Evaluation of Siemens SOMATOM go.Sim default scan protocol doses and image noise versus existing locally optimised protocols.

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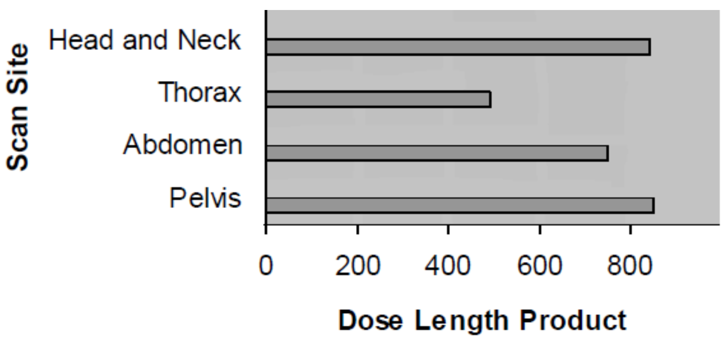
Aims and Background: Siemens SOMATOM go.Sim CT scanner is a comparatively new scanner targeted exclusively at radiotherapy use. In common with other scanners, default scan protocols are provided with install for generic anatomical sites *e.g.* thorax, pelvis *etc*. The use of default scan protocols is appealing for time pressured radiotherapy departments but principals of image and dose optimisation under IRMER remain essential prior to any patient exposure.

Methods: Protocol image noise and exposure doses were assessed at go.Sim commissioning for each protocol using in-phantom (Catphan) images and suitable CT dose modelling software (ImPACT CT dose calculator). These were compared against image noise and exposure dose from comparable existing scan protocols on GE Optima scanner. GE Optima scan protocols had been in clinical use for several years and were subject of a robust local image optimisation process and DLP audit of several hundred patients.

Results: Phantom image noise (standard deviation) from go.Sim scanner ranged from 4.2-2.4 at 200-600mA. This was deemed clinically comparable to existing scan protocol phantom noise which was not less than 7.5 for any protocol. A wide range was calculated for existing protocol doses, reflecting the nature of mA modulation to maintain image quality in smaller and larger patients, but average values ranged from 10mSv (H&N) to 18mSv (pelvis). Patient dose calculation at commissioning is challenging due to lack of data on likely typical mA clinically, but all protocol doses were calculated with a conservative baseline of <10mSv. Protocol DLP for clinical images will be assessed following clinical go live in early October and will be presented. Figure below shows existing protocol doses for common anatomical sites.



Conclusions: go.Sim default scan protocols are suitable for radiotherapy planning scanning and have been demonstrated to have improved image noise and comparable or improved patient exposure doses relative to existing scan protocols established using a robust image optimisation process. Whilst further optimisation maybe possible, default scan protocols are suitable for clinical use. Further optimisation work will also need to take into account the impact of changes in scan protocols on associated AI auto contouring provided with go.Sim scanner.

Preselection of CBCT mode patient size

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Background

CBCT imaging is used to perform a daily online correction for all VMAT prostate, lung and radical pelvis patients. The resulting patient imaging dose ranges from 12 to 25 mGy (CTDIw) per fraction; up to 0.5 Gy across a 20 fraction treatment. Imaging audit showed more than 95% of patients were being imaged using the default "Small" acquisition mode. This indicated that the range of imaging presets could be further optimised and additional guidance in the appropriate use of these presets would be useful. This project aimed to optimise CBCT dose by tailoring the initial preset used to the size of the patient. This abstract reports on the selection of method for evaluating patient size and correlating this with appropriate CBCT presets.

Methods

The mean diameter at isocentre [1] and the tube current time (mAs) from the CT planning scan [2] were recorded for a sample of 203 prostate and prostate node, 81 "other pelvis" (gynae, anus, bladder) and 66 lung patients. To choose which metric to use for patient size, the correlation between methods was checked and the workflow, ease of training for staff and consistency of technique between clinical sites was reviewed. Patients with prosthetic hips (n=10) have higher attenuation (so higher mAs) for the same diameter and so were analysed separately. The patient size indices were categorised into two (for thorax) or three (for pelvis) groups.

Results

Excellent correlation between mAs and mean diameter (cm) was demonstrated for pelvis patients, so either technique for reporting patient size is appropriate. Thorax patients are primarily scanned using 4dCT, for which the mAs is not modulated; this means the mAs is not predictive of patient size and diameter must be used. For consistency across all clinical sites, the initial CBCT preset will be chosen using patient mean diameter. The statistics for mean diameter are shown below for pelvis and thorax patients

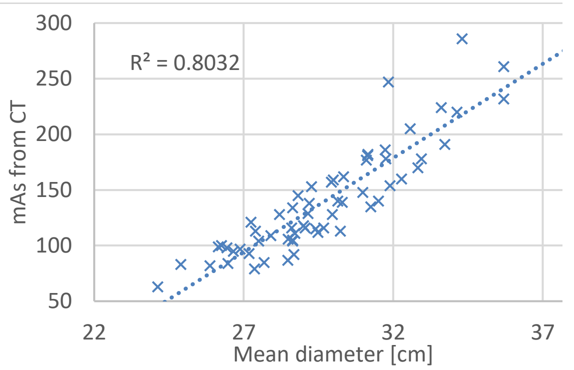

Figure 1: diameter vs mAs correlation for pelvis patients

For both pelvis and thorax the boundaries are shown in Table 1 ("small / medium / large preset"). For pelvis patients with a prosthesis the preset should be increased by one step (e.g. a 27 cm wide patient with a prosthesis should be scanned with CBCT preset medium, not small). This is to account for the increased attenuation the prosthesis adds.

[cm]	Pelvis	Thorax
Minimum	23.9	21.6
Average	29.9	29.2
Std deviation	2.3	3.8
Maximum	41.6	38.5
Small preset	<29	<29
Medium "	29-32.9	None
Large preset	>33	>29

Table 1

Discussion

This work will potentially allow for further dose reduction of the small preset and helps ensure patients are scanned with optimal dose in adherence with IR(ME)R. Until now, suboptimal dose has been used and therefore it has been harder for radiographers to resolve the tumour and organs at risk.

Conclusion

Boundaries of mean diameter for each size preset have been ascertained, and this will be incorporated into department procedures to become routine practice. This preset is the one that the patient will start on; the dose can be increased or reduced as necessary by the radiographers imaging the patient – just as it can be now.

Key references

1) Agnew CE, McCallum C, Johnston G, Workman A, and Irvine DM. (2021) Optimisation of Varian TrueBeam head, thorax and pelvis CBCT based on patient size. Journal of Radiotherapy in Practice page 1 of 9
2) Khan M, Sandhu N, Naeem M, Ealden R, Pearson M, Ali A, et al. Implementation of a comprehensive set of optimised CBCT protocols and validation through imaging quality and dose audit. Br J Radiol (2022) 10.1259/bjr.20220070
3) Khan M, Sandhu N, Naeem M, Ealden R, Pearson M, Ali A, et al. Implementation of a comprehensive set of optimised CBCT protocols and validation through imaging quality and dose audit. Br J Radiol (2022) 10.1259/bjr.20220070

Optimisation of Varian TrueBeam head, thorax, abdomen and pelvis CBCT based on patient size

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Background: The aim of this study was to optimise patient dose and image quality of Varian TrueBeam CBCT images based on patient size for 4 treatment sites; pelvis, abdomen, thorax, and head and neck (H&N).

Methods: An elliptical phantom of small, medium and large size was designed representative of a local population of 120 pelvis, thorax and H&N patients. The phantom was used to establish the relationship between image noise and CBCT mAs exposure settings for pelvis, thorax, head and neck (H&N) and compared to that achieved through the auto mAs setting of a GE Optima CT scanner.
Using this insight, clinical images were optimised in phases and at each phase the image quality graded qualitatively by radiographers. At each phase, the time required to match the images was also recorded from the record and verify system.
No default TrueBeam CBCT settings are available for abdomen. Using the method of radiographer led optimisation of image quality, optimised acquisition settings for use in the abdomen were established.

Results and Discussion: The average patient diameter was a suitable metric to categorise patient size. A single size was determined for H&N patients, while pelvis and thorax patients were divided into three groups with average diameter ≤26cm, >26cm ≤36cm and >36cm.
Phantom measurements showed the power relationship between noise and CBCT exposure settings ranged from -0.15 for thorax, -0.35 for pelvis and -0.43 for H&N. These quantitative phantom measurements provided confidence that phased variation of ~ ± 20% in dose should result in clinically usable images.
Qualitative assessment of almost 2000 images reduced the exposure settings in H&N images by –50%, thorax images by -66%, -25% and +25% for small, medium and large patients and in pelvis images by –80%, -20% for small and medium patients and for large patients the mAs of the default pelvis obese protocol i.e. (+20%kV) were optimised by –35%. These optimised CBCT settings did not affect the time required to match images for these sites.
Using the established average patient diameter groups, CBCT settings for abdomen patients were developed, resulting in final optimised settings for small, medium and large patients of 125kV and 427mAs, 585mAs and 855mAs respectively.

Conclusion: Varian TrueBeam CBCT settings have been optimised for dose and image quality based on patient size for four treatment sites; pelvis, abdomen, thorax and H&N. Quantitative phantom measurements provided insight into the magnitude of the changes it would be possible to implement clinically. The final optimised exposure settings were determined from radiographer qualitative assessment.

Key references

[1] Agnew CE, et al (2020) Optimisation of Varian TrueBeam head, thorax and pelvis CBCT based on patient size. Journal of Radiotherapy in Practice; 10.1017/S1460396920000618
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[5] Wood T, et al. (2015) Accounting for patient size in the optimisation of dose and image quality of pelvis cone beam CT protocols on the Varian OBI system. British Journal of Radiology; 88:20150364