

Title

Comparing the patient experience between a novel 360° gamma camera (VERITON-CT) and a conventional dual head gamma camera.

Authors

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The authors declare no conflicts of interest and nothing to disclose. Neither of the two scanner manufacturers (GE Healthcare or Spectrum Dynamics Medical) were involved in the study design or manuscript review.

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Short title:

Patient experience of VERITON-CT.

Abstract:

*Aims:* To explore whether the novel 360° gamma camera design of VERITON-CT adversely affects the rate of scan non-completion due to claustrophobia or other patient experience factors, when compared to a standard dual-head gamma camera.

*Methods:* Single centre prospective study of all nuclear medicine studies on either of two gamma cameras; the VERITON-CT (Spectrum Dynamics Medical) and Discovery NM/CT 670 (GE Healthcare). It was recorded whether the patient had completed the scan as protocolled or, due to claustrophobia, had a shortened scan or no scan. The patients were also offered a patient experience questionnaire, with domains of comfort, scan time, scan noise and claustrophobia assessed using a five-point Likert scale.

*Results:* Over a four-month period, there were 296 patients scanned on the Discovery scanner and 274 patients scanned on the VERITON-CT scanner. There was a scan non-completion rate, due to claustrophobia, of 1.35 % for the Discovery and 1.46 % for the VERITON-CT scanner. 354/570 (62%) of all patients involved returned their questionnaires. There was no statistical difference between the responses for comfort, scan time, scan noise and feelings of claustrophobia.

*Conclusion:* The study provides evidence that the novel 360° gamma camera design of VERITON-CT does not lead to a significantly increased scan failure rate due to claustrophobia and there is no change in the subjective experience for patients.

Keywords: Claustrophobia, Discovery 670, Gamma Camera, Patient Experience, VERITON-CT.

## Introduction:

Single photon emission computed tomography (SPECT) imaging and hybrid SPECT/CT imaging have undergone multiple developments since the first commercial SPECT/CT scanner became available over twenty years ago (1). Identifying the clinical indication of optimised localisation and quantification of tracer uptake was essential to the increasing clinical utility (1). Moreover, the continued advances in detectors and the emergence of digital cadmium-zinc-telluride (CZT) cameras have allowed for improved extrinsic resolution (2), higher count sensitivity and reduced scan times (3). This allows for superior image quality and presentation using maximum intensity projections. However, this should be balanced with a patient's tolerability of the scan. Although there is limited published data on patient experience of claustrophobia during gamma camera examinations, this is a shared theme with other high technology medical imaging modalities such as magnetic resonance imaging (MRI), where potential negative experiences of discomfort and claustrophobia need to be considered (4-9). One study showed that 10% of children undergoing 3T MRI report feelings of claustrophobia (4) and in another study, up to 40% of adult patients undergoing MRI, experience feelings of unpleasantness due to a 'confined space' (8). A focus on improving our patients' experience and employing a patient-centred approach is paramount in the development and planning of radiology services (10).

In November 2020, a new SPECT/CT scanner with CZT detectors (VERITON-CT) was installed in our local nuclear imaging department as a replacement to one of the older cameras. Unlike conventional dual-head Anger cameras, the VERITON-CT scanner comprises a novel set-up design, with 12 detectors in a 360° configuration that can be moved closer to the patient during image acquisition. During the scanner procurement process, the authors wanted to ensure that

patients would tolerate this novel design. This presented an opportunity for reflection and exploration of the patient experience of nuclear imaging within the department. The aim of this study was to assess claustrophobia in our patients by comparing the local scan non-completion rate, due to claustrophobia, between the new VERITON-CT scanner and a conventional dual-head gamma camera. Secondly, we wanted to prospectively survey our patients about their subjective perception of several experience factors, including claustrophobia. Together, these could provide both objective and subjective measures of scanner tolerability.

#### Materials and Methods:

The institutional review board approved this study and the requirement to obtain informed consent was waived. This study was registered with the local clinical audit department. The local hospital patient experience team was involved from the start of the project and invited to the nuclear imaging department, where they were able to view the available scanners and patient flow areas. Neither of the two scanner manufacturers (GE Healthcare or Spectrum Dynamics Medical) were involved in the study design or manuscript review. On request, Spectrum Dynamics Medical supplied an image highlighting the different scanner designs.

#### *Scanners and patients*

All patients presenting for nuclear imaging scans between 28<sup>th</sup> October 2020 and 12<sup>th</sup> March 2021 were included for analysis. Studies were performed on either of the two department scanners. The Discovery NM/CT 670 (GE Healthcare) was installed in November 2012 and the VERITON-CT (Spectrum Dynamics Medical) was installed in November 2020. The characteristics

of each scanner are shown in Table 1 and a graphical representation of the difference between a conventional gamma camera and the novel design of the VERITON-CT is shown in Figure 1. The patient positioning is very similar between the two scanners. Of note, VERITON-CT scan protocols are generally shorter than corresponding protocols on the Discovery scanner. For example, an oncology whole body bone scan takes approximately 18 minutes on the VERITON-CT (3), while a bone scan and single site SPECT takes 40 mins on the Discovery.

Having considered the volumes and types of scans going through the department and the process of protocol development, initially it was decided that the VERITON-CT scanner would be used for bone, parathyroid and lung imaging with a plan to gradually introduce other indications. During the study period, bone, parathyroid and lung scans were protocolled for either of the two scanners and the local radiology bookings team allocated the patients based on efficient use of scanning slots. Where there was patient anxiety towards the VERITON-CT scanner, patients were also given the option of having their scan on the Discovery scanner instead.

#### *Questionnaire development*

A review of current literature regarding patient experience of medical imaging revealed similar studies of patient experience and tolerability of MRI and nuclear imaging (4-8). Informed by one of these studies (4), a cross-sectional patient experience questionnaire was drafted, which contained four measures of scan experience (comfort, scan time, scan noise and claustrophobia). The draft was reviewed by the hospital patient experience team. The final questions are shown in Figure 2. During the prospective data collection phase, demographic

data for all patients undergoing nuclear imaging were recorded in a spreadsheet along with information about whether they completed their scan as protocolled. After the scan, patients were offered a paper questionnaire to fill in prior to leaving the department. The reception staff then collected the questionnaire from the patient and recorded the responses in the spreadsheet.

#### *Quality checking and statistical analysis*

The prospectively collected data was cross-referenced against a retrospectively generated patient list from the radiology information system, to ensure no patients were missed. An assessment of whether scans were completed, as protocolled, was undertaken. Variations in the survey responses were tested using the Chi-squared test. Differences in the scan non-completion numbers between the Discovery and VERITON-CT scanners were tested using the Mann-Whitney U test. Two-tailed tests were used and a p-value < 0.05 was considered statistically significant. All statistical analysis was performed on GraphPad Prism 9 for macOS.

#### Results:

##### *Study group*

Between 28<sup>th</sup> October 2020 and 12<sup>th</sup> March 2021, there were 296 patients scanned on the Discovery scanner and 274 patients scanned on the VERITON-CT scanner. There was a 62% (354/570) overall questionnaire response rate. The spread of nuclear imaging scan indications across the two scanners is shown in Table 2.

### *Rate of scan non-completion as protocolled*

All patients presenting for nuclear imaging had some form of imaging during their visit. Overall, there were 6/570 (1.05%) patients that failed to complete their scan as initially protocolled, due to claustrophobia (Table 3). Four of these patients were booked on the VERITON-CT scanner, of which one patient was able to have a partial scan on VERITON-CT (Patient 1), two were able to have a partial scan on Discovery (Patients 2 & 3) and one was able to have a complete scan on Discovery (Patient 4). Two further patients were initially booked on the Discovery scanner (Patients 5 & 6) and were only able to have partial scans due to claustrophobia. This gives a composite rate of scan non-completion as protocolled, due to claustrophobia, of 4/274 (1.46 %) for the VERITON-CT scanner and 4/296 (1.35 %) for the Discovery scanner ( $p=0.33$ , Mann-Whitney U test).

### *Survey responses*

The modal responses in the different experience parameters for each of the scanners was as follows: comfort was 'yes very', long scan time was 'no not really', loud scan noise was 'no not at all' and claustrophobia was 'no not at all'. There was no statistical significance in the spread of the five-point scale responses across the two scanners, when compared using Chi-squared test, as follows: comfort ( $p=0.84$ ), long scan time ( $p=0.39$ ), loud scan noise ( $p=0.46$ ) and claustrophobia ( $p=0.44$ ). In particular, the overall subjective reporting of claustrophobia (patients who answered: 'yes very' and 'yes a little') was 15/138 (10.9%) for the Discovery and 25/216 (11.6%) for the VERITON-CT ( $p=0.87$ ). A graphical representation of the spread of survey

responses from all surveyed patients, comparing the VERITON-CT and Discovery scanners, is shown in Figure 3.

#### Discussion:

It is recognised that high technology imaging presents a potential source of patient anxiety, which can be limiting to adequate scan completion (4-9). The authors sought to assess the claustrophobia rate in two ways. Firstly, we recorded the rate of scan non-completion due to claustrophobia and found that very few patients were unable to complete their scan fully on the VERITON-CT or Discovery scanners (1.46% and 1.35% respectively). All patients were able to complete at least part of their scan, which is the most important outcome. Secondly, a survey of subjective perception of several experience factors was conducted. The modal responses support the finding that overall patient experience is positive across the two scanners. Moreover, there was no statistical significance across the responses from the two scanners. This shows that the novel 360° configuration of the VERITON-CT scanner does not significantly affect the subjective patient experience.

It is important to note that there is strong heterogeneity in the patient groups for bone imaging, as there was no dynamic bone imaging protocol established for the VERITON-CT scanner. Hence, bone scans for indications such as post-arthroplasty imaging, which involved three-phase acquisition, were protocolled for the Discovery scanner. This makes subgroup analysis very difficult.

Comfort is essential for nuclear imaging as scan times vary greatly but can be up to one hour long and it is important for the patient to be able to lie relatively still. The patient table for the



two scanners is very similar and it is understandable that there was no difference in perceived comfort. Although, this question is likely to be mainly answered from a physical perspective, it seems likely that if patients were feeling psychological discomfort from claustrophobia, it may also affect the responses to this question. Many of the VERITON-CT scan protocols are shorter than corresponding protocols on the Discovery scanner. For example, an oncology whole body bone scan takes approximately 18 minutes on the VERITON-CT (3), while a bone scan and single site SPECT takes 40 mins on the Discovery. However, there is no observed subjective difference in the patient appreciation of scan time. The results from this study give an overview of patient perceptions of scan time but a separate study including actual time spent on the scanner would be required to draw further conclusions.

The subjective experience of scanner noise also did not reveal any statistical difference between the two scanners. Of note, the measured sound level during CT scanning in the Discovery was 74dB and in the VERITON-CT was 72dB.

For a minority of patients, claustrophobia is a deterring factor when considering medical imaging (4-9). The subjective experience of claustrophobia was relatively low: 10.9% for the Discovery and 11.6% for the VERITON-CT. The nuclear imaging technologists are experts in strategies used to reassure patients and guide them comfortably through the scan as much as possible. With this expertise, all patients attending the department were able to complete at least a part of their scan. It should be noted that 3 patients declined to be scanned at all on the VERITON-CT, whereas all the patients completed at least part of their scan on the Discovery.

There is a potential for subconscious bias amongst the technologists, who are more familiar with the double-headed camera set-up of the Discovery scanner. From an ethical standpoint in

a two-scanner department, it is understandable that patients who showed anxiety towards the VERITON-CT, were given the option to attempt their scan on the Discovery instead. Conversely, the patient scans which were booked on the Discovery scanner were encouraged to complete as much of the scan as they could but were not offered the VERITON-CT scanner as an alternative. This is because the technologists have years of experience in getting patients through their scans on the Discovery scanner. It is, therefore, not possible from our study design to say what the rate of scan non-completion would be for the VERITON-CT scanner if it was the only scanner available. It is possible that some, if not all, of the patients (Patients 2-4) would have partially completed their scans on the VERITON-CT scanner.

We have not sought to assess what an individual patient's experience of both scanners would be as a head-to-head comparison, as this would involve scanning the patient twice and potentially on different days. This would be both impractical and unethical. However, we believe the relatively large numbers in our study allow us to draw reasonable conclusions without the need to scan patients on both scanners. Going forward, the authors aim to establish a protocol for brain ioflupane scans (Datiscans) on the VERITON-CT scanner. This type of scanning brings the detector heads very close to the patient's face and it will be interesting to see whether there is a difference in the rate of scan non-completion due to claustrophobia or the subjective perception of claustrophobia in this cohort of patients.

### Conclusion:

The novel 360° SPECT/CT scanner configuration brings the 12 detectors close to the patient allowing the potential for improved image quality and resolution but raising a question as to

whether this can be tolerated by patients. This observational cohort study provides evidence that this new scanner configuration does not have a significant effect on the rate of scan non-completion due to claustrophobia or the subjective perception of claustrophobia, when compared to the conventional double-headed scanner. This should offer reassurance to nuclear medicine departments considering this novel design.

Appendices:

Nil.

Financial Disclosure:

The authors declare no conflicts of interest and nothing to disclose. Neither of the two scanner manufacturers (GE Healthcare or Spectrum Dynamics Medical) were involved in the study design or manuscript review.

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## KEY POINTS

**QUESTION:** Does the novel gamma camera design of VERITON–CT adversely affect the rate of scan non-completion due to claustrophobia, when compared to a standard dual-head gamma camera?

**PERTINENT FINDINGS:** This observational cohort study shows that the novel 360° SPECT/CT scanner configuration does not have a significant effect on the rate of scan non-completion due to claustrophobia (1.46% compared to 1.35% with the conventional gamma camera) or the subjective perception of claustrophobia (10.9% compared to 11.6% with the conventional gamma camera).

**IMPLICATIONS FOR PATIENT CARE:** The novel 360° SPECT/CT scanner configuration of VERITON-CT has the potential for improved image quality and resolution without a negative impact on the patient experience. This should offer reassurance to nuclear medicine departments considering this novel design.

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Figures:

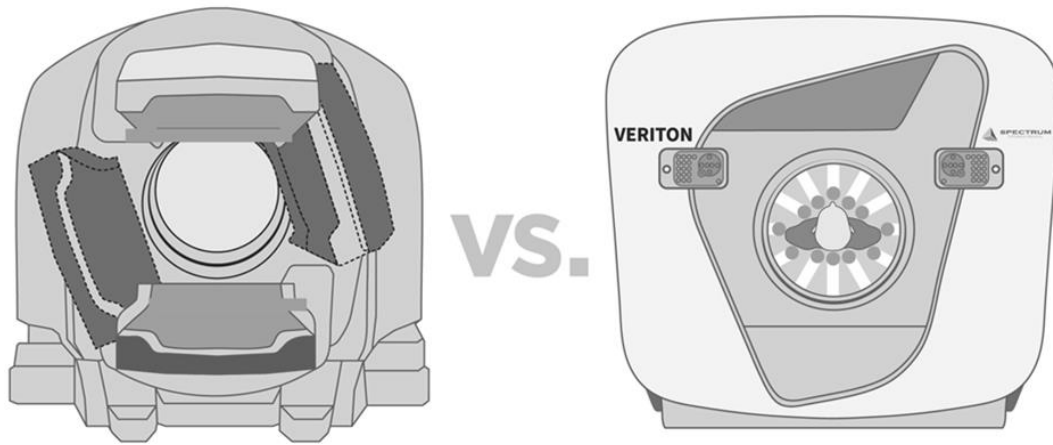


FIGURE 1: Conventional Anger camera (left) when compared to the VERITON-CT scanner (right), with 360° detector design. Image courtesy of and reprinted with the permission of Spectrum Dynamics Medical.

**Patient Questions**

1. Did you feel that lying still inside the scanner was comfortable?

Yes very    Yes a little    So-so    No not really    No not at all

2. Did you feel like you were on the scanner for a long time?

Yes very    Yes a little    So-so    No not really    No not at all

3. Did you find the noise of the scanner loud or intrusive?

Yes very    Yes a little    So-so    No not really    No not at all

4. Did you feel claustrophobic (fear of being closed in or being in a small space) during the scan?

Yes very    Yes a little    So-so    No not really    No not at all

5. Do you have any other comments about the scan?

FIGURE 2: Nuclear Imaging patient experience questionnaire.

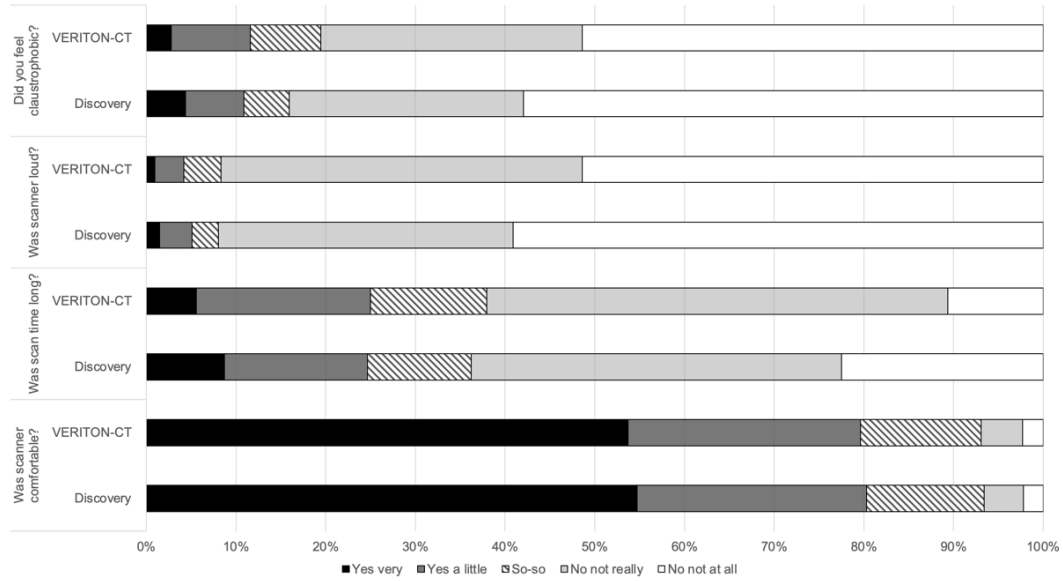


FIGURE 3: The spread of survey responses across the four experience factors.



Tables:

	<b>Discovery NM/CT</b>	<b>VERITON-CT</b>
<b>Gamma Camera</b>	Anger camera	Digital camera
<b>Detector</b>	Sodium iodide scintillator	12 x CZT detectors
<b>Configuration</b>	Dual head around imaging table	Circular pattern around imaging table
<b>Bore Size</b>	70 cm	80 cm
<b>CT</b>	16-slice	16-slice

TABLE 1: The characteristics of the nuclear imaging scanners in our department. CZT - cadmium-zinc-telluride.

	<b>Discovery NM/CT</b>	<b>VERITON-CT</b>
<b>Bone</b>	98	192
<b>Parathyroid</b>	4	27
<b>Lung</b>	16	47
<b>Thyroid</b>	11	0
<b>Renal DMSA</b>	17	0
<b>Renogram MAG3</b>	19	0
<b>Cardiac</b>	40	0
<b>Brain Ioflupane Scan (Datscan)</b>	31	2
<b>Sentinel node Loc and imaging</b>	3	5
<b>Radionuclide SeHCAT bile study</b>	42	0
<b>Gastric Emptying Study (Single)</b>	10	0
<b>Other</b>	5	1
<b>Total</b>	296	274

TABLE 2: The spread of nuclear imaging scan indications across the Discovery and the VERITON scanners over a four-month period.

Patient no.	Scan indication	Comments regarding claustrophobia
<b>Patient 1</b>	Bone	Booked on VERITON-CT but only managed CT, no SPECT.
<b>Patient 2</b>	Bone	Booked on VERITON-CT but partial scan on Discovery.
<b>Patient 3</b>	Bone	Booked on VERITON-CT but partial scan (no CT) on Discovery.
<b>Patient 4</b>	Parathyroid	Booked on VERITON-CT but complete scan on Discovery.
<b>Patient 5</b>	Bone	Booked on Discovery. Head and body done separately.
<b>Patient 6</b>	Bone	Booked on Discovery but only managed SPECT, no CT.

TABLE 3: Patient characteristics of non-completed scans due to claustrophobia.

Graphical Abstract:

