LRI Children's Hospital

Calcium Disorders in Children

Staff relevant to:	Medical and Nursing staff working in UHL Children's Hospital caring for children identified with having a calcium disorder.
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Written by: Reviewed by:	Savitha Shenoy Savitha Shenoy
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Contents

1. Introduction and who this guideline applies to

This guideline is for use in children who have been identified to have calcium abnormality – either hypocalcaemia or hypercalcaemia in A&E, CAU, or PICU/CICU.

2. Hypocalcaemia: Causes and Management

2.1 Definition

Serum Adjusted Calcium <2.1mmol/L

Ionised calcium on blood gas machines can also be used –

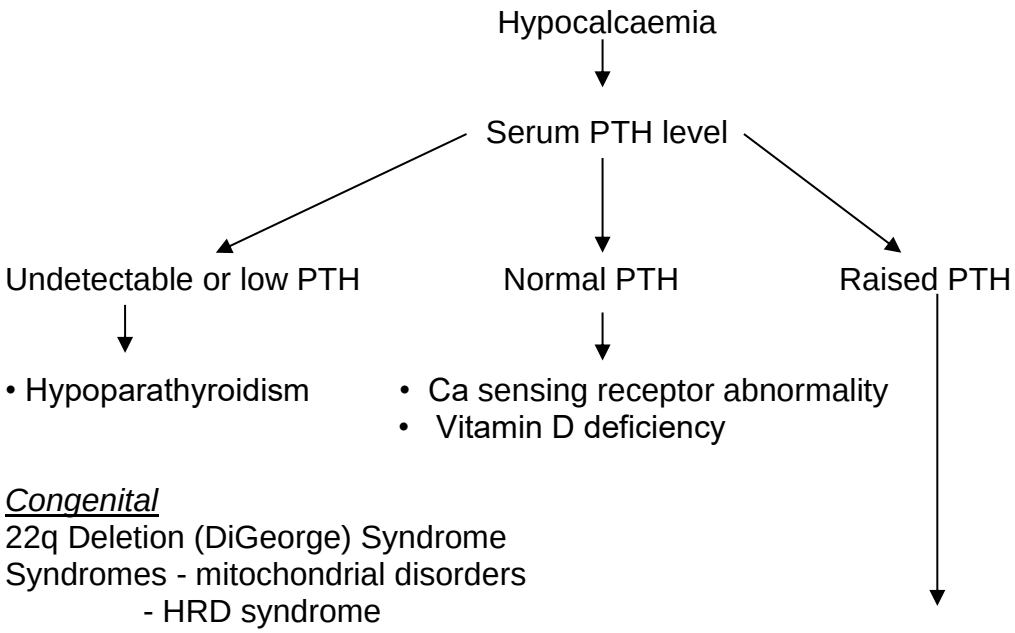
Ionised calcium <1.0 mmol/L
OR
Ionised Calcium <1.2 mmol/L AND symptoms (low cardiac output, seizures, arrhythmia,etc)

(* Use ionised calcium rather than serum calcium if patient has low serum albumin)

2.2 Causes of Hypocalcaemia

Vitamin D deficiency
Hypoparathyroidism
Pseudo hypoparathyroidism
Chronic renal failure
Hypomagnesaemia
Abnormality of calcium – sensing receptor
Other causes in neonates – Prematurity, HIE, Gestational Diabetes, Maternal Hyperparathyroidism

2.3 Algorithm for cause of Hypocalcaemia



2.4 Investigations

Bone profile – plasma calcium, phosphate, alkaline phosphatase
Plasma albumin, creatinine
Serum Magnesium
Plasma 25 – Hydroxyvitamin D
Serum PTH

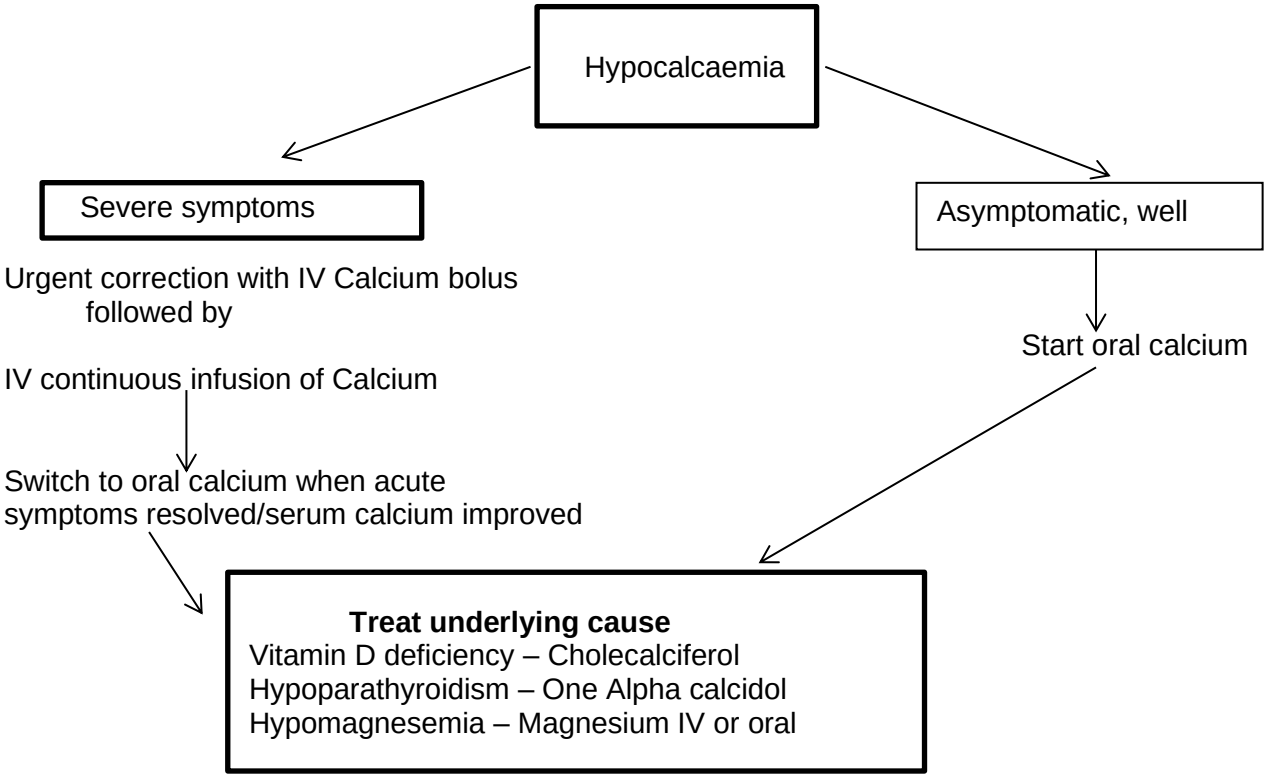
Consider:
Store serum for 1,25-dihydroxyvitamin D
Urine for calcium: creatinine ratio and phosphate
X-ray of wrist of knee

2.5 Management

Treatment is dependent on 2 factors:

1) Presence of severe symptoms such as convulsion, stridor, apnoea (neonates), prolonged QT interval on ECG, tetany
2) Underlying cause of hypocalcaemia

2.6 Hypocalcaemia treatment



Further details of treatment

IV Calcium Gluconate bolus for peripheral/central line administration: in emergency for urgent correction

Preparation	Strength	Dose
10 % Calcium Gluconate	10 mL vial = 2.25 mmol (2250 micromol) Calcium	0.5 mL/kg = 0.11 mmol/kg Max 20 mL (4.5mmol) per dose

Precaution: use central venous line or in urgent situations it may be administered via large peripheral vein – beware extravasation. When administered peripherally, it should be administered very slowly in a preferably large vein to avoid extravasation. Rapid administration can cause extravasation, bradycardia and drop in BP.

For further information refer to IV administration as provided on Medusa.

2.7 Monitoring

1) Infusion site should be regularly checked to identify skin extravasation. Extravasation of IV calcium can cause considerable skin reaction and subsequent scarring in the skin and subcutaneous tissue
2) Continuous ECG monitoring during treatment is essential, particularly those children with known arrhythmia and on Digoxin therapy.

2.8 Continuous IV Calcium Gluconate infusion for peripheral/central line administration-

Dose:

- Neonate: 0.5 mmol/kg/day over 24 hours (may be adjusted to response)
- Child 1 month to 2 years: 1mmol/kg/day (maximum 8.8 mmol) over 24 hours (may be adjusted to response)
- Children over 2 years of age: 8.8 mmol over 24 hours (may be adjusted to response)

Precaution: Avoid extravasation and swap to oral calcium supplements as soon as possible due to risks of extravasation.

Preparation of IV Calcium Gluconate infusion:

Recommended dilution:

Preparation	Strength	Preparation
10 % Calcium Gluconate	10 mL vial = 2.25 mmol (2250 micromol) Calcium	1 vial (10 mL) diluted up to 50 mL with 5% Glucose or 0.9% Sodium chloride = 45 micromol/mL Calcium

Rate of infusion of IV Calcium diluted solution

Neonates	**0.5mls /kg/hour (=22 micromol/kg/hour)**
Children 1 month – 2 years	**1ml/kg/hour (=45 micromol/kg/hour)** Total daily dose must not exceed 195mls (8.8mmol)
Children over 2 years	**8.1ml/hr 24 hours – Total 195ml(8.8mmol)** Total daily dose must not exceed 195 mls (8.8mmol)

Examples

a) A 3 year old child weighs 20kg who needs to have IV Calcium infusion
   - Dose: reaches maximum of 8.8mmol (=8,800 micromols) in 24 hours IV calcium preparation as above provides 45micromol/mL
   - To provide 8,800 micromols/24 hours, total volume of the calcium infusion required is 8800/45 = 195 mls/24 hours
   - Infusion rate is 195/24 = 8.1 mls/hour for 24 hours
     - Equiv mmol/kg/hour = (8800 micromols/24 hours)/20kg = 18 micromol/kg/hour (maximum rate allowed 45 micromol/kg/hour)

b) A neonate who weighs 3.5 kg requiring calcium infusion
   - Dose 0.5 mmol/kg/day = 1.75 mmol/24 hours = 1750 micromols/24 hours Calcium infusion provides 45 micromol/mL
   - To provide 1,750 micromols/24 hours, total volume of the calcium infusion required is 1750/45 = 39mL/24 hours
   - Infusion rate is 39/24 = 1.6 mls/hour for 24 hours
     - Equiv mmol/kg/hour = (1750micromols/24 hours)/3.5kg = 20.8 micromol/kg/hour (maximum rate allowed 22 micromol/kg/hour)

Monitoring during IV calcium infusion (either central or peripheral)

1) Infusion site should be regularly checked to identify any extravasation. Extravasation of IV calcium can cause considerable skin reaction and subsequent scarring in the skin and subcutaneous tissue.
2) Continuous ECG monitoring during treatment is essential, particularly those children with known arrhythmia and on Digoxin therapy.
3) Monitor serum calcium levels every 6 hours and swap to oral calcium as soon as serum calcium level improved to 2.1 mmol/L or more and child becomes symptom free.

2.9 Oral Calcium Supplement

Change the IV calcium to oral calcium supplement once the acute symptoms are resolved and serum calcium improves to at least 1.9 mmol/L or more.

Doses:

Neonate	0.25 mmol/kg/dose 4 times daily, adjusted to response
1 month-4 years	0.25 mmol/kg/dose 4 times a day, adjusted to response
Child 5-12 years	0.2 mmol/kg/dose 4 times daily, adjusted to response
Child 12- 18 years	10 mmol 4 times a day, adjusted to response

Oral Calcium preparations:

Adcal chewable tablet 15 mmol per tablet
Calvive 1000 tablets (dispersible) – 25mmol into 50 ml and give proportion

If child is discharged home on oral calcium supplements, arrange repeat serum calcium on day care ward after a week of treatment. Oral calcium can be discontinued when the serum calcium has returned to normal range in vitamin D deficiency.

In other causes such as hypoparathyroidism. Prolonged oral calcium course may be necessary – seek advice from the Paediatric Endocrine Team.

2.10 Other medications:

1) Cholecalciferol in Vitamin D deficiency:

0 - 6 months age	**3000 IU**/day for 6 weeks
6 months to 12 years	**6000 IU/day** for 8 weeks
12-18 years	**10,000 IU** /day for 8 weeks or 20,000 IU capsule x2/week

Refer to Vitamin D Deficiency and Rickets UHL Childrens Medical Guideline UHLC6/2010

Oral calcium can be stopped when serum calcium levels corrected as stated as above

2) Hypoparathyroidism or Pseudohypoparathyroidism: seek advice from the Paediatric Endocrine Team

The treatment of hypocalcaemia due to hypoparathyroidism or pseudohypoparathyroidism would require calcium (oral or IV as above) to correct hypocalcaemia as well as treatment with appropriate choice of Vitamin D which are 1ά-hydroxycolecalciferol or 1,25 –Dihydroxycoleacalciferol. Other vitamin D preparations such as Ergocalciferol or Cholecalciferol are not suitable choice for this condition.

Choice of Preparation

Preparation	Strength	Dose
1ά-hydroxycolecalciferol (Alphacalcidol) oral drops*	2 microgram/mL (1 drop = 100 nanogram)	25-50 nanogram/kg once daily rounded to nearest drop
1ά-hydroxycolecalciferol (Alphacalcidol) capsule*	250 nanogram, 500 nanogram 1 microgram	25-50 nanogram/kg once daily rounded to nearest capsule
1,25-Dihydroxycoleacalciferol (Calcitriol)	250 or 500 nanogram capsule or 1 microgram/mL solution	15 nanogram/kg (max 250(nanogram) once daily

* Preferred preparation by endocrine team. Oral drops preferred in younger children due to ease of dose titration. Each drop provides 100 nanogram dose. The oral drops can be administered directly over the tongue or on a spoon.

Aim: Maintain serum calcium in lower end of normal range at 2.0 to 2.2 mmol/L to avoid risk of herpercalciuria

3) Magnesium to correct Hypomagnesaemia: refer to BNFC and Medusa

3. Hypercalcaemia – causes and management

3.1 Definition

Serum adjusted calcium > 3.0 mmol/L or > 2.6 mmol/L if symptomatic

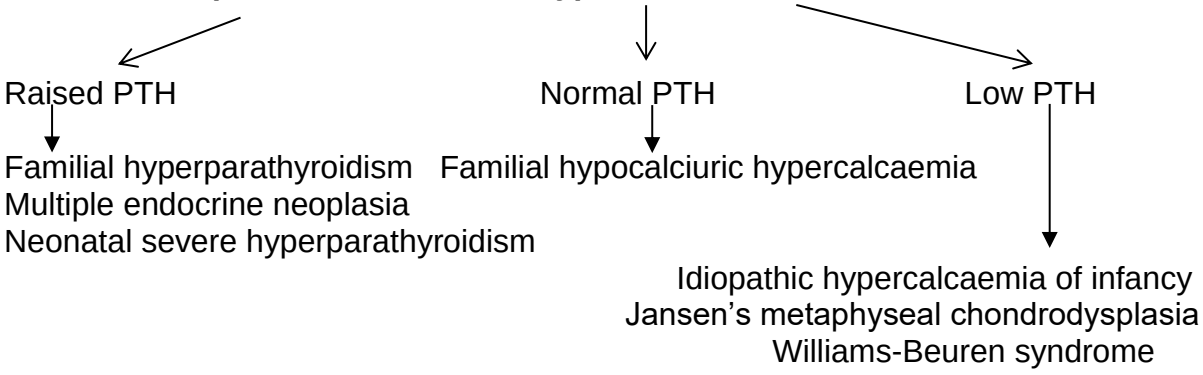
Serum adjusted calcium 2.6 mmol/L to 3.0 mmol/L and asymptomatic – consider general measures

3.2 Clinical features of Hypercalcaemia

Children with hypercalcaemia may not have any symptoms. Clinical features associated with severe hypercalcaemia includes behavioral disturbance, myopathy/proximal muscle weakness, abdominal pain, nausea, vomiting, vomiting due to paralytic ileus, polyuria, polydipsia, dehydration leading on to renal failure, bone pain and others like conjunctivitis.

3.3 Causes of hypercalcaemia

1) Genetic causes of hypercalcaemia



2) Cause of secondary hypercalcaemia

Malignancy
Endocrine – Thyrotoxicosis Addison's disease
Drug induced – Vitamin A intoxication, Vitamin D intoxication, Thiazides
Renal – Chronic renal impairment, Renal tubular Acidosis (RTA), Bartter's Syndrome
Immobilisation
Granulomatous disorders – Sarcoidosis, TB, Subcutaneous fat necrosis

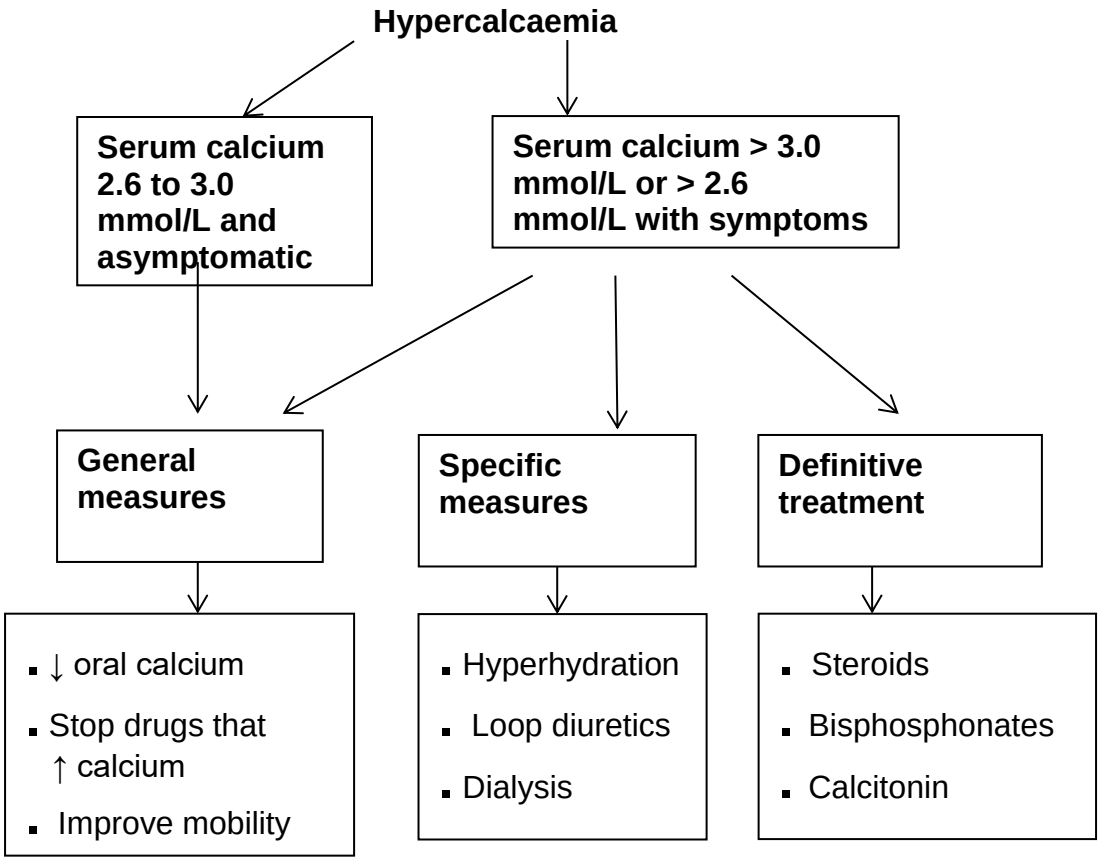
3.4 Investigations

- Bone profile – Calcium, phosphate, alkaline phosphatase
- Renal function
- Serum PTH
- 25-hydroxy Vitamin D
- Thyroid function test
- Urine Calcium: Creatinine ratio
- Store serum for 1,25 – dihydroxy Vitamin D

Subsequent investigations to be considered:

- Renal USS
- Parents bloods for bone profile
- Parathyroid gland USS
- Skeletal Survey

3.5 Management of hypercalcaemia algorithm



3.6 Details of management:

General Measures:

1) Reduce calcium from oral and parental feeds – seek dietician advice to change milk feeds to low calcium formula milk
2) Discontinuation of drugs that lead to hypercalcaemia – oral calcium supplements, Vitamin D supplements, Thiazide diuretics
3) Measures to improve weight bearing mobility of the patient if appropriate
4) Consider discontinuation of sedative drugs to promote mobility if appropriate

Specific measures:

1) Increase urinary calcium excretion with IV fluids – Severe hypercalcaemia can induce volume contraction due to both decreased fluid intake and natriuretic effect of hypercalcaemia. Volume expansion enhances renal calcium excretion by reducing calcium reabsorption.
   Hyperhydration with 0.9% sodium chloride 3L/m2/24hr improves calcium excretion. Encourage oral hydration simultaneously. Monitor serum electrolytes and bone profile 12 hourly whilst on the regime and titrate fluid accordingly.

PS: For Body Surface Area (BSA) – use BNFC table based on patients weight

2) Loop diuretics (Frusemide) – can be helpful to increase calcium excretion provided child is well hydrated. Use of Loop diuretics in a child with intravascular depletion can exacerbate hypercalcaemia and hypokalaemia. Seek advice from the renal team if renal function is deranged before using diuretics.
3) Dialysis – should be considered in severe hypercalcaemia associated with oliguric renal impairment. Advice from renal team should be sought early if in doubt.
4) Specific definitive treatment: the need for specific definitive treatment in management of hypercalcaemia in children is rare. Contact the Paediatric endocrine team for advice in such a scenario if considering use of any of the following therapies:

a) **Oral steroids like Prednisolone** – mechanism is said to be suppression of conversion of 25 (OH) Vitamin D to 1,25 (OH) Vitamin D. It can be helpful in granulomatous conditions and subcutaneous fat necrosis. They can be also helpful in malignancy due to its effect on leukemia cells but it is imperative that malignancy has been ruled out with bone marrow aspiration before steroid is administered.
b) **Bisphosphonates (Disodium Pamidronate)** – will reduce calcium within 24 hours. It should be used in caution in renal impairment and rehydration is essential to prior to commencing IV Pamidronate. Refer to BNFC and Medusa for dosing and administration information.

Hypocalceamia can be observed 12-24 hour after administration. Monitoring serum calcium levels 12 hours and 24 hours after infusion is essential and

treat low calcium levels as required. This can be a challenge in those patient who also have suboptimal 25 (OH) Vitamin D status which also needs correction.

c) **Calcitonin** – inhibits osteoclast activity, intestinal and renal tubule calcium reabsorption. This can be helpful in association with malignancy. Use with caution in renal impairment. Use Calcitonin only after seeking advice from a Specialist Bone Team. Adverse effects include nausea, flushing, paresthesia and local inflammation at the site of administration.

3. Education and Training

None

4. Monitoring Compliance

What will be measured to monitor compliance	How will compliance be monitored	Monitoring Lead	Frequency	Reporting arrangements
Audit of hypocalcaemia and hypercalcaemia management in children	Audit	Dr Shenoy	3 years	Clinical Audit meeting

5. Supporting References

Etiology of hypocalceamia in infants and children. Up to date August 2017

Vitamin D insufficiency and deficiency in children and adolescents. Up to date November 2016

Reynolds BC, Cheetham T. Bones, Stones, Moans and Groans: Hypercalceamia revisited. Arch Dis Child Educ Pract ED 2015; 100:44-51

Davies JH, Shaw NJ, Investigation and Management of hypercalcaemia in children Arch Dis Child 2012; 97:533-8

6. Key Words

Calcium disorders, Hypocalcaemia, Hypercalcaemia, Vitamin D

The Trust recognises the diversity of the local community it serves. Our aim therefore is to provide a safe environment free from discrimination and treat all individuals fairly with dignity and appropriately according to their needs.
As part of its development, this policy and its impact on equality have been reviewed and no detriment was identified.

Contact and review details	
Guideline Lead (Name and Title) Dr Savitha Shenoy - Consultant	**Executive Lead** Chief Medical Officer
Details of Changes made during review: Clarified the definition of hypocalcaemia Added urine phosphate to point 2.4 - investigations for hypocalcaemia Rationale behind medications for treating hypoparathyroidism or pseudohypoparathyroidism	