Periosteal Reaction: A radiographic guide to disease process

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Learning objectives

To illustrate the types and patterns of periosteal reactions at different age groups that can guide to the underlying disease process.

Background

Periosteum covers the outer edge of the bony cortex. It is made of two layers, outer densely packed collagenous layer and the inner osteogenetic periosteal layer. This inner layer is loosely attached and usually the site of traumatic separation and subperiosteal haemorrhage. The inner layer is abounded to the cortex by centrally directed Sharpey's fibers.

Periosteal reaction is a result of bone response to any kind insult. There are various factors, which influence the appearance of periosteal reaction eg. Rapidity of the disease process, intensity, period of injury and patient's age.

Imaging findings OR Procedure details

Intensity: The principal factor influencing its appearance is how fast the insult grows. In slowly growing periosteum reacts slowly, resulting in solid, thick, organised and uninterrupted periosteal reaction. During rapidly growing processes, the periosteum does not have adequate time to respond and lags behind to lay the new bone, resulting in interrupted type of periosteal reaction.

Age: Periosteal reaction is rapid and more aggressive in children. Also, the periosteum is loosely attached as Sharpey's fibers are less numerous and shorter in children as compared to adults.

Unilateral verses Bilateral: This helps further in categorising the disease. Unilateral periosteal reaction is seen in a localised process like trauma, infection, tumour or infection. Bilateral pattern is seen in systemic processes.

Types of Periosteal Reaction:
General rule is that the processes causing rapid bone deposition produce aggressive periosteal reaction whereas slowly progressive entities produce nonaggressive reaction.

1. **Nonaggressive type:**

A. **Solid periosteal reaction (Fig1a, b):** In benign processes like trauma, chronic osteomyelitis, Osteoid osteoma.

Subtypes are:

a. Solid smooth: Thin / Thick

b. Solid buttress: Smooth / Irregular

B. **Laminated (Onion skin type):**

This type of periosteal reaction occurs due to concentric bone deposition around the cortex.

2. **Aggressive Type:**

In aggressive processes like tumours and fast growing infection. For example

A. **Spiculated pattern:**

This can show two types of patterns

a. "Hair on end" pattern (parallel spiculated): Spicules radiate perpendicular to the periosteal surface. e.g in Ewing's sarcoma

b. "Sunburst" pattern (Divergent spiculated): Spicules radiate in divergent pattern rather than perpendicular to the cortex. e.g in Osteosarcoma(1).

B. **Codman's triangle (Fig 2):** This is seen when the periosteum is lifted off the cortex by tumour, pus or blood. The leading edge of the raised periosteum ossifies, seen angled to the cortical surface, resulting in Codman's triangle. Eg: Osteosarcoma, sometimes infection and metastases.

**Differential diagnosis of periosteal reaction:**

1. Arthritides: Psoriatic arthritis, Reactive arthritis, Juvenile chronic arthritis.
2. Metabolic: Hypertrophic Osteoarthropathy (HOA), Thyroid Acropachy.
4. Trauma: Fracture, Stress injuries
5. Drugs: Fluorosis, hypervitaminosis A, Prostaglandins
7. Infection: Osteomyelitis, Septic arthritis,
8. Genetic: Caffey’s disease

Causes of unilateral periosteal reaction:

1 Tumours:

1. **a. Osteosarcoma (Fig3):** Cortical involvement, Sunburst type of periosteal reaction with Codman’s triangle
2. **b. Ewing’s sarcoma:** Medullary involvement with Hair on end type (sometimes onion skin type) periosteal reaction usually along with large soft tissue mass.
3. **c. Chondroblastoma:** Benign cartilage producing tumour typically occurring in epiphysis of skeletally immature bones. Lytic lesion with sclerotic margin. Periosteal reaction occurs with large lesions. Thick, solid and laminated(2).
4. **d. Eosinophilic Granuloma:** Spectrum of Langerhans cell Histiocytosis. Lytic medullary lesions with thick laminated periosteal reaction.
6. **f. Leukaemia / lymphoma:** Long bones are involved in children whereas axial skeleton in adults. Periosteal reaction is thin, laminated or interrupted hair on end. Soft tissue masses with lymphomas.

2 Trauma:

1. **a. Fracture: (Fig4)** Periosteal reaction could be solid or interrupted. Interrupted pattern is seen with fractures associated with greater degrees of motion, complicated and pathological fractures,
2. **b. Stress Injury(Fig5 a & b):** Subtle periosteal reaction in the region of repeated stress. Seen in tibia, metatarsals, pelvic bones and calcaneum(3).

3. **Infection: Osteomyelitis (Fig6) / Infective arthritis:** Depending on the severity of the infection, periosteal reaction may be of aggressive or nonaggressive type. Associated findings like involucrum, sequestrum, discharging sinus tracts, joint effusions seen.
Bilaterally symmetrical periosteal reactions in Adults:

1. **Hypertrophic Osteoarthropathy (HOA) (Fig7a,b):** Periosteal reaction occurs at the metaphysis and diaphysis of the long bones and tubular bones of the hands. The thickness corresponds to the duration of disease activity. Associated findings are periarticular osteoporosis, soft tissue swelling, joint effusions and clubbing of fingers. Painful condition.

1. **Pachydermoperiostitis (Fig8 a, b, c):** Autosomal dominant inherited disorder causing cutaneous thickening of the extremities, face and scalp. Usually affects the adolescent boys and predilection for blacks. Generalised and symmetrical periosteal reaction, merging with the cortex, primarily involving the lower ends of radius and ulna. Contrary to HOA, this is painless condition; periosteal reaction is more solid and spiculated; extends to the epiphyses to produce outgrowths around joints.

1. **Vascular insufficiency:** Confined to lower limbs, below knee. Undulating solid periosteal reaction, initially separate from the cortex, merging with it later. Associated soft tissue swelling. Phleboliths in case of varicose veins.

1. **Thyroid Acropachy (Fig9):** Autoimmune thyroid disease, hypothyroid / hyperthyroid status, 0.5 to 10% of post thyroidectomy status. Solid spiculated lace like periosteal reaction along the diaphysis of the metacarpals and phalanges of hands, especially along the radial side of thumb and index finger. Less commonly feet, lower legs and forearms(4).

1. **Fluorosis:** Due to osteoblastic reaction caused by fluorine. Solid, undulating symmetric periosteal reaction along the tubular bones. Diffuse increase in bone density, especially axial skeleton, ligamentous calcifications.

Bilaterally symmetrical periosteal reactions in Children:

**Children less than 6 months:**

1. **Physiologic periosteal reaction in infancy:** Unilaminar, thin and diaphyseal, seen at 3-4 months age, disappear by 6 months(5).
2. **Congenital syphilis:** Exuberant diaphyseal periosteal reaction.
3. **Prostaglandins E1 therapy:** In infants with ductus dependent CHD(6).
4. **Caffey’s disease:** Seen before 6 months. Laminated periosteal reaction along the mandible, scapula, clavicle, ulna and ribs. Soft tissue swelling,
hyper-irritability and cortical hyperostosis involving mandible and facial bones.

**Children more than 6 months:**

1. **Hypervitaminosis A:** Due to aggressive Vitamin A supplements. Solid periosteal reaction along the long bones, predominantly in the central diaphysis, tapering towards the ends. Usually ulna, lower leb, metatarsals and clavicle. Premature closure of epiphyses. Mandible is not affected, contrary to Caffey's disease.

2. **Acute leukaemia:** Osteopenia, dense zone of provisional calcification and prominent metaphyseal bone resorption.

3. **Metastatic neuroblastoma:** Similar to that of leukaemia.

4. **Scurvy:** 6 months or older. Due to subperiosteal haemorrhages. Most frequent in femur, tibia and humerus.

5. **Rickets:** Mimic of periosteal reaction, due to presence of noncalcified subperiosteal osteoid

6. **Juvenile Chronic arthritis:** Periarticular regions of short tubular bones.

**Bilaterally asymmetrical periosteal reactions:**

1. **Metastases:** Aggressive type- Interrupted, hair on end, subburst

2. **Osteomyelitis:** Aggressive or nonaggressive type depending on the severity of and rapidity of infection.

3. **Arthritides**
   1. **Psoriatic Arthritis:** Periostitis along the phalanges. Exuberant and fluffy periosteal reaction that matures into solid bone and causes apparent bone expansion.
   2. **Reactive Arthritis:** Usually a result of genital or GI infection. Usually calcaneum and metatarsals. Fluffy bone formation along the shaft and metaphysis.

4. **Osteoporosis and osteomalacia:** due to increased risk of fractures. Osteopenia, sometimes osteosclerosis (if secondary osteomalacia).

5. **Non-accidental injury:** Fractures in different stage of healing.

6. **Bleeding diatheses:**

7. **Sickle cell dactylitis:** Short tubular bones of hands. Cortical sclerosis, destruction, bone infarctions and soft tissue swelling.

**Images for this section:**
Fig. 1: Cortical thickening/ solid periosteal reaction in osteoid osteoma
Fig. 2: Fig1a,b Cortical thickening/ solid periosteal reaction in osteoid osteoma
**Fig. 4:** Fig3 Aggressive periosteal reaction in osteosarcoma

**Fig. 3:** Fig2. Ossified edge of periosteum making an angle with cortex forming codman's triangle.
Fig. 8: Osteomyelitis of left ribs cage
Fig. 13: Fig8c. Cutaneous thickening of the extremities, face and scalp. Pachydermoperiostitis
Fig. 12: Fig8b. Generalized and symmetrical periosteal reaction, merging with the cortex. Pachydermoperiostitis
Fig. 11: Fig8a. Generalized and symmetrical periosteal reaction, merging with the cortex. Pachydermoperiostitis
Fig. 9: Periosteal reaction occurring at the metaphysis and diaphysis of the long bone. Hypertrophic Osteoarthropathy
**Fig. 14:** Fig 9. Lace like periosteal reaction along the diaphysis of the metacarpals and phalanges of hands in thyroid acropachy.
**Fig. 6:** Fig 5 a. Stress fractures involving 2nd and 3rd metatarsals associated with mature periosteal reaction

**Fig. 7:** Fig 5 b. MRI appearance of stress fracture with periosteal reaction. Marrow signal changes with hypointense adjacent soft tissue. Plain film correlation is mandatory.
**Fig. 10:** Fig7b. Bilateral symmetrical linear uptake of radiotracer along the shafts of long bones. Hypertrophic pulmonary Osteoarthropathy.
Fig. 5: Periosteal reaction associated with radial shaft fracture
Conclusion

Though there is considerable overlap between the appearances of periosteal reaction, differential diagnosis can be narrowed using a systematic approach, taking into consideration the clinical features, age of the patient, site and morphology of the periosteal reaction, uni/bilateralism, symmetry (in case of bilateral) and associated radiological findings. Type and appearance of periosteal reaction can be used as a guide to the diagnosis of underlying disease process.

References


Personal Information