Purpose
To provide an overview of the model-based iterative reconstruction variant, Veo (GE Healthcare, Waukesha, WI), its unique requirements, its impact on reducing noise and facilitating radiation dose reduction, and to review various CT image artifacts, limitations, and their potential solutions.

Introduction
CT utilization has more than tripled over the past 10 years resulting in an increase in CT dose to the population. Because CT-induced ionizing radiation is associated with a possible increased risk of cancer, there are active efforts to reduce the radiation dose from CT imaging.

Dose-reduction techniques based in filtered back projection (FBP) such as tube current modulation, reduced tube voltage, and the use of a higher pitch are commonplace in clinical, effective, but suffer from the introduction of noise which degrades image quality. FBP has been the dominant mode of image reconstruction for decades owing to its speed and simplicity. However, FBP is limited by relatively simple mathematical assumptions of the imaging system which lead to CT images computed by quantum and electronic noise, which is a significant factor in image quality.

Recently developed novel iterative CT image reconstruction techniques enable the acquisition of CT images at lower radiation doses but with comparable diagnostic imaging quality compared to higher dose CT images reconstructed by FBP.

Iterative Reconstruction
Unlike FBP, iterative reconstruction (IR) algorithms for CT use a model of the noise statistics of photons and electrons to improve the image quality, enabling attenuation correction, patient-specific image quality, and improved diagnostic imaging compared to low-dose CT imaging.

Modern-Based Iterative Reconstruction
Model-based iterative reconstruction (MBIR) is a fully iterative reconstruction that does not blend in FBP data to construct the final images like some other iterative approaches do. MBIR improves upon other IR techniques by utilizing a typical model of the imaging system optics and geometry of the CT machine, including modeling the x-ray tube response, detector response, and x-ray physics such as scatter and crosstalk.

MBIR: Advantages
Image Quality, Noise And Dose Reduction
MBIR has been shown to decrease image noise by up to 58% compared to FBP at abdominal CT and significantly improve subjective image quality (Figure 1). Lessons that are small or subtle and could be obscured by noise on FBP images become more conspicuous on MBIR images (Figure 2).

Artifacts and Limitations
A number of artifacts were encountered that were unique to MBIR images and should be recognized and exploited to render the images non-diagnostic, however, we recommend using standard FBP images to PACS in addition to MBIR for quality control purposes and as back up in case there is significant MBIR artifact.

Ring artifact
Concentric ring artifact was relatively frequently encountered, usually at the level of the lower heart (Figure 4) and occasionally extending into the top of the liver. This artifact was not present in the FBP images. The ring artifact was reproduced in phantoms with simulated cardiac and respiratory motion (Figure 5). Practical solution: Use a faster rotation time to acquire faster data and give more stringent instructions to patients emphasizing breath holding during exam acquisition. If artifact is significant, evaluate affected anatomy on the FBP images or consider reconstructing with high strength (70-80% ASIR).

Transient ghost artifact
In fewer than 5-15% of cases, a “ghost” image of shifted anatomy was superimposed on sequential contiguous MBIR CT slices (Figure 8). No such artifact was present on the FBP images. Practical solution: Reviewing the Veo reconstruction with the identical raw data eliminates this artifact. It is unknown why this artifact occurs.

“Double exposure” artifact
This artifact was only present where the CT scan was momentarily paused at the junction of the abdomen and pelvis (Figure 9). Practical solution: Scan the abdomen and pelvis as one continuous scan, without a pause.

Impact of pitch on MBIR image quality
A higher pitch (>1) leads to a faster MBIR reconstruction time but possibly lower soft-tissue resolution when subjectively assessed, probably because of less image data. Practical solution: Keep pitch near 1 but reduce rotation time to increase speed of acquisition.

Lean patients/paucity of intraabdominal fat
In patients with a paucity of intraabdominal fat it becomes more difficult on Veo images to discriminate soft tissue attenuation structures from one another. This is likely due to a greater need for image detail than in patients in whom fat separates such structures. Intraabdominal fat is required to reduce in these patients and consider supplemental adaptive statistical iterative reconstruction (ASIR) series.

Conclusion
Veo has tremendous promise for reducing CT radiation dose, however, we are aware that must be aware of that can be overcome with a variety of creative solutions.

References