DUAL-ENERGY CT PRIMER

Dual-Energy Scanners

- HMC: Siemens Force (CT2)
- SCH: Siemens Force
- UWMC: GE Revolution
- SCCA: GE Revolution

Protocoling Dual-Energy CTs

- Dedicated dual-energy protocols (almost always performed in dual-energy)
    - MSK CT for Gout
    - Post-angio CT head
- Preferred dual-energy protocols (may be performed in dual-energy if the scanner is available; radiologist can specify dual-energy if necessary)
    - Single phase abdomen/pelvis, chest/abdomen/pelvis, and pelvis
    - Multiphase abdomen and abdomen/pelvis
    - CT KUB
    - CTA abdomen, abdomen/pelvis, and runoff
    - ERAD Trauma pan-scan
    - MSK pelvis, hip, and extremities*
    - Neuro and ERAD spine*
- Other protocols are performed in single-energy, unless otherwise specified

*iMAR (iterative metal artifact reduction) on Siemens CTs may soon replace dual-energy CT for metal artifact reduction

Workflow Notes

- Siemens and GE dual-energy scanners must have dual-energy mode turned on before the scan is started
- Dual-energy series are sent automatically by the CT techs
    - Types of dual-energy series sent depends on the specific protocol

- If additional series are needed, call the CT techs
- Additional analysis may be performed on AW Server (GE) and Syngo.via (Siemens)
    - Specific instructions are beyond the scope of this document
    - Screenshots of graphical and quantitative analyses can be sent to PACS

How to tell if your study was performed in dual-energy

- Siemens:
    - Circular field-of-view dashed line is seen on axial images, representing the dual-energy field
    - There are source images at two energy levels, most commonly 90kV and Sn150kV
- GE:
    - Axial images specify a monoenergetic level (most commonly 70keV or 77keV)

What do these series mean?

- Siemens (HMC, SCH)
    - Axial 90keV and Sn150keV
        - Source images, typically sent with a slice thickness of 0.625mm
        - Generally not used in most clinical scenarios
    - Axial DE mixed 0.6
        - 0.6 represents the mixing ratio, a weighted blend of the low and high energy images
            - Mixing ratio could range from 0.4 to 0.7
        - Used for standard image interpretation
    - Axial MPR _____
        - Specific dual-energy CT applications are included in this series
        - Common naming conventions:
            - "Liver" and "kidney" usually represents iodine map

        - "Bone marrow" represents marrow edema map
        - "Gout" and "kidney stone" represent mineral maps
    - Series naming can be variable among CT techs
    - Tips and pitfalls
        - Use non-affected anatomy as your reference for normal
        - On iodine maps, high atomic number minerals (including calcium) will also be bright
        - For each application, choice of color is arbitrary
            - Iodine overlay is usually orange
        - Color scale is variable
            - If in doubt, perform quantification in Syngo.via
- Axial MPR VNC
    - Standard image – iodine map = virtual non-contrast (VNC)
    - Research ongoing regarding reliability of using VNC as a surrogate for true unenhanced images
- Axial monoenergentic _____
    - Low monoenergetic images (usually 40-50keV) makes iodinated contrast brighter
        - Great for detecting hypervascular lesions
        - Increased image noise and beam hardening artifact
    - High monoenergetic images (usually 120-140keV) decreases image noise and beam hardening artifact
        - Great for evaluating regions limited by metal artifact
        - Suppresses the appearance of iodinated contrast

- GE (UWMC, SCCA)
    - Axial 70keV and 77keV
        - Represent virtual monoenergetic reconstructions
        - Used for standard image interpretation

        - Note that due to GE's dual-energy CT mechanism (rapid kV switching with one receptor), source images at the low (80kV) and high (140kV) energy levels cannot be viewed separately
    - Axial 50keV or 55keV
        - Makes iodinated contrast brighter
        - Great for detecting hypervascular lesions
        - Increased image noise and beam hardening artifact
    - Axial 140keV
        - Decreases image noise and beam hardening artifact
        - Great for evaluate regions limited by metal artifact
        - Suppresses the appearance of iodinated contrast
    - Axial VUE
        - Standard image – iodine map = virtual unenhanced (VUE)
        - Research ongoing regarding reliability of using VUE as a surrogate for true unenhanced images
    - Axial Iodine(water)
        - Pure iodine map without anatomic overlay
        - High atomic number minerals (including calcium) will also be visible
    - For other applications, such as mineral maps and marrow edema, manual analysis on AW Server is necessary

Parting words

- In many studies, specific dual-energy outputs are not needed for image interpretation
- Most dual-energy applications are not robustly validated
    - For example, we do not know what iodine concentration correlates with renal mass enhancement and whether this varies between patients and scanners
    - In borderline and ambiguous cases, caution is suggested when interpreting dual-energy outputs
- All dual-energy outputs can be reconstructed into coronal and sagittal
- Color maps can be misleading

- Choice of color is arbitrary
- Use non-affected anatomy as a reference for normal
- If in doubt, perform quantification in Syngo.via (Siemens) or AW Server (GE)
- Dual-energy output quantification cannot be performed in our current PACS

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