Can Virtual Noncontrast Images Truly Replace True Noncontrast Images?

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Virtual Non-Contrast (VNC) Images

- VNC: Contrast component is removed from dual energy contrast scan to mimic images from a non-contrast scan.
Material Decomposition

- In diagnostic x-ray imaging range, two main interactions: photo-electric and Compton effects.
- Any material’s mass attenuation coefficient can be expressed as a linear combination of the coefficients of two so-called basis materials
  - Iodine & water
  - Iodine & soft tissue
  - Calcium & soft tissue
Material Decomposition

- Projection or image based material decomposition

**Proj.-Based**
- Proj. (low E)
- Proj. (high E)

**Image-Based**
- Proj. (low E)
- Proj. (high E)

Proj. (low E) → Proj. (M1) → Image (M1)
Proj. (high E) → Proj. (M2) → Image (M2)

Proj. (M1) → Proj. (low E) → Image (low E)
Proj. (M2) → Proj. (high E) → Image (high E)
Material Decomposition

80 kV (HU) → 140 kV (HU)

I₂ → I₂ + Tissue

Tissue
Material Decomposition

I\textsubscript{2} + Tissue

80 kV (HU)

140 kV (HU)

Tissue
Material Decomposition

80 kV (HU)  

Unknown Material 1  
Unknown Material 2  

I₂  

Tissue  

140 kV (HU)
Accuracy of VNC

- Base materials (Iodine & Water/Soft tissue)
- Non base materials (Bone/Stone)
Accuracy of VNC

- Materials decompose into components of base materials
- ‘Effective’ concentration of base materials
VNC Image Quality - Noise

- Material decomposition amplify image noise

Yu et al, RSNA, 2014
Noise Reduction in VNC

- Noise reduction techniques performed in material decomposed images, e.g. VNC

VNC (FBP)  VNC (Denoised)

S. Leng et al, Med Phy, 2011
Grant et al, Inv. Rad. 2014
S. Leng et al, Radiology, 2015
### Image Noise and NPS

- 5 torso-shaped phantoms
- Scanned using 2 scanner models (Flash & Force) and multiple Dual Energy modes
- Virtual Unenhanced

*Montoya et al, AAPM, 2016*

<table>
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<tr>
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<th>System A</th>
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<th>System B</th>
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<td>TNC</td>
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Image Noise and NPS

System A (100/Sn140 kV)

System B (90/Sn150 kV)
VNC Image Quality

System A  Spatial Resolution  System B

TNC

VNC

7 lp/cm

Montoya et al, AAPM, 2016
VNC Applications - Vascular

- Post EVAR Exam
  - Typical protocol consists of 3 scans

Non Contrast  CTA
DECT for Endoleaks Detection

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100% Sensitivity; 97% Specificity

100% Sensitivity; 97% Specificity

Stolzmann et al, Radiology, 2008

1st Generation Dual source scanner
Dose Saving with VNC

- As VNC increases image noise, this should be accounted during dose reduction calculation, e.g. at matched noise and image quality.

- Dose reduction varies with kV selection, beam filtration, and phantom sizes

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Yu et al, RSNA, 2014
Renal Mass and Adrenal Nodules

- Adrenal nodules: incidental findings on contrast-enhanced CT.
- A threshold value of 10 HU or less on unenhanced CT indicates the presence of microscopic lipid within an adenoma.

Ho et al, AJR, 2012
Pre-existing iodine contrast

Patient underwent recanalization of the intracranial bifurcation of the right internal carotid artery. (a) SECT shows hyper-attenuation. (b) Iodine overlay shows the hyper-attenuation corresponds to an area of diffuse contrast material. (c) VUE image shows an area of subtle hypo-attenuation related to the infarct. (d) FU unenhanced CT demonstrates near-complete washout of the contrast.

Gupta et al, Radiology, 2010
Acute head trauma with IV contrast had been previously administered. (a) SECT shows right frontal intraparenchymal hyperattenuation. (b) Iodine overlay image shows no corresponding area of hyperattenuation. (c) VUE image shows hyperattenuation, suggestive of intracranial hemorrhage. (d) FU unenhanced CT scan confirms the hemorrhage.

Gupta et al, Radiology, 2010
72-year-old female with acute subarachnoid hemorrhage and acute ICH secondary to a ruptured anterior communicating artery aneurysm. The TNC images depict multifocal acute subarachnoid hemorrhage and trans-ependymal CSF flow from acute hydrocephalus, which are not identifiable on the VNC image.

Courtesy Dr. Rajiv Gupta, MGH
Summary

- VNC removes iodine component from CE-DECT.
- 'Iodine component' of the non-iodine material is removed.
- To overcome noise amplification during material decomposition, noise reduction techniques are used in VCN.
- Dose reduction needs to be considered at matched image quality.
- Strictly speaking, VNC is not the same as TNC. But may be sufficient to answer certain questions.
- VNC is great for certain clinical applications, but not others.