Ask EuroSafe Imaging

Tips & Tricks

CT Working Group

Iterative reconstructions in CT

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Key points

- **Iterative reconstructions may provide significant dose reductions (ranging from 10% to 90%) and image quality improvements in CT imaging. However, the dose reduction potential highly depends on the clinical task and iterative algorithm.**
- Statistical iterative algorithms have been implemented in modern CT scanners already for several years. Recently, more advanced model based algorithms have been developed, which further model the scanner optics and physics. Furthermore, modelling also requires more computations, which effect the reconstruction time.
- Image quality improvements include primarily noise reduction and artefact reduction (statistical modelling), but new model based iterative reconstruction methods may go further to improve spatial resolution.
- **Basic principle of iterative reconstruction**: initial image estimate (e.g. traditional FBP image) is projected forward to provide simulated raw-data, which is compared to original measured raw-data (sinogram) projections. Based on the differences between the simulated and measured raw-data, corrections are performed and projected back to provide new image estimate. Iterative loop is repeated until suitable convergence is achieved or maximum number of iterations has been performed. The final image estimate is the output reconstructed image.
- Depending of the method, iterative reconstruction may alter the **image texture** and the effect is **non-linear**. This increases the need for more comprehensive clinical image quality evaluations, also utilising model observers for objective image quality metrics (detectability index) with specific clinical tasks.

Iterative reconstructions

- Repeated forward and back projections
- Several steps:
  - Assume an image (empty or FBP),
  - Compute projections from the image,
  - Compare to the original projection data and
  - Update the image based on the difference between calculated and actual projections.

General model of iterative reconstruction

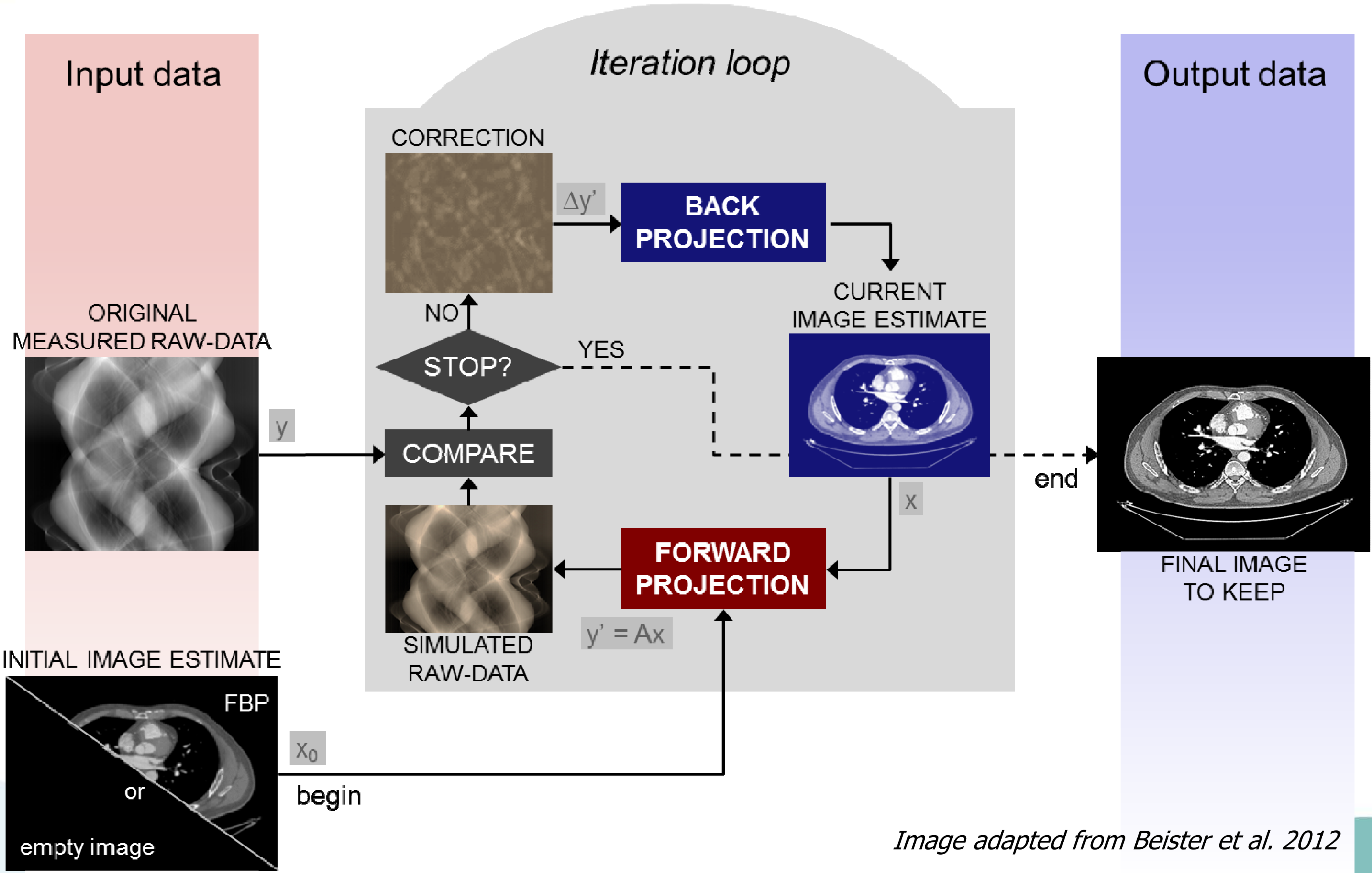


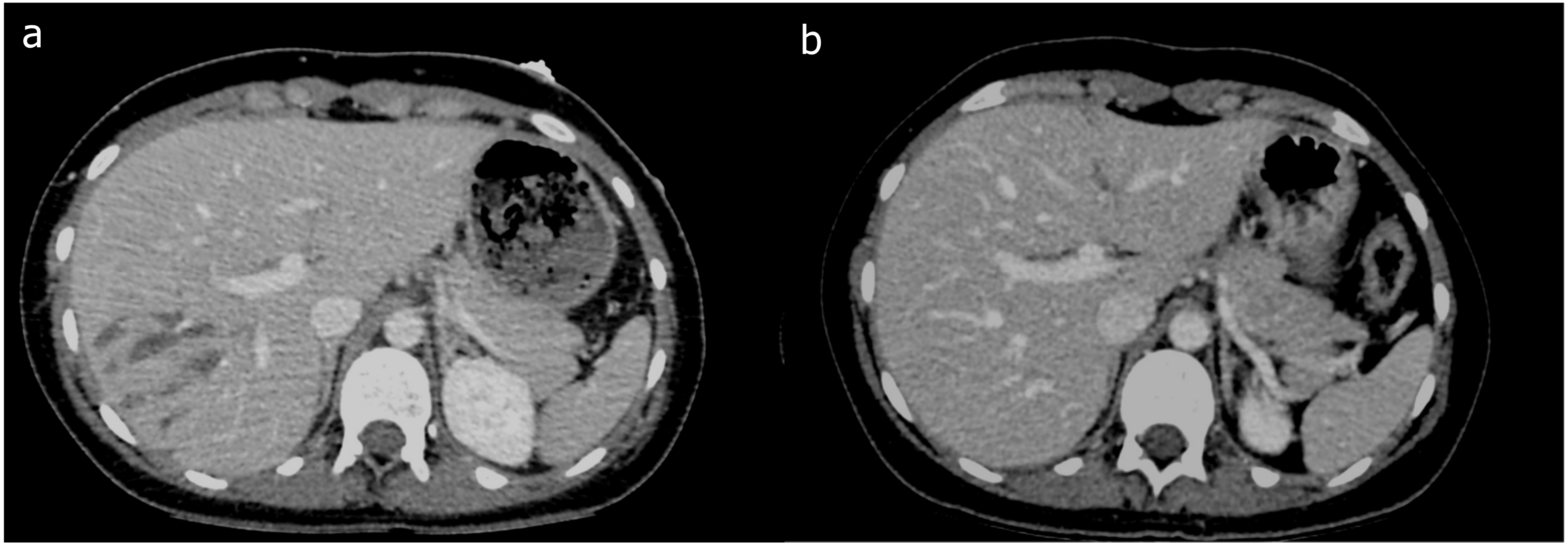
Image adapted from Beister et al. 2012

Iterative reconstructions

- Dose (way to use it)
  - Same dose better ImQ
  - Lower dose same ImQ
- Artefact reduction
- Better low contrast resolution and same spatial resolution → better visibility in soft tissues (however, depending on indication and corresponding structures)
- Users needs appropriate training

Iterative reconstructions

By keeping the same image quality in comparison with FBP images, iterative reconstruction can reduce the dose by about 40-80 % depending on the type of algorithm used.



Abdominopelvic CT images from a 26-year-old patient performed for the follow-up of a post-traumatic hepatic fracture. Transverse 2-mm slices of the abdominopelvic full-dose CT with FBP reconstruction (a) and of the half-dose CT with AIDR 3D (b). Note the comparable image noise between the full-dose FBP (a) and the low-dose AIDR 3D (b) sets despite a significant dose reduction for the low-dose CT scan (529 mGy.cm *vs.* 267 mGy.cm, respectively).

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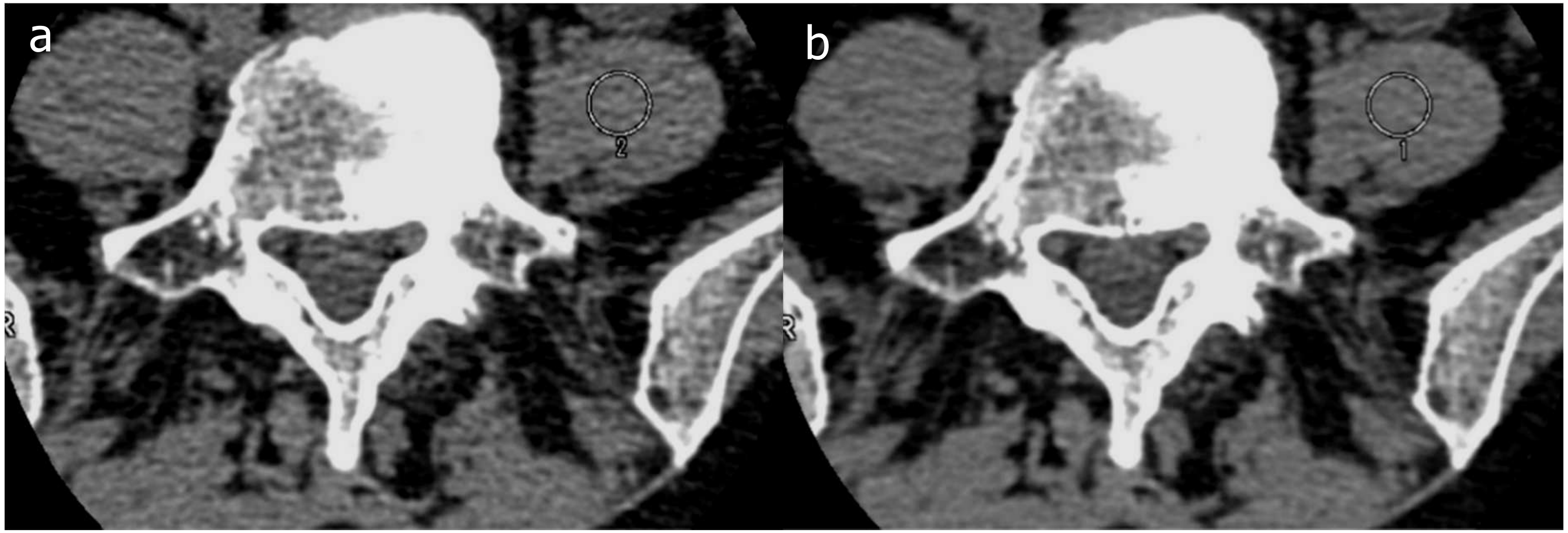
Iterative reconstructions

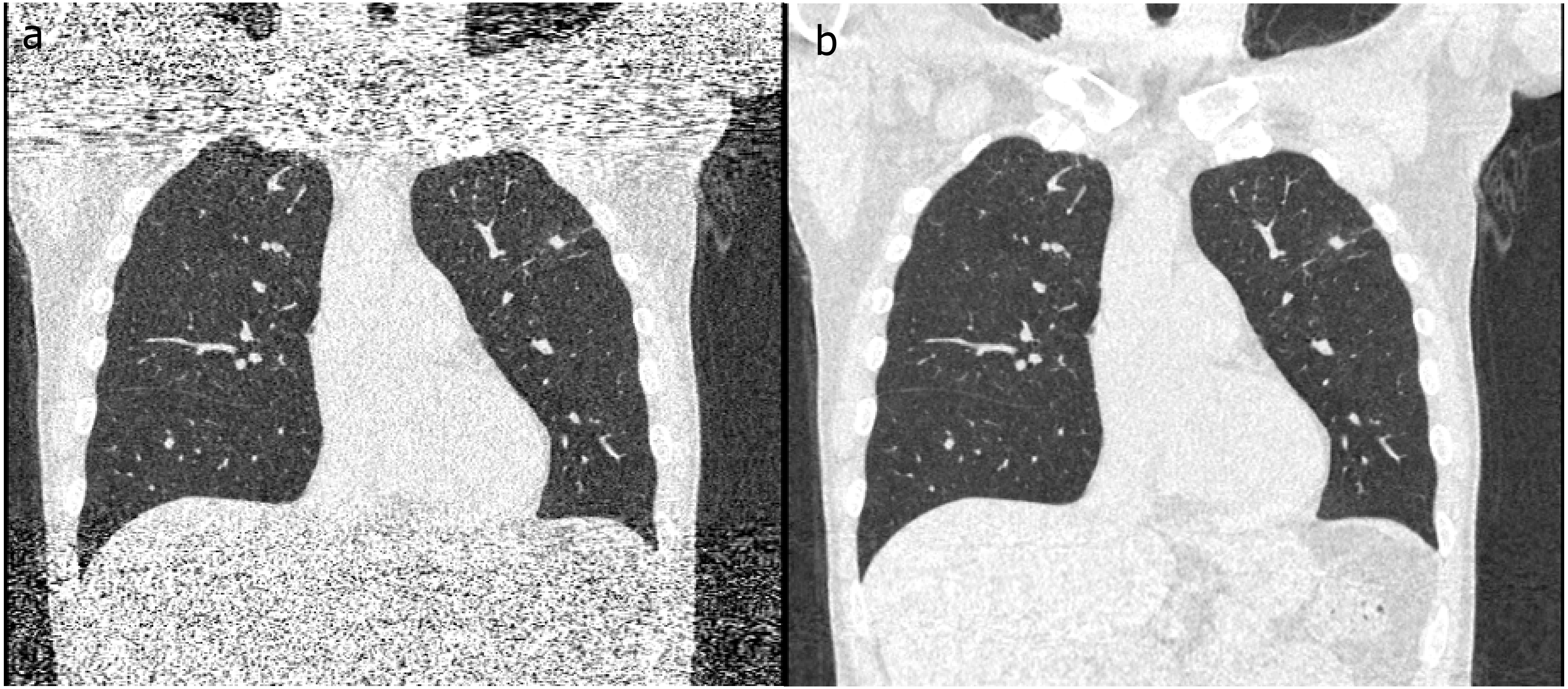
Iterative reconstruction can reduce image noise in comparison with standard filtered back projection reconstruction.



Transverse lumbar spine CT image in a 56-year-old woman reconstructed with traditional filtered back projection (FBP) (a) and iterative reconstruction (AIDR) (b). Note the noise reduction with AIDR compared to FBP (standard deviation values of the ROIs placed in left psoas are 21.1 HU with FBP and 14.5 HU with AIDR, which corresponds to a noise reduction of 31%).

Iterative reconstructions

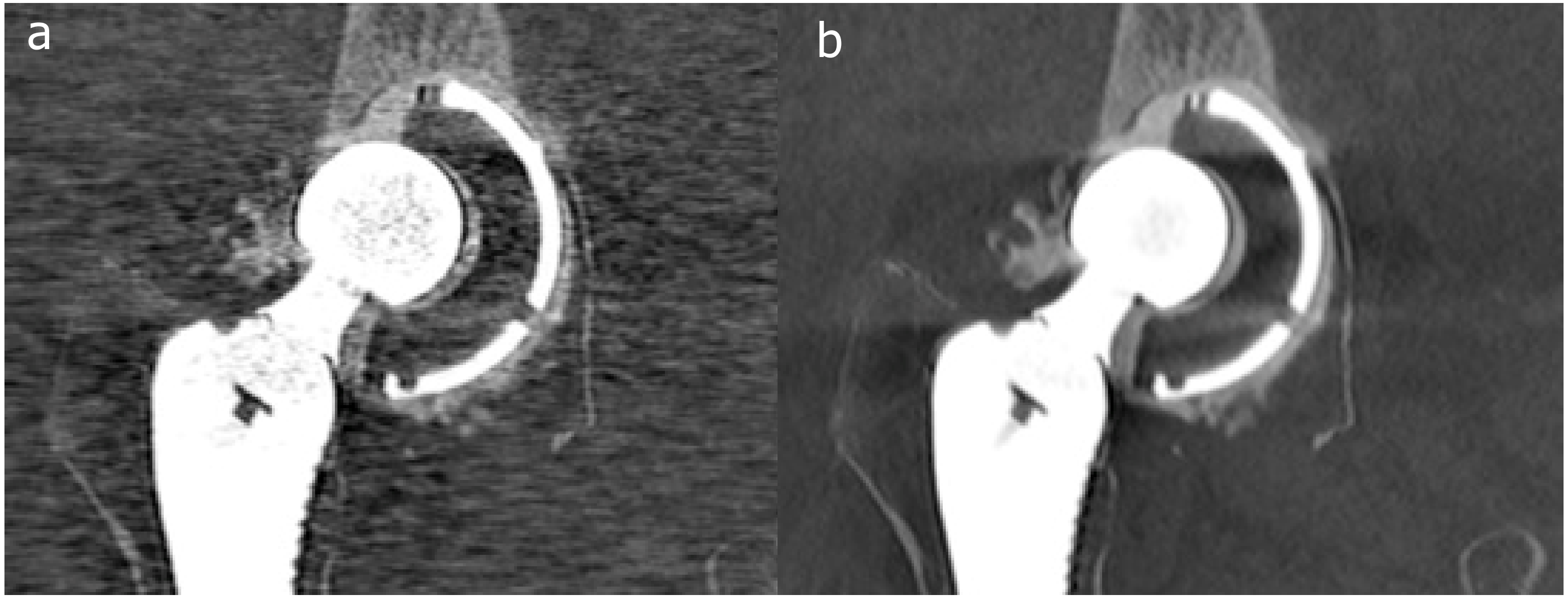
Reduction of structured noise by iterative reconstruction



Comparison of image quality between FBP and iterative reconstruction of a low dose chest CT. Coronal reformation with FBP reconstruction (a) and iterative reconstruction AIDR 3D (b). Note the reduction of the structured noise with iterative reconstruction in comparison with FBP reconstruction.

Iterative reconstructions

Iterative reconstruction can also improve image quality by reducing the image artifacts.



Comparison of image quality between FBP and iterative reconstruction for a patient with a hip prosthesis. Coronal reformation of an acquisition with 135 kVp, 50 mAs and with FBP reconstruction (a) and iterative reconstruction AIDR 3D (b). Note the reduction of the metal and streak artifacts with iterative reconstruction in comparison with FBP reconstruction.

Iterative reconstructions

New iterative reconstruction algorithms are still in development with further image quality improvement and dose reduction potential.

CT-scan of a 83 years-old man with anticoagulant-related sub-capsular liver hematoma. Coronal reformations with FBP reconstruction (a) AIDR 3D reconstruction and FIRST reconstruction (c) Note the improvement of image quality with second generation of iterative reconstruction FIRST (c) compared to first generation AIDR 3D (b) and FBP (a).

Core team

- Be informed before use
- Get knowledge about all possibilities (1st + 2nd generation)
- Ask medical physicist to explain
- Train yourself (start from FBP ImQ)
- Co-operate with radiologists (at the start they will need longer time for same report – disappointed)
- Find correct ratio between image quality, noise and dose.
- Radiologists need time to get used to different noise pattern.
- Image texture is typically different then in FBP.

Remarks

- There are no specific anatomical regions – or issues with pediatric patients - where dose saving or image quality effect would be limited by Iterative Reconstruction in general.
- There are many different Iterative Reconstruction algorithms already in the market (which are continuously evolving) and they have different effects on the final image outcome (e.g. artifact suppression, noise decrease, noise and image texture change, resolution effect, etc.)
- It should be emphasized that when taking Iterative Reconstruction methods into use for new clinical applications or scan indications, the users should carefully evaluate the clinical image quality.

References

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