Utility of Dual-Energy CT to Evaluate Patients with Hip and Pelvis Pain in the ER Setting

- Johnson, T., Moran, E., Glazebrook, K., Leng, S., Fletcher, J., and McCollough, C.
- An educational review
- ER011

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Disclosure

- CHM: Research grant, Siemens Healthcare.
- The other authors have no financial disclosures.
Goals and objectives

- Understand the concept of Virtual Non-Calcium (VNCa) dual energy CT imaging.
- Review several cases involving VNCa dual energy CT.
- Discuss the benefits of VNCa dual energy CT images.
Numerous visits are paid each year to the emergency department for musculoskeletal pelvic pain.

Radiographs obtained in this situation are often inconclusive in the setting of nondisplaced fractures.

CT can be helpful in assessing indeterminate findings, but is often limited by osteopenia in elderly patients.
Emergency department scenario

- MRI has traditionally been the gold standard for detecting osseous pathology related to bone marrow edema.
- Unfortunately, MRI is time intensive and is not universally available during off hours.
- In contradistinction, CT is often readily available in the emergency setting.
- CT can also be useful when MRI is contraindicated.
Dual energy CT

- Dual Energy CT (DECT) is a new and powerful imaging technique.
- DECT works by acquiring attenuation data using two different x-ray spectra.
- Attenuation data acquired at a second x-ray spectrum allows decomposition of different materials:
  - Ex. separation of bone marrow from trabecular bone.
- Same radiation dose as single energy CT.
Dual energy data can be acquired through multiple techniques:

- Rapid switching of x-ray tube potential
- Dual x-ray sources
- Multilayer detector
  - New technique that obtains low and high energy data sets at the same time.
- Photon-counting detectors
  - Experimental technique that performs signal analysis to separate high and low energy data sets.
Virtual non-calcium imaging

- Through removal of calcium signal from cancellous bone, VNCa images can be obtained to visualize the marrow space.
- Conventional images are also provided from this same data set, enabling evaluation for both fractures and edema from a single exam.
Virtual non-calcium imaging

- VNCa DECT is extremely useful in demonstrating osseous bruising from:
  - Occult fractures involving the hips and sacrum
  - Avascular necrosis (AVN) of the hip
  - Other painful pathology such as metastatic disease
Virtual non-calcium imaging

- Pache et al. 2010 investigated 21 patients with acute knee trauma (2 observers) using MRI as gold standard:
  - Sensitivity 86.4/86.4% and specificity 94.4/95.5%
  - Good to excellent agreement
    - Femur $\kappa = 0.78$, tibia $\kappa = 0.87$

- Guggenberger et al. 2012 investigated DECT VNCA detection of traumatic bone marrow edema in the ankle of 30 patients (2 observers) using MRI as gold standard:
  - Visual grading
    - Sensitivity 90/90% and specificity 80.5/81.6%, $\kappa = 0.66$
Cases I – III
Fractures
Case I – Sacral fracture

Acute S5 fracture November 2014
• Note edema

Healed S5 fracture April 2014
• Note resolution of previous edema
Case II – Femoral head/neck fracture

Possible fracture

VNCa shows edema on left

Cortical disruption

Normal right

Fx. left

Fx. left

VNCa shows edema on left
Case III – Intertrochanteric fracture

Radiographically occult fracture

VNCa edema at fracture
Reddy et al. in 2014 examined VNCa DECT in patients with suspected hip fractures.

DECT was compared to a gold standard of clinical or imaging follow-up with confirmation of hip fracture:

- Sensitivity 90%
- Positive predictive value 86%
- Mean age 77 years
  - Demonstrate utility in osteoporotic patients

**Teaching point:** DECT with VNCa can help identify fractures that are occult on radiographs or single energy CT, particularly in osteoporotic patients.
Case IV
Avascular necrosis
Case IV – AVN

• 59 year old woman:
  – Presents with right hip pain
  – Radiographs and CT were negative for acute abnormality
  – CT showed healed right sacral insufficiency fracture

Healed sacral insufficiency fracture
Case IV – AVN continued

DECT shows bone marrow edema in both femoral heads suspicious for AVN
• Follow-up MRI:
  – Performed 12 days after radiographs & CT.
  – Demonstrated changes related to bilateral AVN.
Discussion

- In 2014 Barile et al. examined the use of single energy CT in patients with MRI proven avascular necrosis of the femoral head.

- CTs were performed either before or after MRI:
  - 89% of MRI proven cases were missed with single energy CT.

Teaching point: DECT with VNCa can help distinguish acute and chronic osseous pathology. For example, old trauma from acute avascular necrosis.
Case V

Metastatic disease
Case V – Metastatic disease

63 year old woman with new left hip pain:
• Known lung cancer
• Negative CT abdomen/pelvis 2 months previously
18% of all health care visits are related to musculoskeletal conditions.

Commonly this includes:
- Arthritis, back and neck pain, injuries, and osteoporosis.

Although less common, approximately 350,000 people in the U.S. die with bone metastases:
- Often silent, but can cause pain/fracture.

**Teaching point:** DECT with VNCa can help identify non-traumatic osseous pathology such as metastatic disease.
Conclusion

- VNCa DECT imaging can be helpful in identifying occult radiographic and single energy CT fractures.
- Osseous edema serves as an important indicator of pathology.
- Edema can be helpful in differentiating acute and chronic processes.
Conclusion

- VNCa DECT can detect pathology such as avascular necrosis or metastatic disease that may be occult on radiography or single energy CT.
- These findings have been shown to parallel edema seen on T2 weighted MRI sequences.
Conclusion

- Advantages of VNCa DECT:
  - Increased availability
  - Decreased cost
  - Useful in patients who are unable to undergo MR imaging
  - Provides detailed information about osseous architecture
Conclusion

- Advantages of VNCa DECT:
  - Ability to exclude pathology and thereby obviate the need for additional imaging with MR.
Conclusion

- Limitations:
  - Large body habitus will attenuate low kVp potentially limiting this technique.
  - Normal red marrow can confound findings by replacing fatty marrow.
Summary

- VNCa imaging is a new technology that is readily available with dual energy CT machines.
- We believe this is a tremendously powerful tool that can be helpful in assessing acute, subacute, and chronic musculoskeletal pelvic pathology in the emergency setting and thereby help prevent further patient morbidity.
References


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