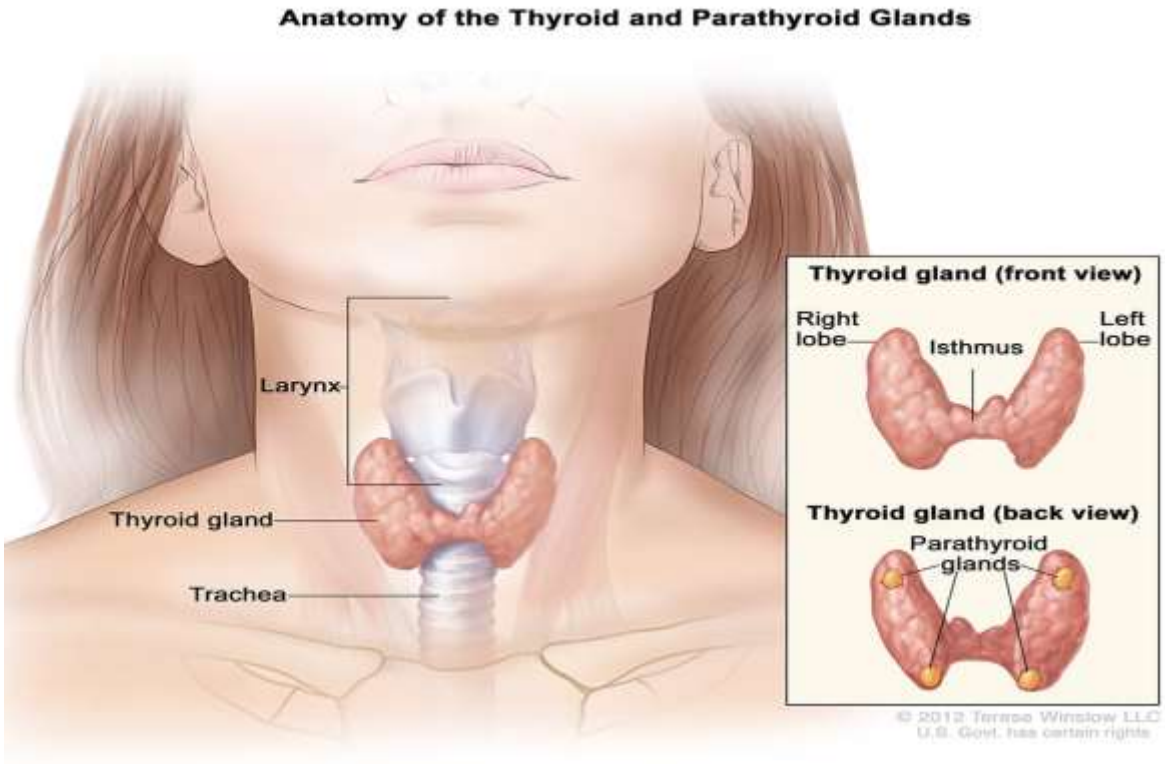
Parathyroid glands disorders

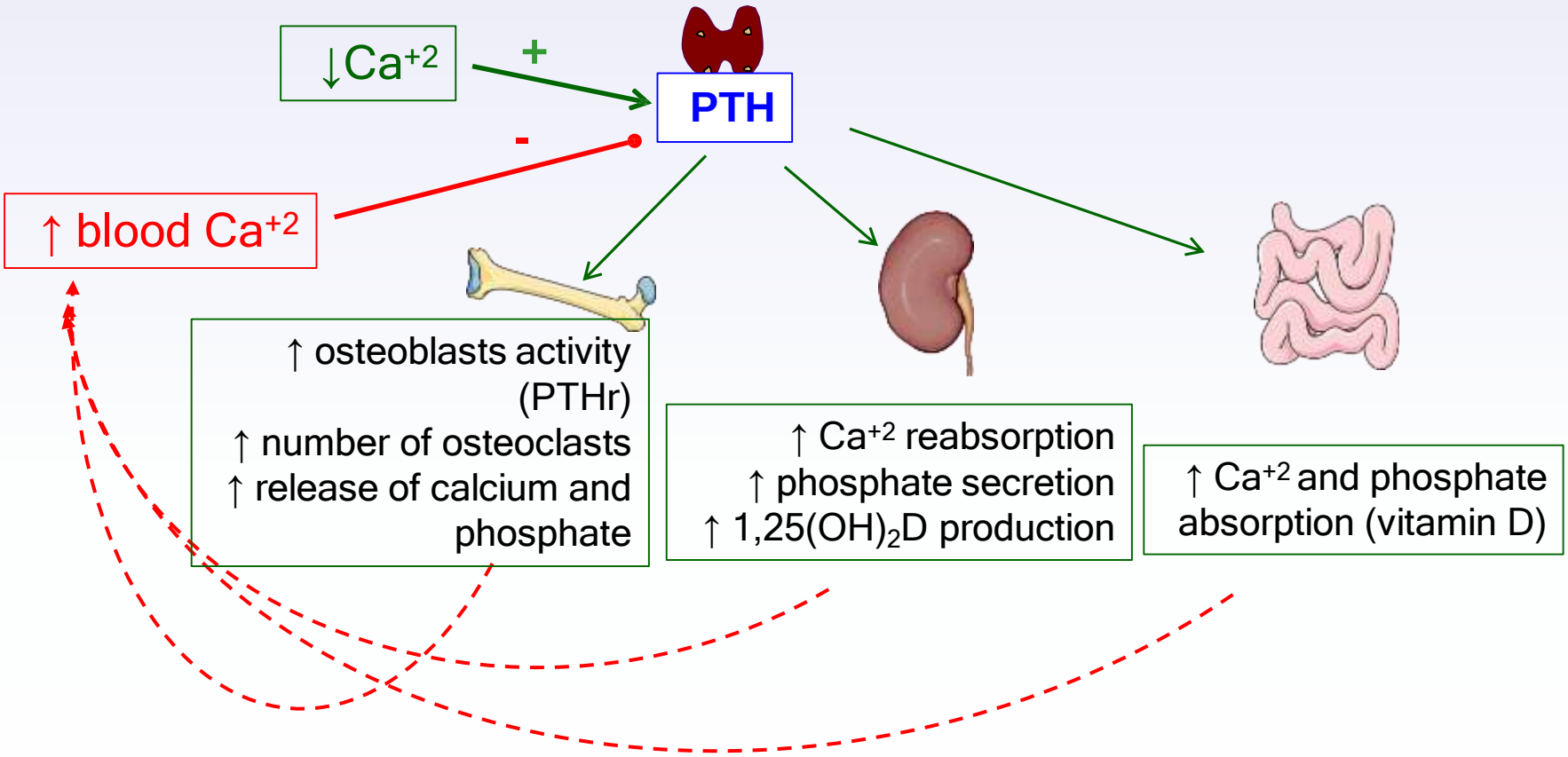
DR.AHMAD ALTARAWNEH

The parathyroid glands are two pairs of glands usually positioned behind the left and right lobes of the thyroid. Each gland is a yellowish-brown flat ovoid that , usually about 6 mm long and 3 to 4 mm wide, and 1 to 2 mm anteroposteriorly.

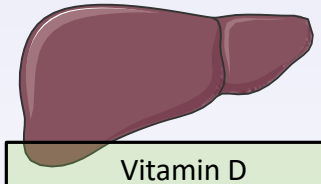
There are typically four parathyroid glands



The effect of parathyroid hormone



Synthesis and regulation of active vitamin D (calcitriol)



↓ Serum phosphate

↑ Serum phosphate

PTH

\+

\+

\+

FGF 23

(-)

Vitamin D 25-hydroxylase

Vitamin D 1α-hydroxylase

\+

\+

\+

\+

7-dehydrocholesterol

Cholecalciferol (Vitamin D3)

25(OH) cholecalciferol (Calcidol)

$1,25(OH)_2$ cholecalciferol **(Calcitriol)** **Active vitamin D**

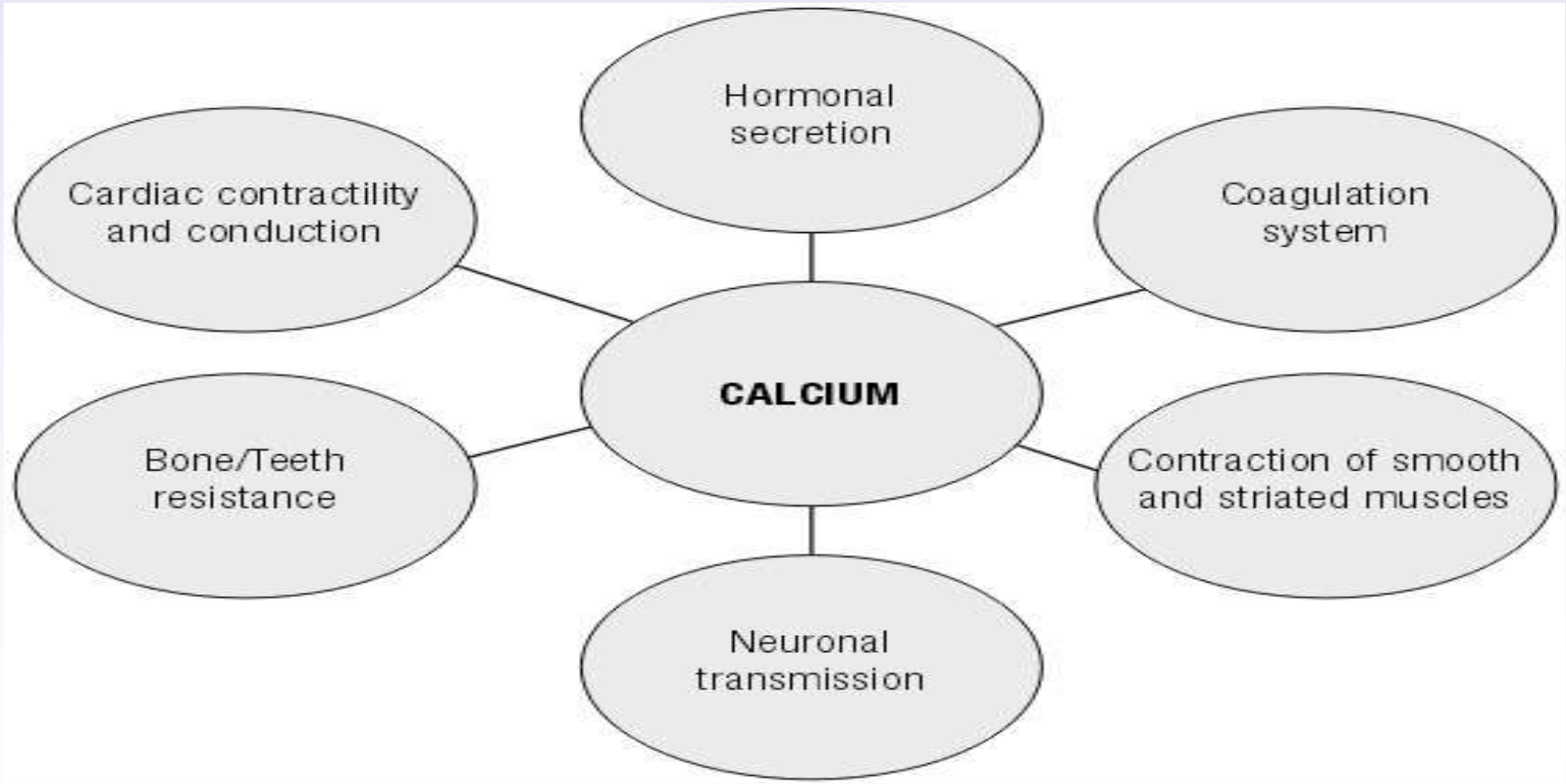
Dietary sources

Ergocalciferol (Vitamin D2)

Major mediators of calcium and phosphate balance

Serum		
Ca_s	P_s	**Parathormone (PTH)**
↑	↓	• increases the release of calcium and phosphate from bones • stimulates the formation of active vitamin D in the kidneys (activation of 1 α hydroxylase) • reduces calciuria and increases phosphaturia
		Vitamin D
↑	↑	• increases the uptake of Ca and P in the gastrointestinal tract
		Calcitonin (low physiological importance)
↓		• decreases the uptake of Ca in the gastrointestinal tract • increases calciuria • reduces bone resorption
		FGF 23 (Fibroblast Growth Factor 23)
	↓	• increases phosphaturia

Calcium



Ca concentration is tightly regulated

Different forms of calcium

99%

Most of the calcium in the body is stored in the bones as hydroxyapatite

Calcium in the serum:

- 45% - free ionised form ← physiologically active
- 45% - bound to proteins (predominantly albumins)
- 10% - complexed with anions (e.g. citrate, sulfate, phosphate)

Typically measured in routine blood tests

The total serum calcium concentration is adjusted to reflect any abnormality in albumin, the major calcium binding protein. The formula to use is:

corrected calcium = measured total serum calcium in mg/dL + 0.8 x (4.0 - patient's serum albumin concentration in g/dl).

Normal laboratory values

Test	Specimen	Conventional Units	SI Units
Calcium	serum	8.5-10.3 mg/dL	2.12-2.57 mmol/L
Ionised calcium	plasma	4-5.2 mg/dL	1.0-1.3 mmol/L
Calcium	urine	M < 300 mg/d F < 250 mg/d	M < 7.5 mmol/d F < 6.2 mmol/d
Phosphorus	serum	2.5-4.5 mg/dL	0.81-1.45 mmol/L
PTH (intact)	serum	11-67 pg/mL	

M-male, F-female

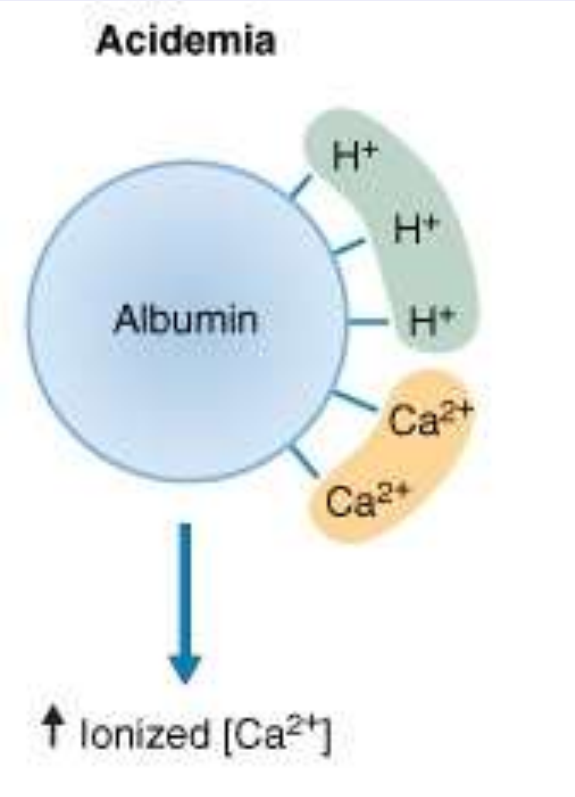
Factors affecting calcium concentration

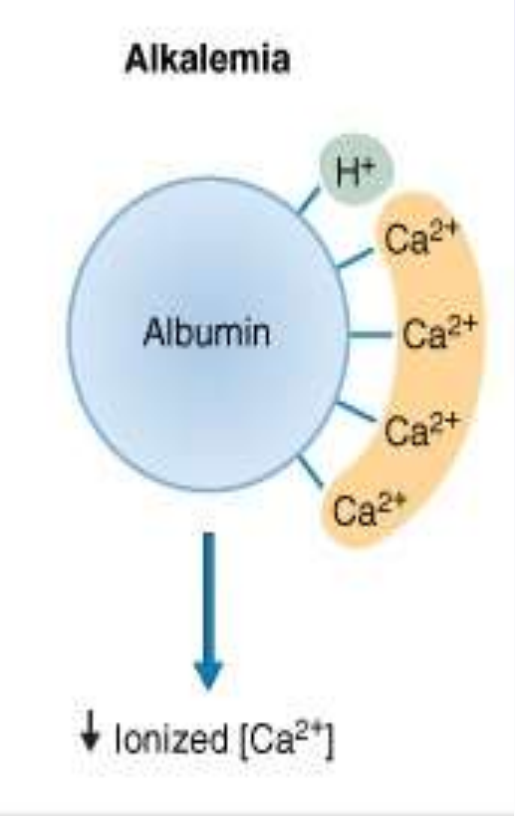
1) Changes in plasma protein concentration
-Increased [protein] – increased total [Ca2+]

2) Changes in anion concentration
-Increased [anion] – increased fraction of Ca2+ that is complexed – decrease ionized [Ca2+]

3)Acid base abnormality

Acid Base Abnormality





Causes of hypercalcemia

Parathyroid mediated
Primary hyperparathyroidism (sporadic)
Inherited variants
Multiple endocrine neoplasia (MEN) syndromes
Familial isolated hyperparathyroidism
Hyperparathyroidism-jaw tumor syndrome
Familial hypocalciuric hypercalcemia
Tertiary hyperparathyroidism (renal failure)

Non-parathyroid mediated
Hypercalcemia of malignancy
PTHrp
Increased calcitriol (activation of extrarenal 1 alpha-hydroxylase)
Osteolytic bone metastases and local cytokines
Vitamin D intoxication
Chronic granulomatous disorders
Increased calcitriol (activation of extrarenal 1-alpha-hydroxylase)

Medications
Thiazide diuretics
Lithium
Teriparatide
Abaloparatide
Excessive vitamin A
Theophylline toxicity

Miscellaneous
Hyperthyroidism
Acromegaly
Pheochromocytoma
Adrenal insufficiency
Immobilization
Parenteral nutrition
Milk-alkali syndrome

Hyperparathyroidism

Primary - PTH secretion is disproportionately high in relation to the serum calcium concentration.

Secondary to kidney failure, severe vitamin D and calcium deficiency. Reversible, after removing the cause of the disorder.

Tertiary - is excessive autonomous secretion of parathyroid hormone after a long period of secondary hyperparathyroidism.

TABLE 3

Lab Comparison

Hyperparathyroidism	Calcium	PTH	Vitamin D	Phosphate
Primary	↑	↑→	↑	↓
Secondary	↓→	↑	↓	↑ or ↓
Tertiary	↑	↑↑	↓	↑

Key: ↑Elevated, ↓decreased, →normal.

Source: Brashers. *Pathophysiology.* 2015.[6]

Primary hyperparathyroidism)PHPT)

Primary hyperparathyroidism is characterised by secretion of PTH that is excessively disproportionate to serum calcium levels, resulting from a primary defect of parathyroid cells.

PHPT results from:

• one or more adenomas	80-85%
• hyperplasia of all parathyroid glands	10-15%
• parathyroid carcinoma	fewer than 1%

PHPT - familial hereditary syndromes

Hereditary forms of PHPT account for 5% of cases:

- Multiple endocrine neoplasia (MEN)1,2A
- Hereditary hyperparathyroidism – jaw tumor syndrome

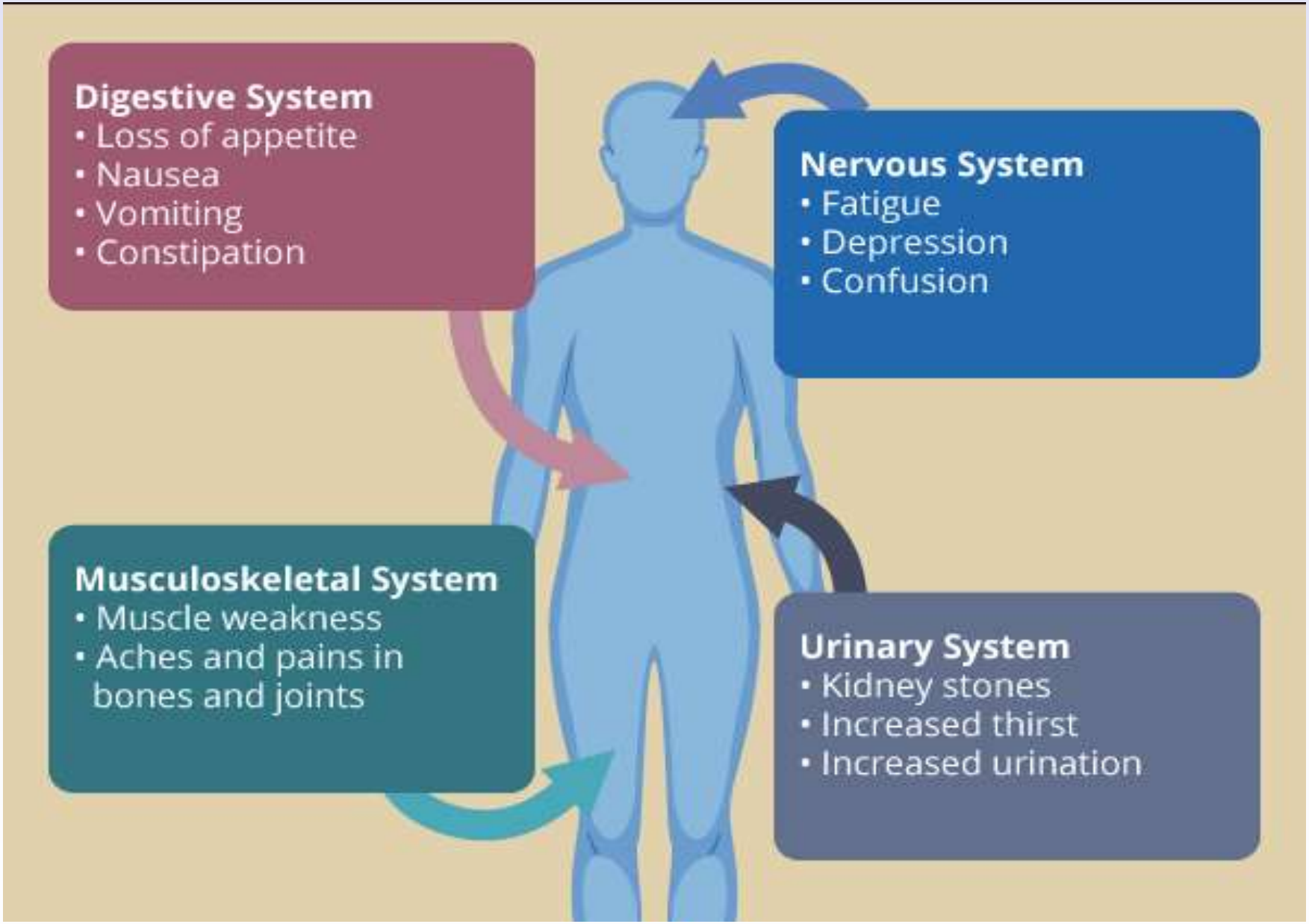
Primary hyperparathyroidism –clinical forms

- The most common clinical presentation of PHPT is asymptomatic or low symptomatic disease
- Atypical occurences include normocalcemic PHPT and parathyroid crisis.

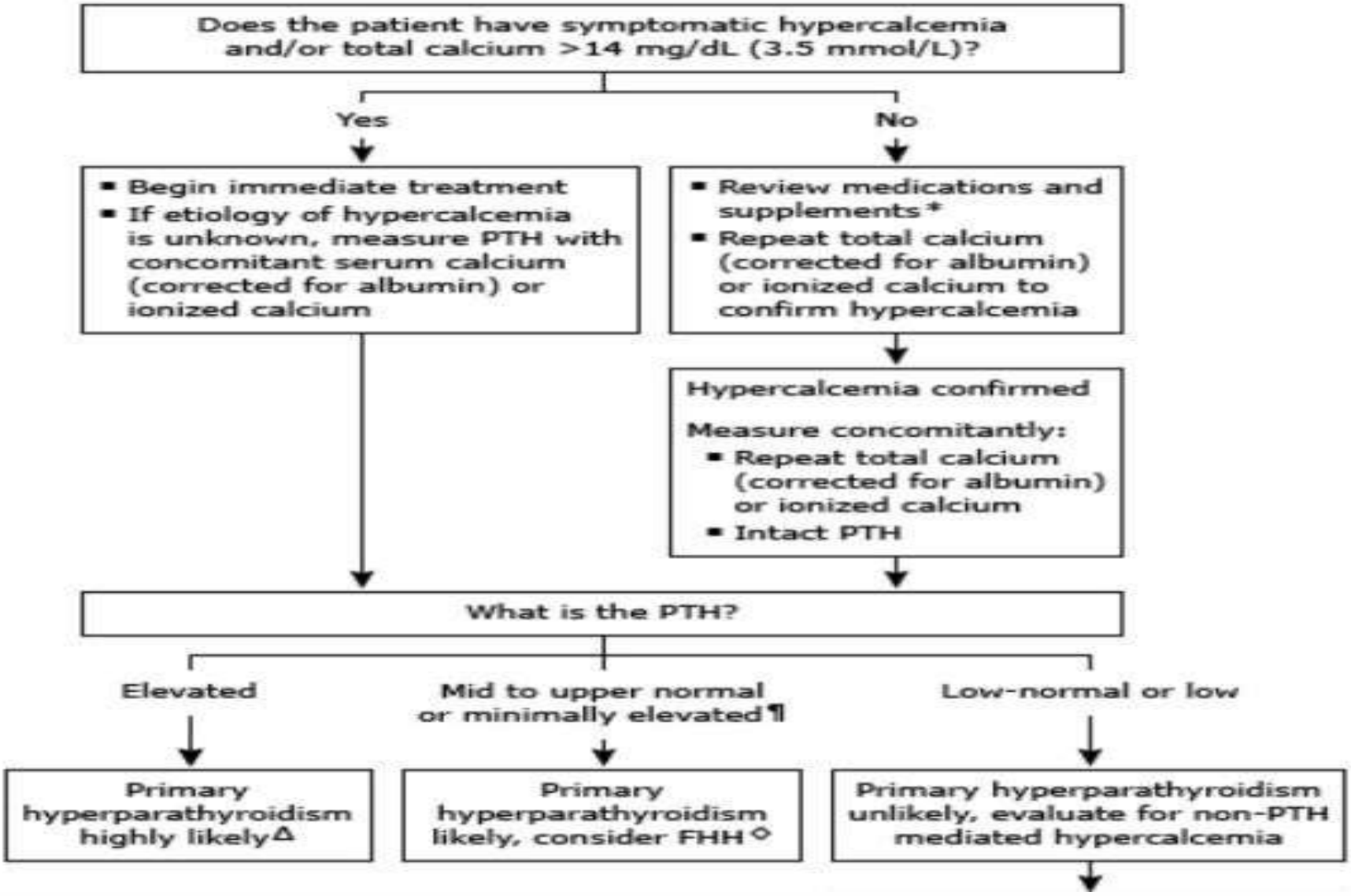
Classical clinical consequences of PHPT

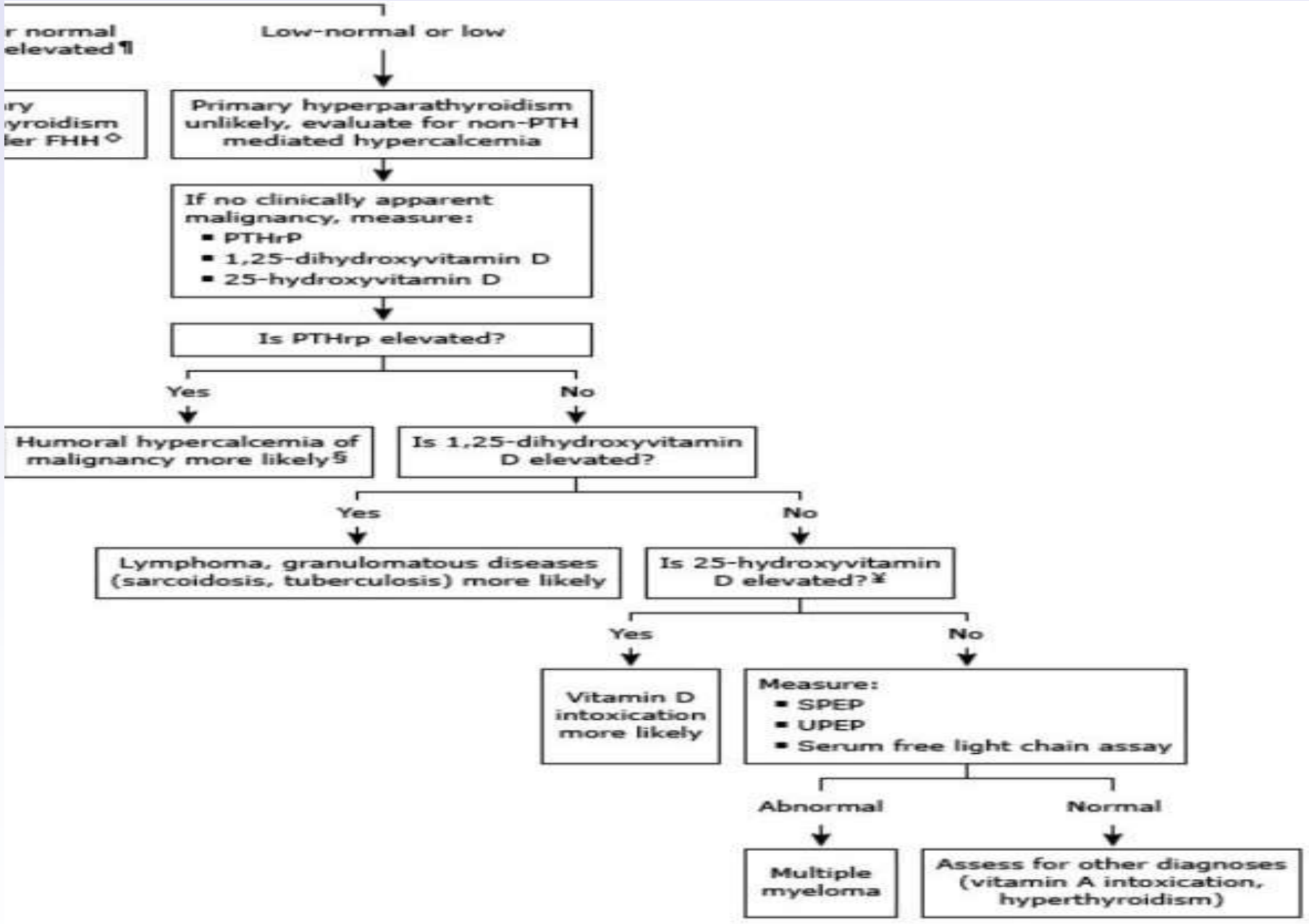
Bones, stones, abdominal groans, and psychic moans

Bone destruction	Hypercalcemia	Hypercalciuria
Osteopenia	Peptic ulcer disease	Urolithiasis
Osteoporosis	Pancreatitis	Nephrocalcinosis
Bone deformities and fractures	Constipation, nausea, vomiting or loss of appetite	Nephrogenic diabetes insipidus
Osteitis fibrosa cystica, brown tumors	Polydipsia and polyuria	
	Renal failure	
Bone pain , myalagia	Cardiovascular features: hypertension, arrhythmia	
	Tiring easily or weakness	
	Neuropsychiatric disorders	
	Parathyroid crisis	

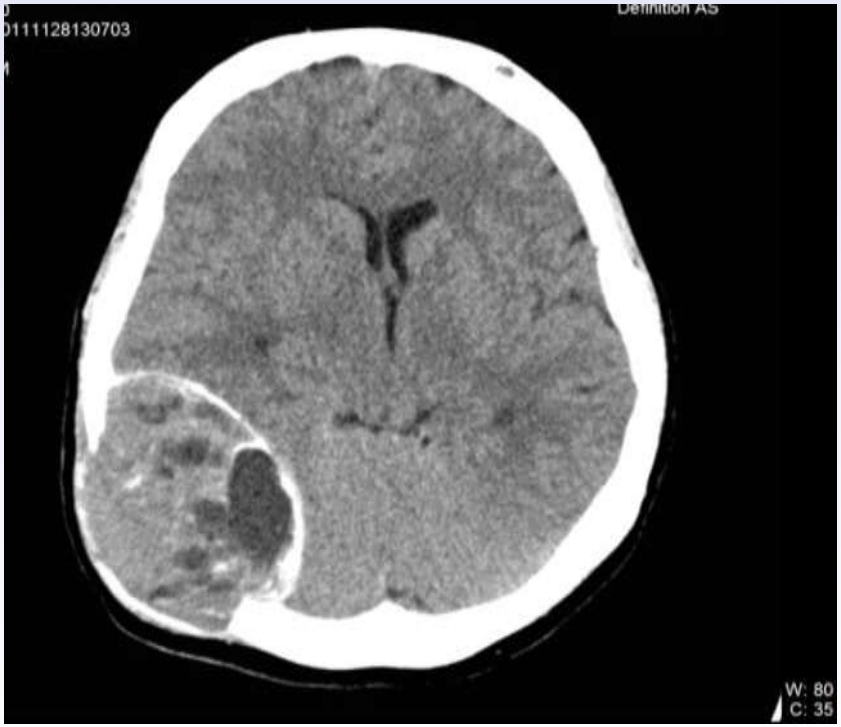

Digestive System
• Loss of appetite
• Nausea
• Vomiting
• Constipation
Nervous System
• Fatigue
• Depression
• Confusion
Musculoskeletal System
• Muscle weakness
• Aches and pains in bones and joints
Urinary System
• Kidney stones
• Increased thirst
• Increased urination

Diagnostic approach to hypercalcemia in adults




r normal
elevated¶
Low-normal or low
ry
yroidism
ler FHH◇
Primary hyperparathyroidism unlikely, evaluate for non-PTH mediated hypercalcemia
If no clinically apparent malignancy, measure:
PTHrP
1,25-dihydroxyvitamin D
25-hydroxyvitamin D
Is PTHrp elevated?
Yes
No
Humoral hypercalcemia of malignancy more likely§
Is 1,25-dihydroxyvitamin D elevated?
Yes
No
Lymphoma, granulomatous diseases (sarcoidosis, tuberculosis) more likely
Is 25-hydroxyvitamin D elevated?¥
Yes
No
Vitamin D intoxication more likely
Measure:
SPEP
UPEP
Serum free light chain assay
Abnormal
Normal
Multiple myeloma
Assess for other diagnoses (vitamin A intoxication, hyperthyroidism)

Primary hyperparathyroidism – bone destruction



brown tumor :focal, benign bony lesion caused by localized, rapid osteoclastic turnover of bone, resulting from direct effects of PTH, they are rarely seen in clinical practice

Familial Hypocalciuric Hypercalcemia (FHH)

The reason of FHH is inactivating mutation of the calcium .sensing receptor in parathyroid glands

↑Serum calcium and ↑ N PTH

but

- Urine calcium is low less than 100 mg/24H

.FHH is a rare, lifelong, benign condition

Calculation of calcium/creatinine excretion ratio

CaE = [Urine Ca (mmol)/urine Cr (mmol)]

× [(plasma Cr (micromol)/1000)/plasma Ca (mmol)]

= <0.01 in FHH

= >0.02 in PHPT

These numeric parameters are not fully sensitive or specific and genetic

Common causes of secondary hyperparathyroidism

Disorder	Comment
Chronic kidney disease (CKD) GFR below 60 ml/min)	Impaired 1,25$(OH)_2$D production, hyperphosphatemia
Decreased calcium intake	
Calcium malabsorption	Vitamin D deficiency, celiac disease, chronic pancreatitis, post gastrectomy syndrome, bariatric surgery
Renal calcium loos	Renal hypercalciuria
Drugs	Bisphosphonates (inhibiton of bone resorption), anticonvulsants, furosemide, phosphorus

Tertiary hyperparathyroidism

A state of excessive secretion of parathyroid hormone after longstanding secondary **hyperparathyroidism** and resulting in hypercalcemia.

Or secondary **hyperparathyroidism** that persists after successful renal transplantation

Primary hyperparathyroidism - treatment

1. Selective parathyroidectomy

- The treatment of choice for **symptomatic** disease is surgical removal of the hyperactive parathyroid glands.
- Parathyroidectomy (PTX) should only be performed by highly experienced surgeons.

2 . Pharmacotheraphy

In many people, the disease may remain mild or asymptomatic for a long period. In these patients, as well as in those after an unsuccessful PTX, who are unwilling to undergo or considered unsuitable for surgery it attempts to apply a symptomatic pharmacotherapy.

So far treatment with calcimimetics or bisphosphonates seems to be the most promising.

Medical Management of Primary Hyperparathyroidism

Medicine	Effect
Calcimimetics (cinacalcet)	• Decrease calcemia and calciuria • Reduce, but not normalise PTH • Do not affect BMD
Bisphosphonates (alendronate)	• Improve BMD • Do not alter serum calcium
Denosumab (?)	• RANKL antagonist - decrases bone resorption

Patients with low serum 25-hydroxyvitamin D should be repeatedely administered with doses of vitamin D that bring its serum levels to 20 ng/ml at a minimum (with caution, so as not to aggravate hypercalcemia).

Primary hyperparathyroidism - indications for surgery in asymptomatic PHPT

Measurement	Surgery Recommended [a]
Serum Calcium	**> 1.0 mg/dl (0.25 mmol/L) above normal**
Skeletal	**A. Bone Mineral Density** by DXA **T score < -2.5** SD at lumbar spine, hip (total or femoral neck) or radius (distal 1/3 site)[b] or presence of **fragility fracture** **B. Vertebral fracture** by X-ray, CT, MRI or VFA
Renal	A. Creatinine clearance < 60 ml/min B.24h urine for calcium > 400 mg/d (>10 mmol/d) and increased stone risk by biochemical stone risk analysis **C. Presence of nephrolithasis** or nephrocalcinosis by X-ray, US, or CT
Age	< 50 years

[a] Surgery is also indicated in patients for whom medical surveillance is neither desired nor possible.
[b] the use of Z-scores instead of T scores is recommended in evaluating BMD in premenopausal women and men younger than 50 y

**According to: Guidelines for the Management of Asymptomatic Primary Hyperparathyroidism: Summary Statement from the Fourth International Workshop. Bilezikian et al.,JCEM,2014,99*

Localisation studies

Localisation studies should not be used to establish the diagnosis of PHPT or to determine management.

They should be done after a decision for surgery has been made.

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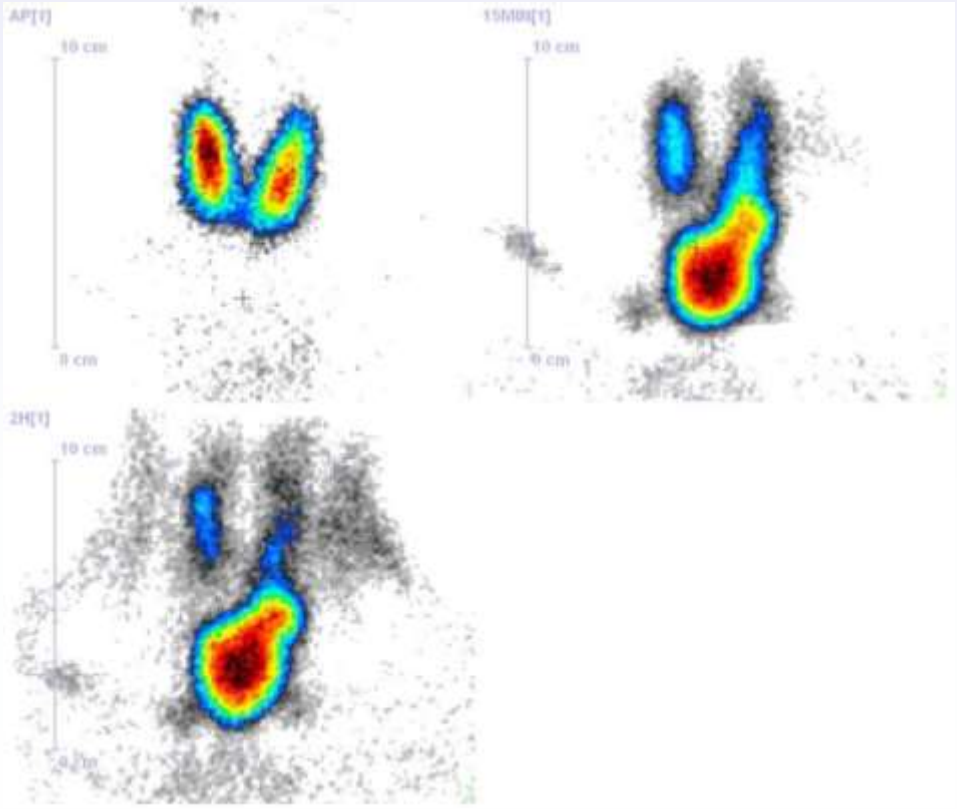
PHPT - localisation tests

The type of imaging	Comments	Sensitivity*
Ultrasonography	Usually a hypoechoic parathyroid adenoma posterior to the thyroid parenchyma with peripheral vascularity seen on colour Doppler. US provides additional anatomic information about the thyroid gland.	up to 80%
Technetium-99m sestamibi scintigraphy		60-90%
SPECT – Sestamibi-single photon emission computed tomography		~ 90%
SPECT-CT		

Parathyroid scintigraphy
(99mTc+MIBI and 99mTc)



PHPT - postoperative hypocalcemia

Hypocalcemia	**The cause of hypocalcemia**
Transient and mild	suppression of the remaining normal parathyroid tissue
(hungry bone syndrome)	The sudden drop in PTH levels leads to decreased resorption (remodeling) of old bone calcium and increased bone formation. This makes bones “hungry” for calcium
Permenant Accompanied by hyperphosphatemia and low PTH levels	hypoparathyroidism

Treatment of severe hypercalcemia)parathyroid crisis)

- Hydration with normal saline
- Bisphosphonates iv. (pamidronate, zoledronic acid)
- Calcitonin sc., im.

Hypoparathyroidism

Hypoparathyroidism is the state of decreased secretion or activity of parathyroid hormone (PTH). This leads to decreased blood levels of calcium (hypocalcemia) and increased levels of blood phosphorus (hyperphosphatemia).

differential diagnosis(Hypocalcemia)etiologies by mechanism

Hypoparathyroidism	Vitamin D deficiency	Low dietary intake of Ca^{+2}	Miscellaneous mechanisms
PTH ↓, N	PTH ↑		
Thyroidectomy or other neck surgery	Low calcitriol: • ↓ intake of dietary Vit. D • Inadequate sunlight exposure • Malabsorption syndrome		Osteoblastic bone metastases
I 131 therapy for G-B disease or thyroid cancer			Pancreatitis
Autoimmune hypoparathyroidism	↓ conversion of 25OHD to $1,25(OH)_2D$ • Renal failure • Hyperphosphatemia • Vitamin D dependent rickets, type 1		Hungry bones syndrome
Infiltration of parathyroids			Hyperphosphatemia
Hypomagnesemia	Calcitriol resistance • Vitamin D resistant rickets		Multiple transfusions
Congenital /genetic			Acute respiratory alkalosis
PTH resistance (pseudo hypoparathyroidism) PTH ↑)	↑ inactivation of vit. D (e.g. carbamazepine, phenytoin)		

Causes of deficient PTH secretion or activity in hypoparathyroid disease states

1. **Acquired** deficiency of parathyroid hormone secretion (> 99% of all cases):

- Surgical removal of the parathyroid glands (usually unintentionally)
- Radiation therapy to the neck, infiltration of parathyroids
- Hypomagnesemia
- Calcimimetics
- Autoimmune:
  - isolated hypoparathyroidism
  -APS 1 (autoimmune polyendocrine syndrome caused by mutations of the autoimmune regulator (AIRE) gene) → antibodies anty CaSR

2. **Resistance to parathyroid hormone** (pseudo-hypoparathyroidism), (extremely rare). Inability of the kidneys and bones to respond to the PTH being produced by normal parathyroids.

Diagnostics of hypoparathyroidism

1. Blood tests:

- **↓ calcium levels**
- ↑ phosphorus levels
- **↓ PTH levels** (but normal or elevated in pseudohypoparathyroidism)
- ↔ ALP
- ↔ magnesium
- ↔ creatinine
- ↓ $1,25(OH)_2D$

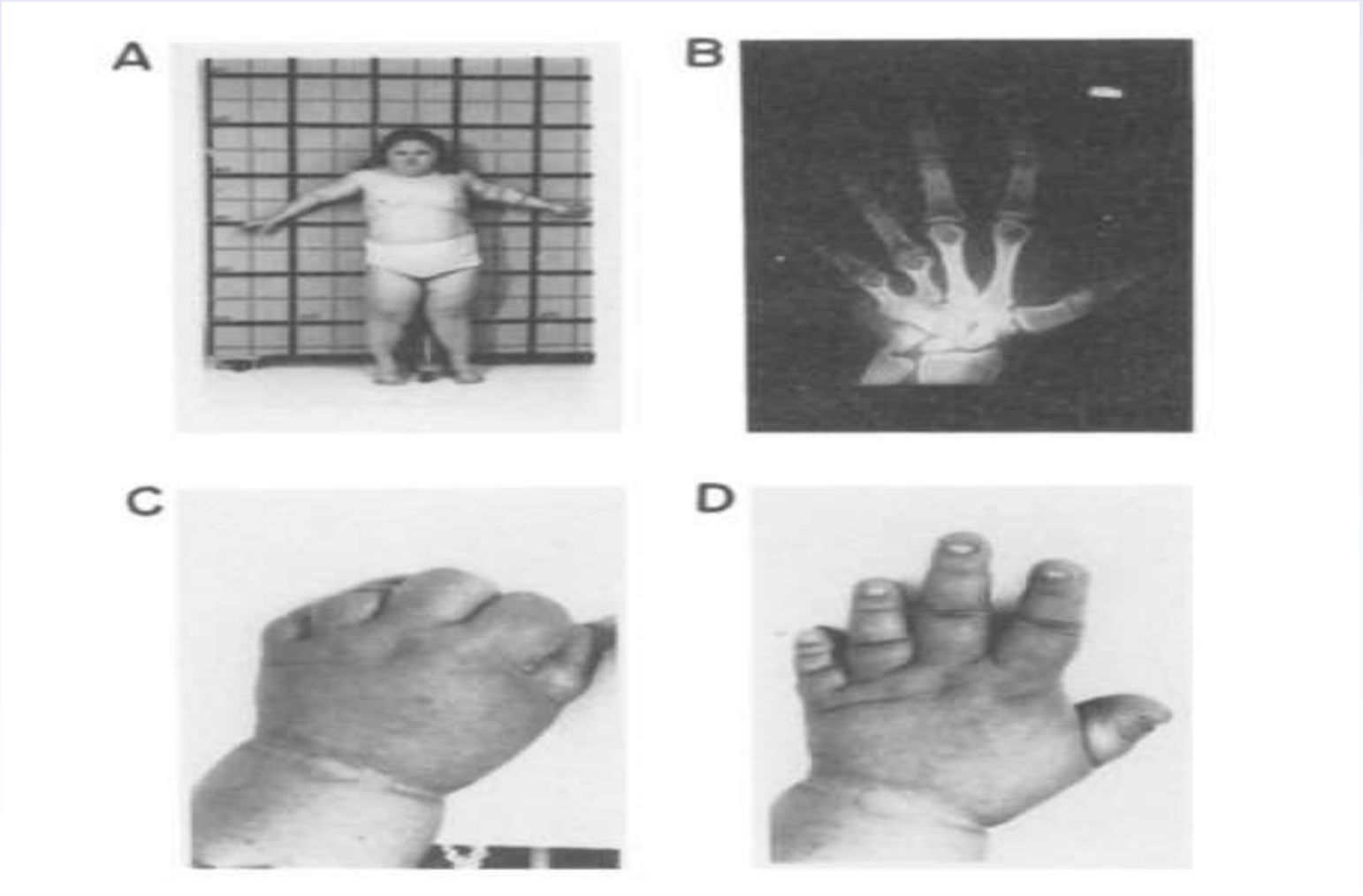
2. 24 urine low calcium excretion

3. ECG: prolonged QT interval

Table 6.6 Investigation of hypocalcaemia

	ALP	PO_4	PTH	Vitamin D	U&E	Mg
Vitamin D deficiency	↑	↓	↑	↓	N	N
Hypoparathyroidism	N	↑	L	N	N	N/↓
Pseudohypoparathyroidism	N	↑	↑↑	N	N	N
PPI-induced hypomagnesaemia/hypocalcaemia	N	N	N	N	N	↓↓

pseudo-hypoparathyroidism



Hypoparathyroidism – symptoms

The major clinical manifestations of hypoparathyroidism are referable to hypocalcemia and are related to the severity and chronicity of the hypocalcemia.

Subjects who develop severe hypoparathyroidism quickly (for example, after neck surgery) can feel tired, irritable, anxious or depressed and demonstrate spontaneous or latent tetany.

Clinical features

↑neuromuscular excitability. In order of ↑ severity, these include:

Tingling—especially of fingers, toes, or lips.

Numbness—especially of fingers, toes, or lips.

Cramps.

Carpopedal spasm.

Stridor due to laryngospasm.

Seizures.

The symptoms of hypocalcaemia tend to reflect the severity and rapidity of onset of the metabolic abnormality.

ECG : LONG QT

Signs

Chvostek's sign is elicited by tapping the facial nerve in front of the ear. A +ve result is indicated by twitching of the corner of the mouth. Slight twitching is seen in up to 15% of normal ♀ , but more major involvement of the facial muscles is indicative of hypocalcaemia or hypomagnesaemia.

Trousseau's sign is produced by occlusion of the blood supply to the arm by inflation of a sphygmomanometer cuff above the arterial pressure for 3min. If +ve, there is carpopedal spasm, which may be accompanied by painful paraesthesiae.

The methods of treatment of hypoparathyroidism:

- Calcium carbonate 1-4 g/d orally, during and between meals
- Activated vitamin D analogues e.g. alfacalcidolum 1-3 µg/d
- Vitamin D supplementation 400–800 IU/d to patients treated with activated vitamin D analogues
- Magnesium supplementation in case of deficiency

- **Treatment of acute severe hypocalcaemia**

Iv calcium

CASE 1

46 yrs old female pt , present to the clinic as she incidently found that she has high serum calcium 11.6 mg/dl (8.5-10.5) she reports no symptoms

What is your approach to this pt ??

CASE 1

Albumin 4.2 g/dl
Pth 55 pg/ml (10-65) , kft nl , vitamin d3 nl
Deffrential ????
Manegemnt ???

CASE 2

A 68-year-old female with a background of stage four chronic kidney disease (CKD) presents with the following blood results to the nephrology clinic. She has had progressive CKD over many years
PTH 19.1 pmol/l (1.05 - 6.83)
Adjusted calcium 2.84 mmol/l (2.1-2.6)
What endocrine abnormality is she most likely to have given her background?
Tertiary hyperparathyroidism
Secondary hyperparathyroidism
Multiple endocrine neoplasia 1 (MEN1)
Pseudohypoparathyroidism
Primary hyperparathyroidism

CASE 3

37 yrs old m pt , known to have crohns dx , he underwent ileo-cecal resection one month ago
He presents to ER complaining of numbness , perioral parasthesia , muscle twitching
Labs show hypocalcemia ca 6.5 pth 20
He was given multiple calcium infusions , which fail to releive sx and to raise calcium to desired level
What is your explanation

Case 4

A 60-year-old man who is known to have lung cancer comes for review. For the past three weeks he has lost his appetite, has been feeling sick and generally feels tired. On examination he appears to be mildly dehydrated. You order some blood tests:

Calcium 11.5 mg/dl
Albumin 40 g/l
Glucose (random) 6.7 mmol/l
Creatinine 115 µmol/l

Which one of his existing medications is most likely to be contributing to his presentation?

Amlodipine
Simvastatin
Bendroflumethiazide
Aspirin
Lisinopril