Comparison of plain unenhanced scan to virtual non contrast (reconstructed from post contrast imaging) on the NAEOTOM photon counting scanner

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Background

- Photon counting CT (PCCT) uses photon counting detectors to individually detect, count and sort each X-ray photon by its energy.

- This allows higher spatial resolution, reduced image noise, increased contrast, lower radiation dose, fewer artifacts and spectral imaging.

- Spectral imaging - Use energy information to better characterize tissue and differentiate between materials.

Background

- Non Contrast CT - Useful for; Acute bleed, Adrenal lesion characterisation.
- Virtual Non Contrast (VNC) - Processed from contrast enhanced sequence using photon energy measurement to generate ‘non contrast’ images.
- Benefits VNC - Reduced radiation dose, Reduced scan time.
- Potential pitfalls of VNC - Increased radiographer time during post processing, Increased data storage.

Objective

- It is currently not well understood how accurate **virtual non-contrast (VNC)** images are and whether or not they can be considered an accurate and reliable substitute for **true unenhanced sequences (TNC)**.
- This study compares the **average Hounsfield unit measurement (AvHU)** for defined anatomical locations on true unenhanced acquisition to virtual non-contrast (VNC) images produced on the NAEOTOM photon counting scanner.

Methods

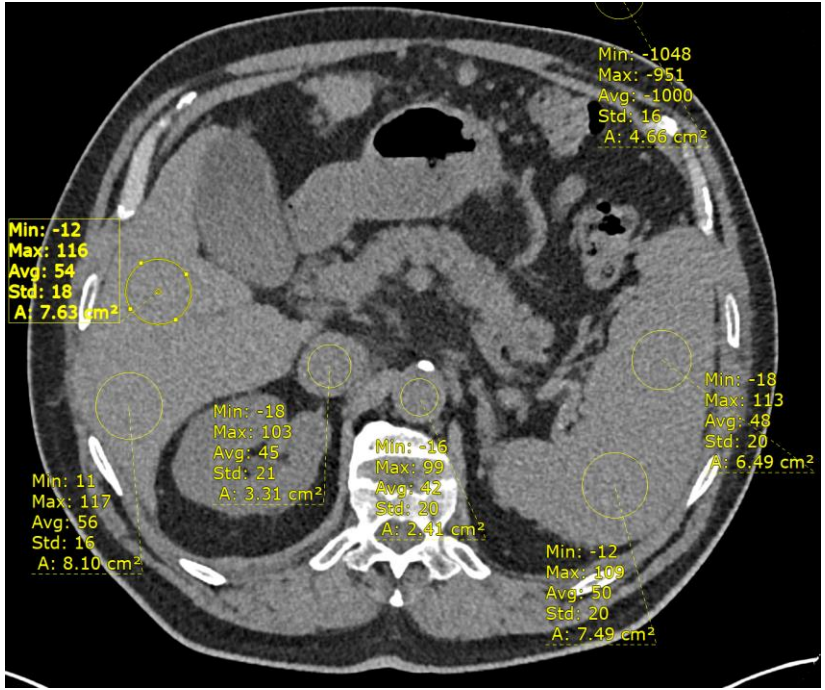
- Retrospective review of multiphase CT studies completed on the NAEOTOM photon counting scanner between 11/07/2025 - 20/11/2025.
- Studies with a true unenhanced (TNC) and contrast enhanced sequence with a post processed virtual non contrast (VNC) of the abdomen were included.
- Studies with true unenhanced and only VNC derived from portal venous phase excluded due to insufficient data numbers. All included studies had VNC generated from arterial phase acquisitions.

Methods

Regions of interest (at least 1.5cm^2 where anatomically possible) were placed on defined anatomical location on the true unenhanced and VNC sequences.

The following structures were selected for comparison:

- Liver – excluding vessels (x3 ROI)
- Spleen (x3 ROI)
- Central aorta – excluding the vessel wall
- Left psoas muscle – excluding heterogeneous areas
- IVC
- Air (outside the body)



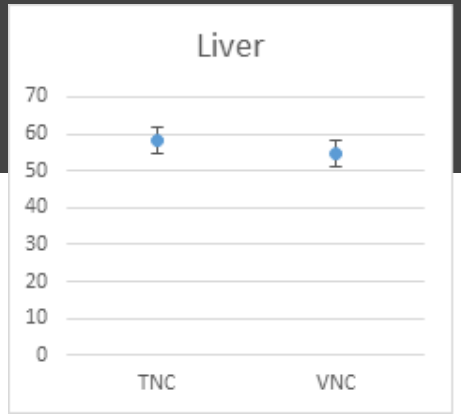
Results

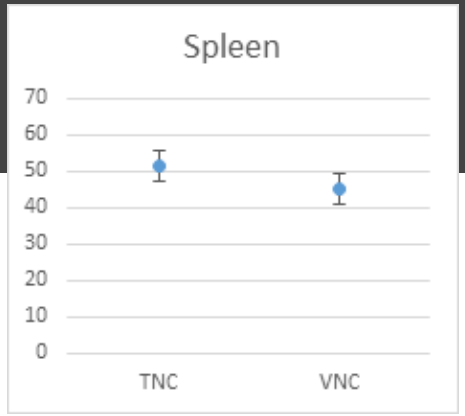
	TNC		Arterial VNC		VNC HU Difference		95% Confidence interval for VNC difference		
Tissue	Mean	SD	Mean	SD	Mean	SD	Lower	Upper	P value
Av Liver	58.06	7.89	54.88	8.62	3.18	5.81	0.78	5.58	0.061
Av Spleen	51.37	2.31	45.16	10.3	6.21	9.26	2.39	10.03	0.01
Aorta	46.36	5.48	23.68	11.58	22.68	13.35	17.17	28.19	0.001
IVC	46.4	6.16	30.24	11.19	16.16	13.18	10.72	21.6	0.001
Psoas	51.91	4.63	42.77	8.21	8.74	8.6	5.33	19.94	0.001
Air	-996.8	3.82	-997.9	4.23	1.08	4.73	-0.87	3.03	0.264

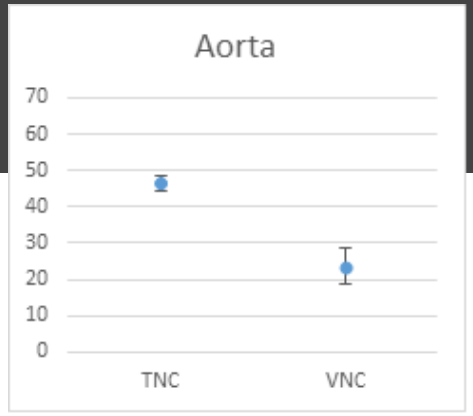
- Figure 1: *Mean TNC HU, VNC HU and VNC difference for each tissue,*
- *TNC = True Non Contrast, VNC = Virtual Non Contrast, HU = Hounsfield Units, SD = Standard Deviation, Av = Mean Average, IVC = Inferior Vena Cava*

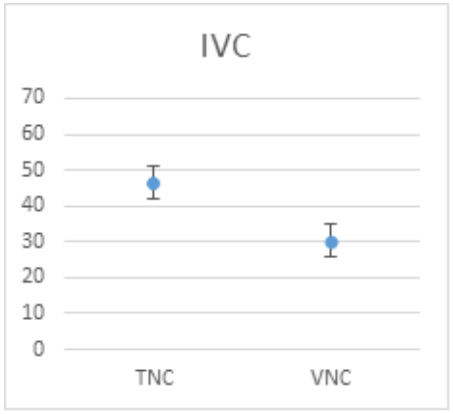
Results

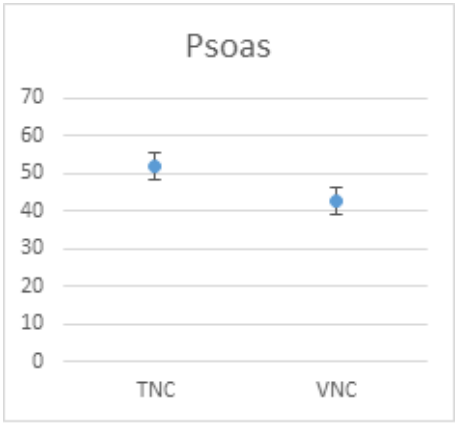
Mean HU with 95% confidence intervals

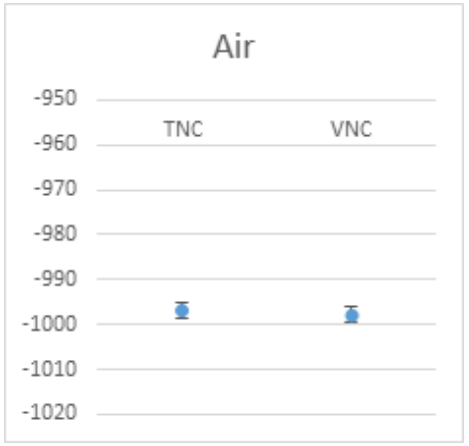












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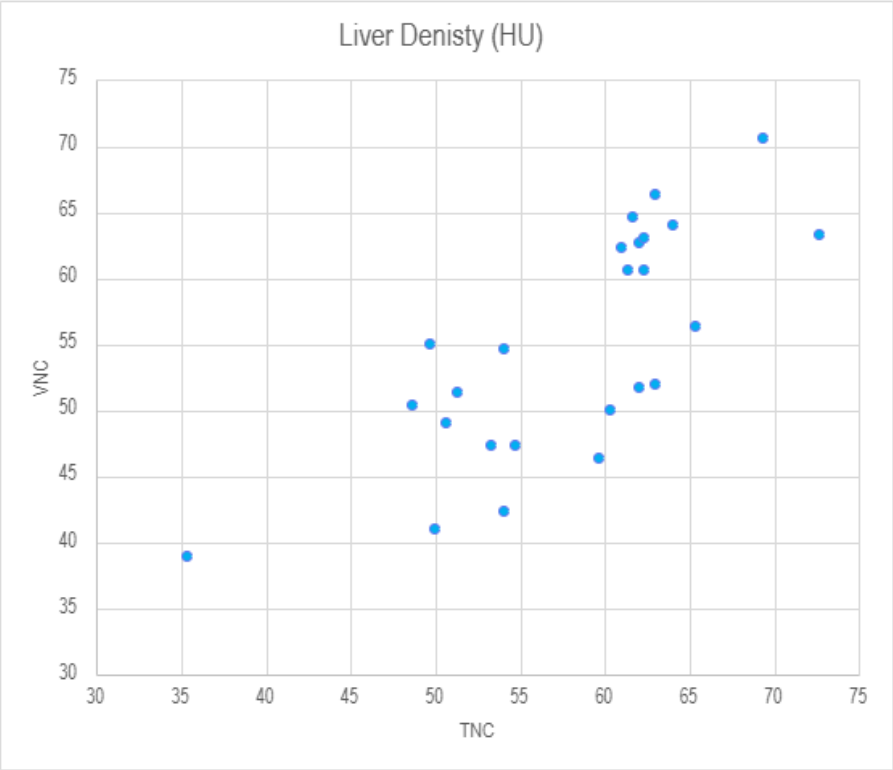
Results



Mean Liver HU for each study

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Discussion

- Significant differences between recorded avHU on TNC and VNC sequences for most areas of interest (non-significant for liver and air) suggesting underestimation of the true tissue density.
- Aorta and IVC demonstrated the highest mean HU difference. One of the key uses of non-contrast imaging is assessing for acute bleeding, and this study suggests VNC may be least accurate when assessing the density of blood.
- VNC may be a useful surrogate for TNC if the interpreting radiologist is aware of the difference.
- Limited initial studies on PCCT derived VNCs [1,2,3] look into the potential for VNCs to be used as a useful alternative to TNCs and have also found discrepancies and recommended improvements.

Conclusion

- The results demonstrate that in our centre, the VNC images systematically underestimate tissue attenuation compared with TNC, with statistically significant differences observed in most tissues.
- Nevertheless, VNC may still function as a pragmatic surrogate for TNC when its limitations are recognised, and when tissue-specific attenuation differences are accounted for during interpretation.

Further work

- Furter work is required to characterise the exact adjustment required for VNC to be used as a surrogate for TNC.
- In addition, evaluation of VNCs derived from the portal venous phase is necessary to determine if the VNC difference is impacted by the phase of the acquisition it is derived from.

References

1. Gerstner AK, Risch F, Canalini L, Widmann G, Gizewski ER, Bette S, Hellbrueck S, Kroencke T, Decker JA. Photon counting detector CT-derived virtual non-contrast images of the liver: comparison of conventional and liver-specific algorithms across arterial and portal venous phase scans. BMC Med Imaging. 2025 Aug 4;25(1):311. doi: 10.1186/s12880-025-01849-0. PMID: 40760417; PMCID: PMC12323134.

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3. Gadsbøll EL, Aurumskjöld ML, Holmquist F, Baubeta E. Virtual non-contrast images in photon-counting computed tomography: impact of different contrast phases. Acta Radiol. 2024 Sep;65(9):1147-1152. doi: 10.1177/02841851241271202. Epub 2024 Aug 14. PMID: 39140849.