. 2017;41(3):324-77.
8. Pironi L, Arends J, Bozzetti F, Cuerda C, Gillanders L, Jeppesen PB, et al. ESPEN guidelines on chronic intestinal failure in adults. Clin Nutr. 2016;35(2):247-307.
9. Lal S, Teubner A, Shaffer JL. Review article: intestinal failure. Aliment Pharmacol Ther. 2006;24(1):19-31.
10. Gavin NC, Button E, Keogh S, McMillan D, Rickard C. Does Parenteral Nutrition Increase the Risk of Catheter-Related Bloodstream Infection? A Systematic Literature Review. JPEN J Parenter Enteral Nutr. 2017;41(6):918-28.
11. Jochum F, Moltu SJ, Senterre T, Nomayo A, Goulet O, Iacobelli S, et al. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Fluid and electrolytes. Clin Nutr. 2018;37(6 Pt B):2344-53.
12. Joosten K, Embleton N, Yan W, Senterre T, nutrition EEECwgopp. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Energy. Clin Nutr. 2018;37(6 Pt B):2309-14.
13. Fivez T, Kerklaan D, Mesotten D, Verbruggen S, Wouters PJ, Vanhorebeek I, et al. Early versus Late Parenteral Nutrition in Critically Ill Children. N Engl J Med. 2016;374(12):1111-22.
14. van Zanten AR. Should We Increase Protein Delivery During Critical Illness? JPEN J Parenter Enteral Nutr. 2016;40(6):756-62.
15. Koletzko B, Goulet O, Hunt J, Krohn K, Shamir R, Parenteral Nutrition Guidelines Working G, et al. 1. Guidelines on Paediatric Parenteral Nutrition of the European Society of Paediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) and the European Society for Clinical Nutrition and Metabolism (ESPEN), Supported by the European Society of Paediatric Research (ESPR). J Pediatr Gastroenterol Nutr. 2005;41 Suppl 2:S1-87.
16. Mesotten D, Joosten K, van Kempen A, Verbruggen S, nutrition EEECwgopp. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Carbohydrates. Clin Nutr. 2018;37(6 Pt B):2337-43.
17. Khan LU, Ahmed J, Khan S, Macfie J. Refeeding syndrome: a literature review. Gastroenterol Res Pract. 2011;2011.
18. Riskin A, Picaud JC, Shamir R, nutrition EEECwgopp. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Standard versus individualized parenteral nutrition. Clin Nutr. 2018;37(6 Pt B):2409-17.
19. Domellof M, Szitanyi P, Simchowitz V, Franz A, Mimouni F, nutrition EEECwgopp. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Iron and trace minerals. Clin Nutr. 2018;37(6 Pt B):2354-9.
20. O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis. 2011;52(9):e162-93.
21. Hill S, Ksiazyk J, Prell C, Tabbers M, nutrition EEECwgopp. ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Home parenteral nutrition. Clin Nutr. 2018;37(6 Pt B):2401-8.
22. Olthof ED, Nijland R, Gulich AF, Wanten GJ. Microbiocidal effects of various taurolidine containing catheter lock solutions. Clin Nutr. 2015;34(2):309-14.
23. Gabriel JA. Catheter lock solutions to prevent CVAD-related infection. Br J Nurs. 2020;29(3):S25-S9.

24. Mehanna HM, Moledina J, Travis J. Refeeding syndrome: what it is, and how to prevent and treat it. BMJ. 2008;336(7659):1495-8.
25. Boot R, Koekkoek K, van Zanten ARH. Refeeding syndrome: relevance for the critically ill patient. Curr Opin Crit Care. 2018;24(4):235-40.
26. The Children's Hospital at Westmead. Intravenous fluid management - CHW (guideline no.1/C/09:8070-01:03). http://webapps.schn.health.nsw.gov.au/epolicy/policy/1751/download. 2015.
27. Sydney Children's Hospital Randwick. Intravenous fluid and electrolyte therapy - SCH practice guideline (guideline no. 1/C/13:7033-01:02). http://webapps.schn.health.nsw.gov.au/epolicy/policy/3017/download. 2016.
28. The Sydney Children's Hospital Network. Central venous access devices (CVAD) practice guideline (guideline no. 2013-9037v6). https://webapps.schn.health.nsw.gov.au/epolicy/policy/5119/download 2020.
29. The Sydney Chidlren's Hospital Network. Aseptic non touch technique policy (policy no. 2017-007v2). https://webapps.schn.health.nsw.gov.au/epolicy/policy/4819/download. 2019.

Appendix 1

Composition of multivitamins solutions

Vitamins	Vitalipid N Infant (10mL)	Soluvit N (10 mL)	Cernevit (5 mL)
A (Retinol)	690 microg		3500 Units
D2 (Ergocalciferol)	10 microg (400 Units)		
D3 (Cholecalciferol)			5.5microg
C (Ascorbic acid)		100 mg	125 mg
E (Alpha tocopherol)	6.4mg		11.2 Units
K (Phytomenadione)	200 microg		
B1 (Thiamine)		3.1 mg	3.51 mg
B2 (Riboflavin)		3.6 mg	4.14 mg
B3 (Niacin)		40 mg	46 mg
B6 (Pyridoxine)		4 mg	4.53 mg
B12 (Cyanocobalamin)		5 microg	6 microg
Folic Acid		400 microg	414 microg
Pantothenic acid/		15 mg	17.25 mg
Biotin		60 microg	69 microg

Composition of Baxter AuSPEN Trace Elements

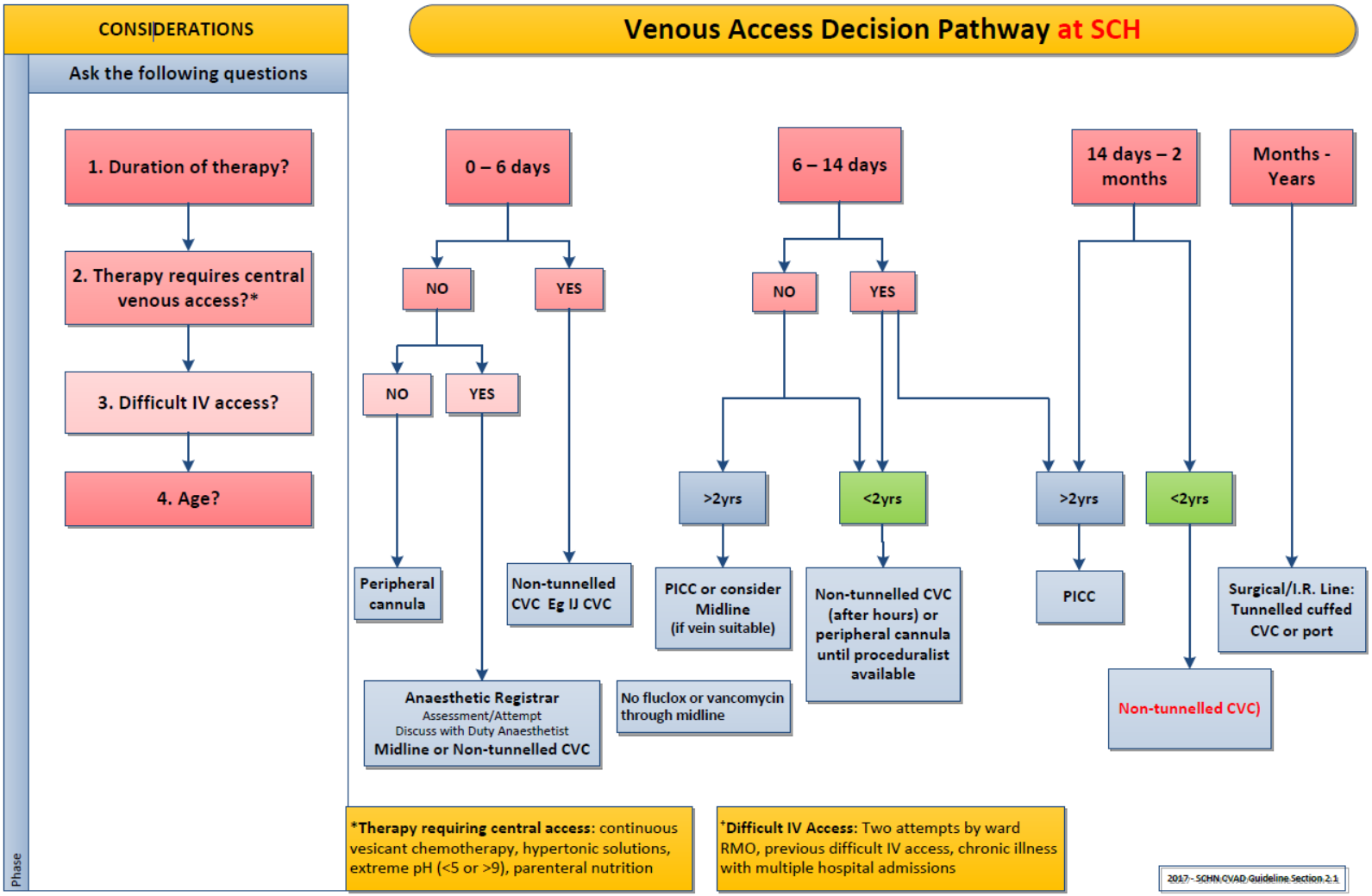
Element	Micrograms per mL	Micromoles per mL
Zinc	91	1.4
Copper	38	0.58
Manganese	2.2	0.04
Selenium	3.1	0.04
Chromium	0.25	0.005
Iodine	6.4	0.05

Appendix 2

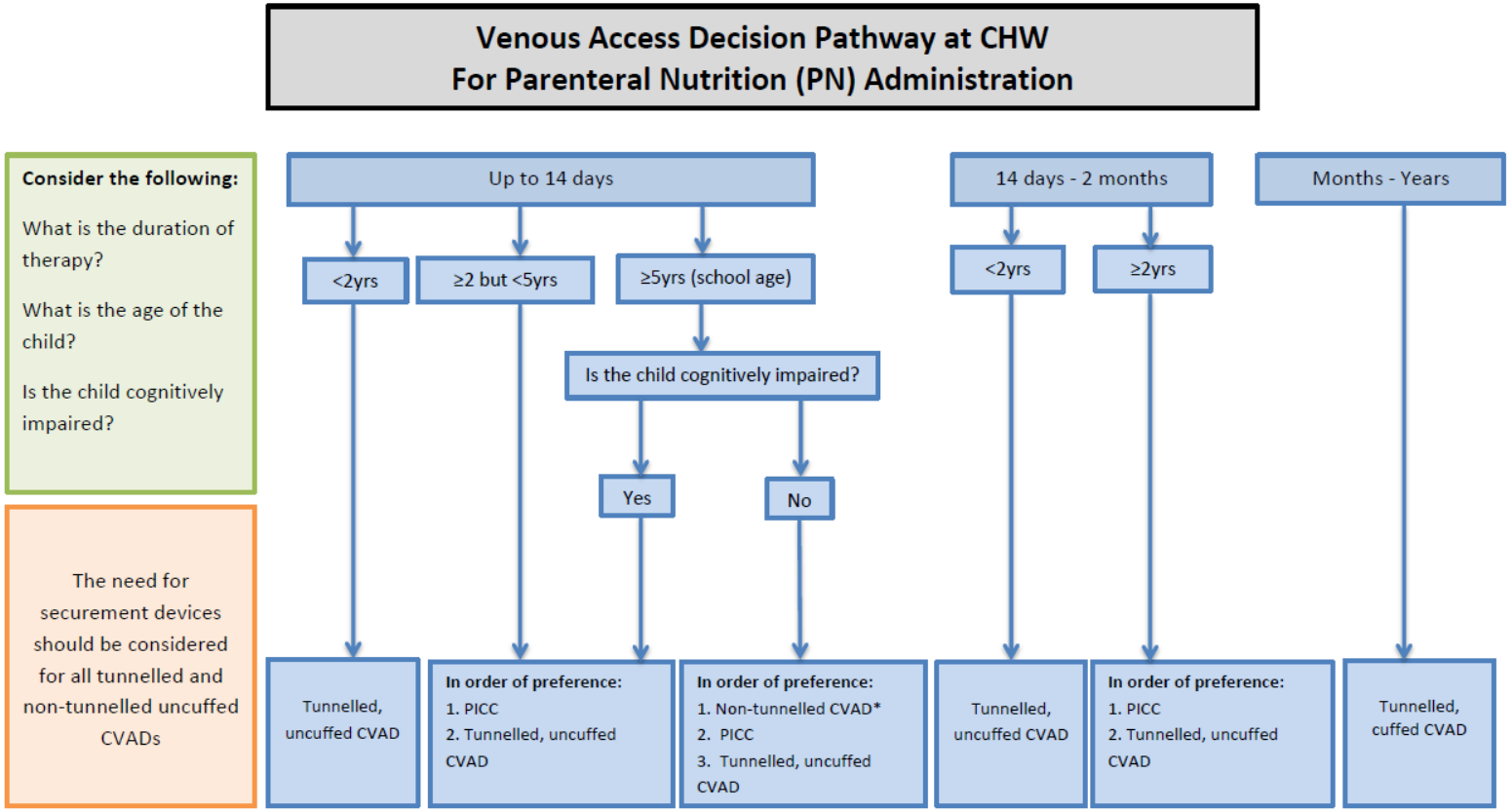
Laboratory Investigations for patients on PN

Frequency	Laboratory Investigation
Initial daily bloods then twice a week	• EUC • CMP • BSL • LFTs • triglycerides
Monthly or Bimonthly (in addition bloods above)	• FBC • Serum glucose • Iron Studies • Urine electrolytes
Quarterly (in addition to monthly)	• Folate • Vitamin B_{12} • Vitamin A • Vitamin D • Vitamin E • Coagulation screen • Selenium • Zinc
Annual (in addition to quarterly) **(to be discussed with GI consultant)**	• Copper • Manganese • Chromium • Carnitine • Essential fatty acids • HbA1c • AFP • Random urine electrolytes • Random urine iodine
Additional long term investigations **(to be discussed with GI consultant)**	• Liver and renal ultrasound • DEXA scan • CXR • Dental review • Venous doppler US

Appendix 3


CONSIDERATIONS
Ask the following questions
1. Duration of therapy?
2. Therapy requires central venous access?*
3. Difficult IV access?
4. Age?
Phase
Venous Access Decision Pathway at SCH
0 – 6 days
6 – 14 days
14 days – 2 months
Months - Years
NO
YES
NO
YES
NO
YES
>2yrs
<2yrs
>2yrs
<2yrs
Peripheral cannula
Non-tunnelled CVC Eg IJ CVC
PICC or consider Midline (if vein suitable)
Non-tunnelled CVC (after hours) or peripheral cannula until proceduralist available
PICC
Surgical/I.R. Line: Tunnelled cuffed CVC or port
Anaesthetic Registrar
Assessment/Attempt
Discuss with Duty Anaesthetist
Midline or Non-tunnelled CVC
No fluclox or vancomycin through midline
Non-tunnelled CVC)
*Therapy requiring central access: continuous vesicant chemotherapy, hypertonic solutions, extreme pH (<5 or >9), parenteral nutrition
†Difficult IV Access: Two attempts by ward RMO, previous difficult IV access, chronic illness with multiple hospital admissions
2017 - SCHN CVAD Guideline Section 2.1

Appendix 4



*** This excludes femoral lines**

NOTE: This is a guideline. There may be deviations in these recommendations on a case-by-case basis as determined by the treating teams involved in consultation with the PN/Gastroenterology team. Any deviations should be documented in the patient's medical record.

PN therapy is not an emergency treatment. If an appropriate line is unable to be inserted due to difficult venous access or unavailability of resources/trained staff, the patient may not receive PN and may require Interventional Radiology or Anaesthetics at a later time for line insertion.

Appendix 5

The ANTT Approach: Parenteral Nutrition Procedures

This table provides an assessment of risk factors and decision making when applying the ANTT approach to clinical procedures involving parenteral nutrition.

The 'ANTT-Approach': Parenteral Nutrition Procedures

This table provides an assessment of risk factors and decision making when applying the ANTT-Approach to clinical procedures involving parenteral nutrition.

Procedure Type	1. Procedure Risks	ANTT Type	2. Environment Management	3. Decontamination/ Protection (PPE)	4. Aseptic Field Management	5. Non-Touch Technique
PN Preparation/ Administration	• Few key parts • High activity environment • Relatively short duration, straight forward procedure.	Standard ANTT	• Remove or avoid any environment risks	• Hand cleaning • Non-sterile gloves • Tray cleaning for **general aseptic field**	• Key parts protected by **micro critical aseptic field** • Supported by a **general aseptic field** • Perform preparation of field by bedside where possible	• Non-touch technique is essential
PN Disconnection	• Few key parts • High activity environment • Shorter duration • Technically simple procedure	Standard ANTT	• Remove or avoid any environment risks	• Hand cleaning • Non-sterile gloves • Tray cleaning for **general aseptic field**	• Key parts protected by **micro critical aseptic field** • Supported by a **general aseptic field** • Perform preparation of field by bedside where possible	• Non-touch technique is essential