Over-ranging in CT scanners: comparison of equipment models and medical practices in France

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Keywords:
Action 9 - Facilitation of research in advanced topics of radiation protection, Radioprotection / Radiation dose, CT, Dosimetry, Physics, Radiation safety, Dosimetric comparison

Aims and objectives:

Over the last decades, manufacturers of multi-slice CT scanners have invested tremendous efforts to maintain high image qualities while reducing patient exposure to ionizing radiation [1, 2, 3, 4]. Although various studies have proven lower patient doses on latest CT scanners, little is known about over-ranging [5, 6]. Indeed, faster CT acquisitions and larger total collimations are expected to yield greater over-ranging potentially increasing the total scan length and thereby affecting DRLs. Most manufacturers have introduced some features to limit over-ranging, but their efficiency is currently not proved for all scanner models [7, 8, 9]. Hence, the present study investigates over-ranging in modern multi-slice CT scanners currently in clinical use in France.

Methods and materials:

CT exposure data of ~24250 patients, collected between 2013 and 2018 by 9 medical physicists in more than 150 public and private French hospitals, were retrospectively analysed. Over-ranging was calculated as the difference between total exposed scan length and total imaged scan length (Fig.1). Per each scanner, mean over-ranging ± standard deviations were calculated.

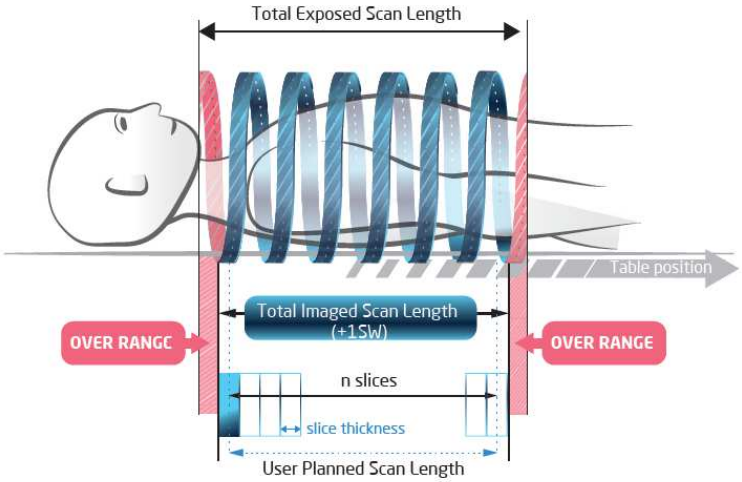

Fig. 1. Location of over-ranging.

Inclusion criteria were the availability of slice thickness, collimation and pitch. Over-ranging in fourteen different CT models from GE, Philips and Siemens were compared. The impact of

collimation and pitch on over-ranging was also studied. Over-ranging values inherent to CT scanners with ~2 cm and ~4 cm total collimation were compared.

Additionally, for each manufacturer and scanner model, the efficiency over time of solutions introduced for the management and limitation of over-ranging on latest CT models was investigated. For each manufacturer and a given total collimation (~2 or ~4 cm), data from different scanner models where pooled together when identical over-ranging values were obtained for a given pitch-collimation combination.

This leads to the following merging:

- GE Optima CT 520 / 540 / 580
- GE Optima CT 660 (before 2016)
- GE Optima CT 660 from 2016 and Revolution Evo
- Philips Ingenuity Flex 32
- Philips Ingenuity Core 64 / Core 128 / Elite / CT
- Siemens Somatom Definition AS64
- Siemens Somatom Definition AS+ / Edge / Flash

Results:

In this study, 74% of analysed data were collected from private hospitals and 26% from public institutions. A total of 155 CT scanners were included, their distribution per manufacturer and per model type is given in Fig. 2.

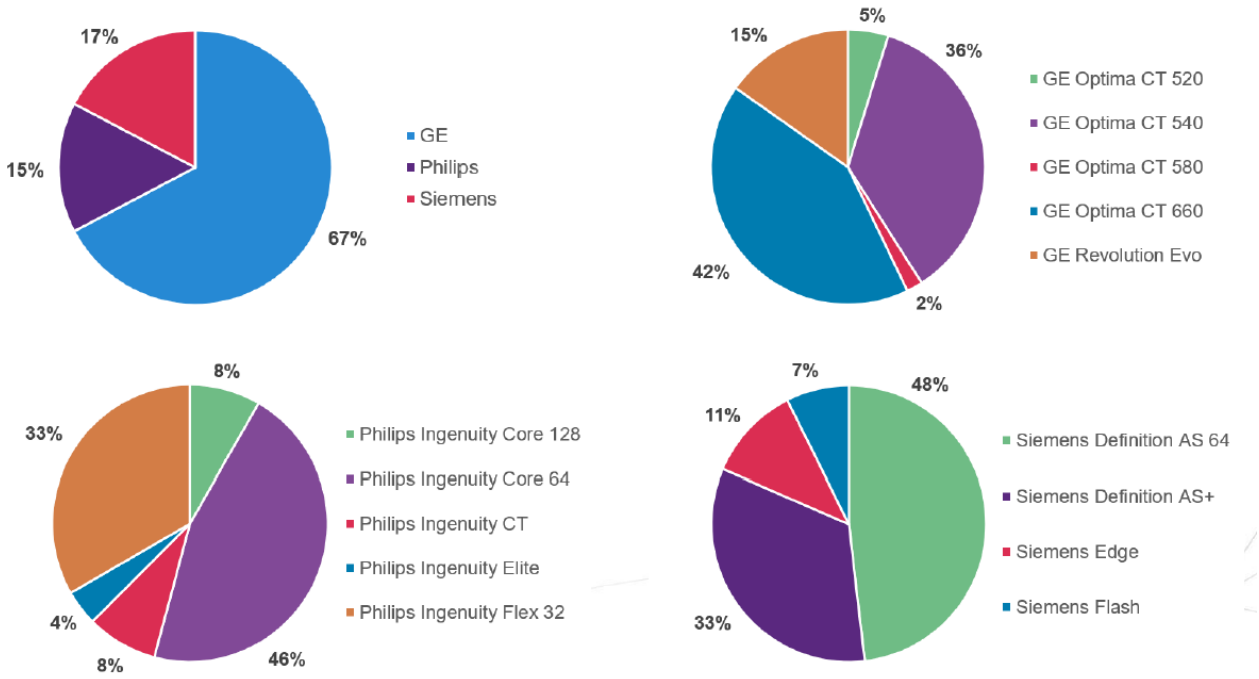

Fig. 2. Distribution within the study sample per manufacturer and per model type.

Over-ranging (L_{ov}) for each CT protocol collimation and pitch were plotted for ~2 and ~4 cm total collimation CT scanners (respectively Fig.3 and Fig.4).

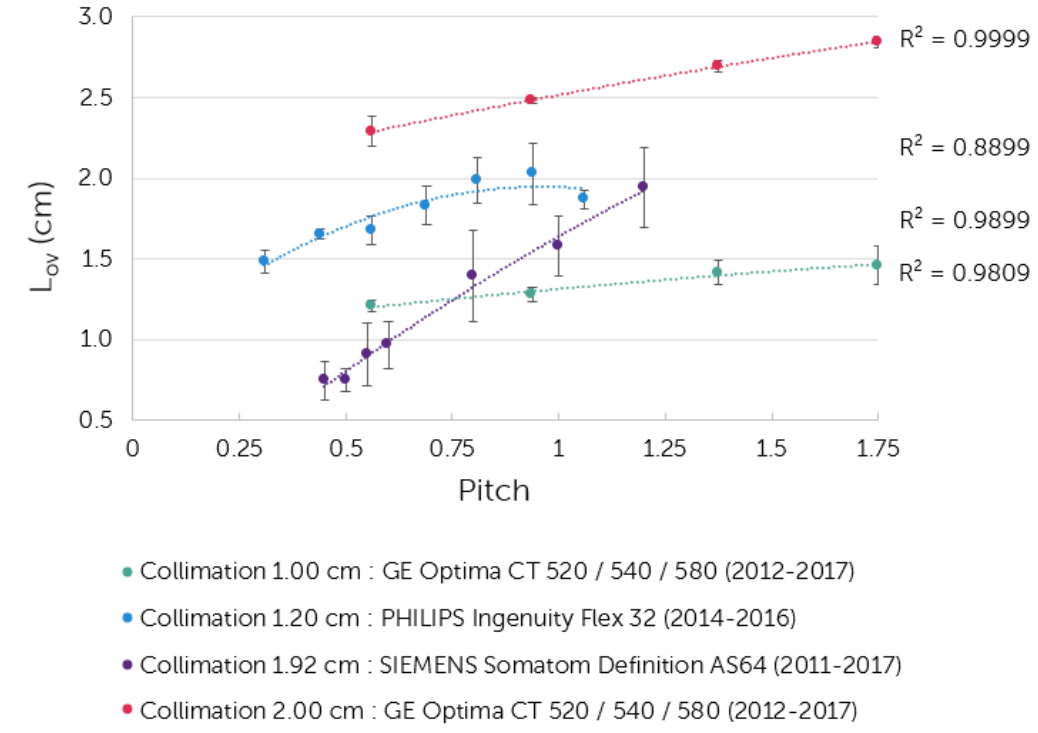

Fig. 3: Over-ranging for ~2 cm total collimation CT scanners.

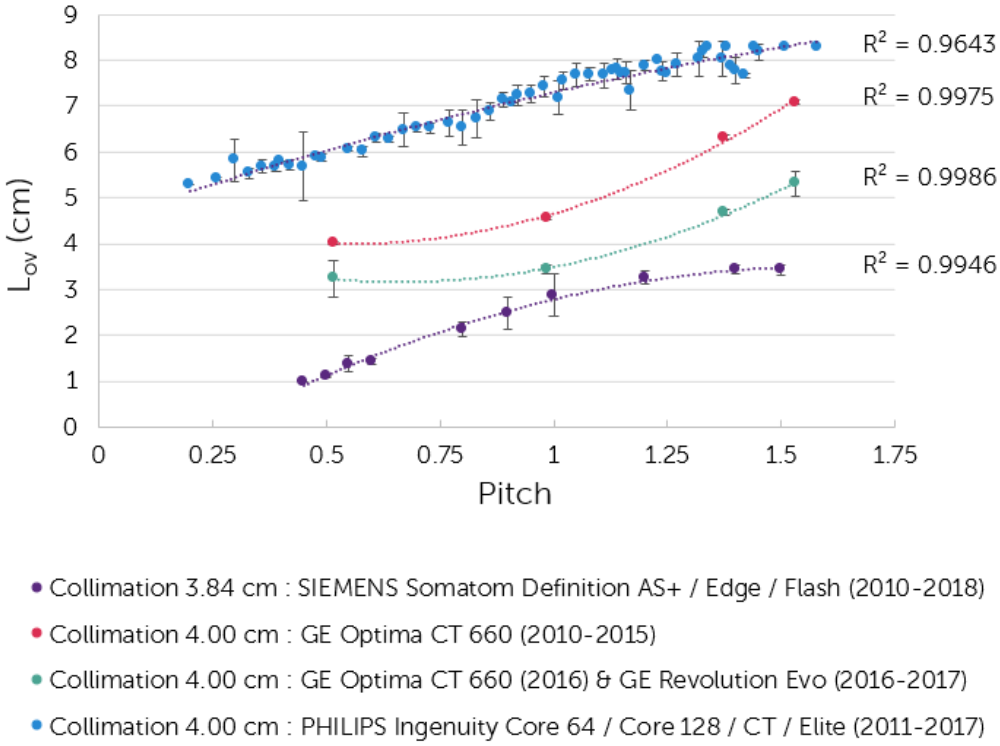

Fig. 4. Over-ranging for ~4 cm total collimation CT scanners.

When individually studying the impact of collimation, it was found that increasing collimation from 2 to 4 cm would yield a two-folds increase in over-ranging for an identical manufacturer and equipment model. Meanwhile, for two ~4 cm maximum collimation CT scanners of Siemens and Philips, an over-ranging value up to 5.9 times higher was found for Philips although identical collimation (~4 cm) and pitch (0.45) were considered. Additionally, for GE Optima CT 660 scanners, a 20-25% reduction of over-ranging was observed before and from the year 2016 (Dynamic z-axis tracking technology).

Since each CT scanner manufacturer use collimation and pitch in a different way to achieve high quality images (Siemens and Philips consider a similar approach), typical CT protocols for head, chest, abdomen-pelvis and lumbar acquisitions were collected to compute over-ranging. This comparison was done for the three most widely used CT scanners in our sample: GE Optima CT 660, Philips Ingenuity Core 64 and Siemens Somatom Definition AS+ scanners. Fig. 5 shows that, for all clinical applications, lowest over-ranging values can be obtained on Siemens Somatom Definition AS+ although this model involves a 3.84 cm total collimation. In opposition, Philips Ingenuity Core 64 was the model to induce largest over-ranging on all anatomical sites. In the specific case of head CT, the computed over-ranging was similar for Optima CT 660 and Siemens Definition AS+ although the former involved a 2 cm total collimation vs. 4 cm on the latter scanner. The largest registered difference in over-ranging was of 5.3 cm for abdomen-pelvis CT acquisition (Philips Ingenuity Core 64: collimation 4 cm, pitch 0.984, L_{ov} 7.4 cm vs. Siemens Somatom Definition AS+: collimation 3.84 cm, pitch 0.75, L_{ov} 2.1 cm).

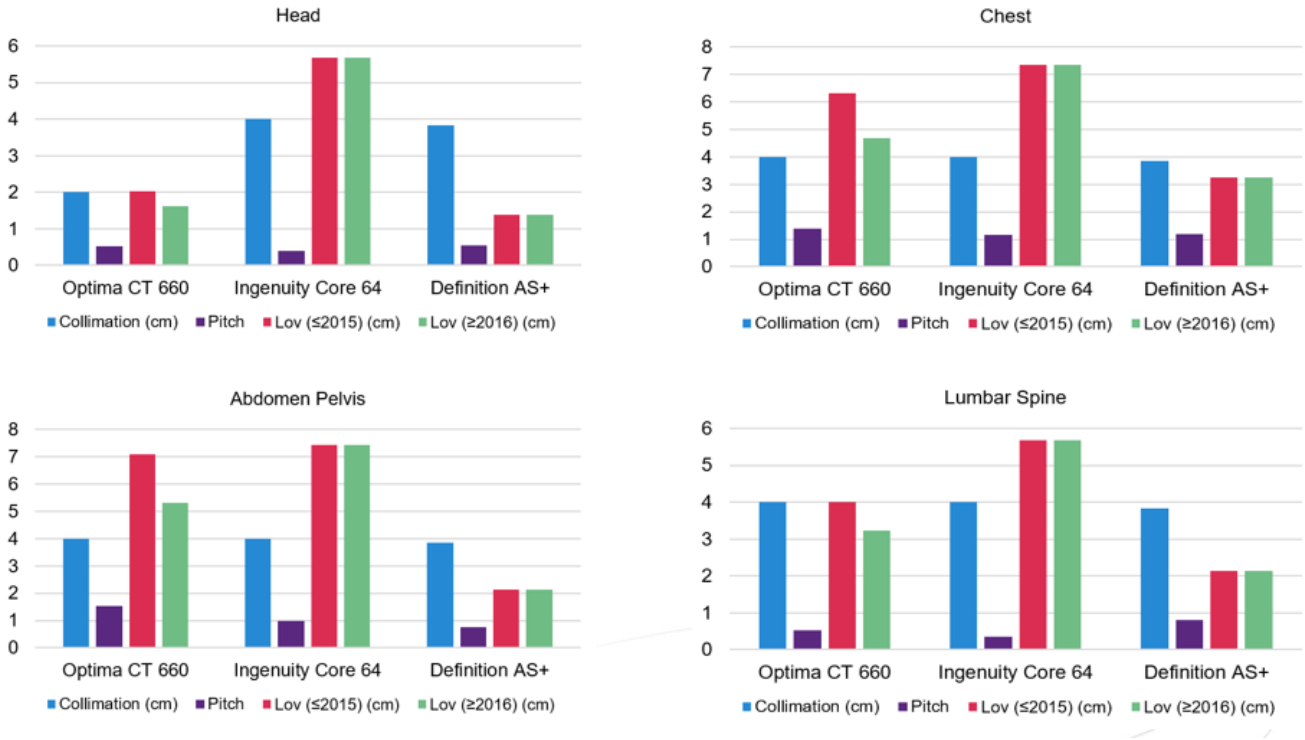

Fig. 5 Collimation, pitch and associated over-ranging (L_{ov}) for three ~4 cm maximum collimation CT scanners for four protocols.

Conclusion:
The present study showed large variability in over-ranging among manufacturers and equipment models proving that additional care is still needed to limit at best unnecessary exposure. For a same clinical indication, the difference in over-ranging exceeded 5 cm for two ~4 cm total collimation CT models from two different manufacturers. The present study may also be used to further expand local optimisation strategies and local/national DRLs defining good practices in terms of total imaged scan length accounting for over-ranging.

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