Chronic Kidney Disease-Mineral Bone Disorder

CKD-Mineral and Bone Disorder (CKD-MBD) refers to a systemic disorder of mineral and bone metabolism due to chronic kidney disease (usually stage G3b–G5), characterized by:

- **Abnormalities in calcium, phosphate, PTH, or vitamin D metabolism**
- **Bone pathology (renal osteodystrophy)**
- **Vascular or soft tissue calcification**

It is strongly associated with **increased cardiovascular morbidity and mortality** in CKD patients.

Pathophysiology

Key Drivers:

1. **Phosphate Retention**
   ? GFR ? ? phosphate excretion ? **hyperphosphatemia**
2. **Hypocalcemia**
   - Phosphate binds calcium in blood ? ? free serum calcium
   - ? 1?-hydroxylase activity ? ? conversion of 25(OH)D to 1,25(OH)?D (calcitriol) ? ? intestinal calcium absorption
3. **Secondary Hyperparathyroidism**
   - Hypocalcemia + hyperphosphatemia + low calcitriol ? ? PTH secretion
   - Chronic elevation ? **parathyroid hyperplasia** ? **bone resorption** and eventually **tertiary hyperparathyroidism**

Typical Laboratory Findings

Marker	Finding in CKD-MBD
Serum Phosphate	? (Hyperphosphatemia)
Serum Calcium	? or low-normal
Parathyroid Hormone (PTH)	?
1,25(OH)? Vitamin D	?
Alkaline Phosphatase (ALP)	? in high bone turnover

Clinical Features

- **Skeletal** : Bone pain, fractures, skeletal deformities (renal osteodystrophy)
- **Extraskeletal** : Vascular calcification, soft tissue calcification, pruritus
- **Cardiovascular** : Arterial stiffness, valvular calcification ? ? cardiovascular mortality

Diagnostic Criteria (KDIGO)

CKD-MBD includes:

- Biochemical abnormalities
- Bone abnormalities (renal osteodystrophy)
- Vascular/soft tissue calcification

Management Principles

Therapeutic Goals

- Normalize **serum calcium**
- Maintain **serum phosphate** < 1.8 mmol/L (~5.5 mg/dL)
- Maintain **PTH** within 2–3× upper limit of normal (ULN)
- Prevent **vascular/soft tissue calcification**

1. Phosphate Management

- **Dietary phosphate restriction**
- **Phosphate binders** :
  - **Calcium-based** : calcium acetate, calcium carbonate
  - **Non-calcium** (used if hypercalcemia is present):
    - **Sevelamer** (non-absorbable polymer)
    - **Lanthanum carbonate**
    - **Iron-based binders** (e.g., ferric citrate)

2. Vitamin D Supplementation

- Used to suppress PTH and correct hypocalcemia
- Forms:
  - **Calcitriol** (1,25(OH)?D)
  - **Alfacalcidol** (1?-hydroxyvitamin D)
- Use cautiously in patients at risk of **hypercalcemia or hyperphosphatemia**

3. Calcimimetics

- **Cinacalcet** : Increases calcium sensitivity of the parathyroid gland ? ? PTH secretion
- Used in:
  - **Secondary hyperparathyroidism unresponsive to vitamin D**
  - **High calcium/phosphate levels**
  - **Dialysis patients**

4. Parathyroidectomy

- Consider in **severe, refractory secondary or tertiary hyperparathyroidism** not responding to medical therapy

Important Notes

- **Hypercalcemia in CKD** is concerning and may:
  - Worsen renal function
  - Suggest **tertiary hyperparathyroidism** or vitamin D/calcium overtreatment
- Avoid **aluminum-containing binders** due to risk of aluminum toxicity (encephalopathy, osteomalacia)

High-Yield Pearls

- **CKD-MBD is a systemic disorder** , not just a bone problem.
- **Vascular calcification** , especially coronary artery and aortic valve calcification, is a key contributor to mortality in CKD.
- Monitor calcium, phosphate, ALP, and PTH **regularly** in CKD stage 3 and beyond.
- Calcium and phosphate **should not both be elevated** —risk of calciphylaxis.

Target Lab Ranges

Marker	Target in CKD G3b–G5
Phosphate	< 1.8 mmol/L (< 5.5 mg/dL)
Calcium	Normal range (8.5–10.2 mg/dL)
PTH	2–9 × ULN (depending on CKD stage)
Ca × P product	< 55 mg^2/dL^2