Nuclear Medicine in the Evaluation of Trauma

Materials for medical students

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Radionuclide methods in traumatology

- **Musculoskeletal trauma**
  - Bone scan

- **Trauma to internal organs** (hematoma, laceration, fracture, perforation, leaks)
  - Renal scan
  - Myocardial scan
  - Hepatobiliary scan
  - (Liver / spleen scan) - CT preferred
  - (Testicular scan) - US preferred

- **Head trauma**
  - CT preferred
  - Cerebral perfusion scan - brain death
  - Cisternography - CSF leak
Bone scan in trauma

- Very sensitive
- Detects areas of abnormal bone turnover
- Shows areas that need further radiol.evaluation
- Provides objective evidence of disorder when X ray negative
Bone scan

- Tracers: diphosphonates (Tc-99m MDP, HDP)
- Dose: 500-900MBq
- Tracer localization (chemisorption onto surface of bone trabeculae) depends on:
  - blood flow
  - capillary permeability
  - bone metabolism (activity of osteoblasts, osteoclasts, new bone formation)
Bone scan

- Patient preparation
  - Pre-test: none
  - Post-injection: good oral hydration
  - Frequent voiding
  - Perchlorate p.o. preinj. to decrease rad.
dose to thyroid
Bone scan

- **Methods**
  - Regular - imaging @ 2-4 hrs post injection
  - 3-phase (dynamic angiogram + blood pool + delay)
  - Planar or SPECT
  - Whole body ANT & POST, additional views (lat., oblique)
  - Parallel hole or pinhole collimator (for small structures)
Bone Scan in Trauma

- Fractures & occult fx
- Child abuse (except skull fx)
- Stress fractures (insufficiency fx, fatigue fx)
- Avulsion injuries
- Shin splints
- Bone bruises (contusion)
- RSD (reflex sympathetic dystrophy)
- Osteochondral lesions
Diagnosis of Fractures

- Plain X ray, X ray tomography - if neg >>>
- Bone scan
  - if neg >>> stop work-up
  - if diagnostic >>> treat
  - if more information needed >>>
- CT (subtle changes) or
- MRI (subtle changes, soft tissue trauma, bone bruise, precise dx of limited area)
Fractures on Bone scan

- **Acute fx**
  - Positive on all 3 phases
  - Positive immediately after trauma in most pts
  - 90% sensitivity if imaged in < 48 hrs
  - If scan neg. in pts > 75y >>>> repeat scan in 3-7 d

- **Bone scan remains positive for 6-24 mo**
  (healing fx)
Acute compression fractures

80 y/o F w osteopenia
fell 6 wks prior
Rib fractures
Multiple fx’s

59 F w breast ca
MVA 10 d ago
Osteogenesis imperfecta
Bone Bruise

- Direct trauma with disruption of trabecular bone but not cortical bone
- X ray - negative
- Bone scan - 3-phase positivity
- MRI - bone marrow involvement (hemorrhage)
Leg & Foot Trauma
Shin / thigh splints

- Continuous spectrum from shin splint to stress fx
- Stress related periostitis along muscle insertion sites
  (soleus, tibialis posterior, adductor longus/brevis, gluteus max)
- X ray - negative
- Bone scan
  - Flow, blood pool - normal
  - Delay- vertical, linear uptake along posteromedial tibial cortex (mid- or distal 1/3) medial or lateral femoral cortex (proximal 1/3)
Shin Splints
Shin splints, thigh splints
Thigh splints - mechanism

Adductor brevis

Adductor longus
Stress Fractures

- Fatigue fractures
  Abnormal stress on normal bone
  (jogging, gymnastics, skating, military)

- Insufficiency fractures
  Normal stress on abnormal bone
  (osteoporosis, osteomalacia, RA, HPT, steroids, radiation Rx)
Stress fractures

- Pathophysiology - repetitive microtrauma (athletes)
- Symptoms - pain, swelling
- Common locations:
  - Tibia - proximal or distal 1/3
  - Fibula - distal 1/3
  - Metatarsals (2\textsuperscript{nd}, 3\textsuperscript{rd})
  - Tarsal bones (calcaneus, navicular)
  - Femoral neck
  - Inferior pubic ramus
  - Lower lumbar spine (spondylolysis)
Stress fractures

- X ray may be initially negative (2-4 wks)
- Bone scan, MRI – positive earlier
- Bone scan 3-phase positivity
  - Flow + for ~ 1 mo
  - Blood pool + for ~ 2 mo
  - Delay + for ~ 9-12 mo
- Rx - restrict sports for 4-6 wks
Stress fractures
Metatarsal stress fracture
Metatarsal stress fracture
Metatarsal stress fx
Plantar fasciitis

- **Heel pain**
- **Post-traumatic inflammation of plantar ligament due to**
  - athletic overuse
  - prolonged standing
  - walking on hard surface
- **Bone scan**
  - Focal blood pool + delayed uptake
  - in inferior posterior calcaneus
Plantar fasciitis
Achilles tendonitis
Impingement syndromes

- **Posterior impingement sy (os trigonum sy)**
  - Excessive repeat plantar flexion (compression between posterior calcaneus & posterior tibia)
  - Ballet dancers, gymnasts

- **Anterior impingement sy**
  - Excessive repeat dorsal flexion >>> hypertrophic spur on dorsum (talus & anterior tibia)
  - Ballet dancers, gymnasts, high jumping
Posterior impingement syndrome (os trigonum stress fx)
Femoral neck stress fracture

- Thigh or groin pain in athletes
- Must distinguish femoral neck stress fx from pubic ramus stress fx
- Must treat / immobilize early to prevent complete fx, AVN
Femoral neck Fx

76F w L groin pain
X ray neg
X ray
2 weeks later
Intertrochanteric fracture

93 F, fall 6 days ago, Rt hip pain
IT fx
Avascular necrosis (AVN)

- **Etiology**
  - trauma (fx)
  - steroids, alcohol abuse
  - pancreatitis, fat embolism
  - vasculitis, SS disease
  - idiopathic

- **Pathophysiology: bone ischemia**

- **Diagnosis**
  - MRI most sensitive
  - bone scan useful
AVN

- Common locations
  - Femoral head (Legg-Perthes in children)
  - Carpal (scaphoid, lunate), tarsal (talus)
  - Long bones, ribs in SS

- Bone scan
  - Initially “cold”
  - Revascularization starts in 1-3 wks, from periphery, diffusely “hot”, lasts for months
IT Fx + AVN

50 M w fall a few weeks ago
IT fx + AVN
Sacroccocygeal Fx
Sacral insufficiency fx

ANT

POST

79 F fell 1 mo ago
(“Honda” sign)
Pelvic fractures

4 days post fall

1 month later
Spine trauma
Spondylolysis

- Stress fx of posterior vertebral elements (pars interarticularis) due to repetitive trauma
- Teenagers, young adults
- Hyperextension sports (gymnastics, diving, weight lifting, soccer, hockey)
- Genetic predisposition?
- L5 > L4 > L3
- Frequently bilateral >>> spondylolisthesis
A. Superior articular process
Transverse process
Pedicle
Lamina and pars interarticularis

B. Vertebrae body
Spinal canal
Pedicle
Superior articular process
Transverse process
Lamina
Inferior articular process
Spino process
Spondylolysis

- X ray
  Normal or sclerosis, later lucency 2º fx

- Bone scan
  Increased uptake in pars interarticularis
  SPECT better than planar

- Rx – discontinue activity
Pars interarticularis defect

14 y/o F basketball player trauma 1 mo prior
Pars defect
Transverse process fracture
Hand & Wrist Trauma
Wrist fractures

- **Scaphoid fx - most common**
  - 70-80% carpal fx
  - Fall on outstretched hand
  - Common complications - AVN, non-union

- **Hook of hamate fx**
  - Direct injury from handles (tennis, golf, baseball)

- **Radial / ulnar styloid fx**
fall, injured Rt wrist
Fracture of radius + scaphoid

S/P fall, suspect scaphoid fx
X ray neg.
Scaphoid Fx

14 y/o M
fell 6 wks ago,
X ray negative
Hook of the hamate fracture

R wrist pain
Hook of the hamate injury - mechanism
Reflex Sympathetic Dystrophy
(Sudeck’s atrophy, Shoulder-hand sy, Causalgia, Chronic regional pain sy)

- Sympathetically mediated disorder (vasomotor instability)
- Etiology
  - Trauma (blunt, fracture)
  - MI
  - Stroke/CVA
  - Infection
  - Idiopathic
- Symptoms: exquisite pain, tenderness, edema, skin changes, locally warm or cold UE or LE
Reflex Sympathetic Dystrophy (RSD)

- **Bone scan**
  - Early stage: 3-phase positive
  - Later stage (> 6 mo): only delayed phase posit.
  - Delayed phase MDP: diffuse increased uptake in entire limb, “periarticular accentuation” in small joints
  - Children: often all 3 phases ↓ or ↓↓↑
  - Sensitivity: 60-95%

- **X ray**
  - Periarticular ST edema
  - Late changes- bone resorption, osteopenia
Reflex sympathetic dystrophy (RSD)

73 F w Rt hand/wrist pain
no trauma
Non-accidental injury

1 mo old baby w intracranial hemorrhage, Lt parietal fx
Non-accidental trauma

3 month-old baby boy with intracranial and retinal hemorrhages skeletal X rays negative
Muscle trauma (Rhabdomyolysis)

weight lifting

CNM 2001: 344
Muscle uptake (Rhabdomyolysis)

pt w Ewing sarcoma,
s/p BKA,
walking on crutches
Trauma to internal organs
Hepatobiliary Scan

- Tc-99m IDA (disofenin, mebrofenin)
  - dose ~ 150-250 MBq i.v.
  - imaging of liver, abdomen, pelvis over 1 hr
  - delayed images if 1st hr negative

- Bile leak - activity anywhere in peritoneal cavity

- Common after laparoscopic cholecystectomy

- Usually seals off spontaneously

- Leak clin. more significant if no transit into bowel seen (needs surgical intervention)
Bile leak
Liver - Spleen Scan

- **Tc-99m sulfur colloid**
  - dose ~ 150-250 MBq i.v.
  - SPECT imaging better than planar

- **Parenchymal defects**
  - laceration, rupture, hematoma

- **Splenosis**
  - splenic implants on peritoneum following spleen rupture
Splenosis

MVA 30 y ago,
S/P splenectomy

Tc-99m S.C.
Pleuroperitoneal leak

Pt. on peritoneal dialysis

ANT

Rt LAT
Renal Scans

- **Tc-99m MAG3 or DTPA**
  - ~ 100-300 MBq
  - Dynamic images over 20-30 min
  - Assessment of perfusion, function, leaks

- **Tc-99m DMSA**
  - ~ 150-250 MBq
  - Static images @ 2-4 hrs post injection
  - High resolution needed for renal morphology
    - pinhole, SPECT
  - Parenchymal defects - laceration, rupture, hematoma
  - Extrinsic defects - perinephric / retroperiton. hematoma
Urine leak

0-1 min

1-2 min

4-5 min

9-10 min

14-15 min

19-20 min

late view
Testicular scan

- Indications:
  - Acute torsion
  - Delayed torsion
  - Epidymitis / orchitis

- Tc-99m pertechnetate
- Flow + immediate static images
- “Donut sign”
  - Late torsion
  - Abscess
  - Trauma (hematoma)
  - Tumor
Cisternography

- In-111 DTPA intrathecally
- CSF leak - paraspinal (meningeal tears)
- CSF rhinorrhea, otorrhea
  - imaging
  - counting nasal pledgets for radioactivity
  - pledget / plasma ratio
Cerebral perfusion

- Tc-99m HMPAO or ECD
  - dose ~ 800 MBq
- Post-traumatic perfusion defects
- Assessment of brain death - role of NM complementary
  - no flow
  - no parenchymal uptake
Head Trauma
? Brain death?

15 y/o F with intracranial bleed
Brain death