Institutional doses for chest CTA examinations using a 16-slice system

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Abstract. According to the council directive 2013/59/EURATOM, an important tool for the optimization of the radiation doses delivered to patients is the Diagnostic Reference Levels (DRLs). The Greek Atomic Energy Commission (GAEC) reports the national DRLs, based on institutional dose levels reported from various hospitals. There is a lack of national DRLs regarding various examinations and among them is the Computed Tomography Angiography (CTA). In this work, the dose delivered to patients during chest CTA examinations, at the University Hospital of Patras (UHP), is presented. Thirty standard sized patients were evaluated using a 16-slice CT system. The median value of the volume Computed Tomography Dose Index (CTDIvol) was 12.07 mGy and the median value of the Dose Length Product (DLP) was 429.66 mGy·cm. These values were comparable or higher than the corresponding values of the existing bibliography. The values reported could contribute in the establishment of the national DRLs.

1. Introduction
An important tool for the optimization of the radiation dose delivered to patients is the Diagnostic Reference Levels (DRLs). The DRLs were initially introduced in 1990 by the International Commission on Radiological Protection (ICRP 60) and in greater detail in 1996 (ICRP 73) [1,2]. Later in 2003, an ICRP report stated that: “The DRLs are a form of investigation level for medical imaging” and secondly, claimed that: “using the DRLs we can avoid radiation dose to the patient that does not contribute to the clinical purpose of a medical imaging task” [3].

For a given dosimetric quantity, the DRLs are typically set at the 75th percentile of the dose distribution. The concept of the DRLs has been endorsed, among others, by the International Atomic Energy Agency, the National Council on Radiation Protection, as well as the European Commission. The council directive 2013/59/EURATOM which should be adopted by the European Countries by the 6th of February 2018, states that (Article 4): “Diagnostic Reference Levels means dose levels in medical radiology practices for typical examinations for groups of standard-sized patients and for broadly defined types of equipment”. In addition, this directive states that (Article 56): “Member States shall ensure the establishment, regular review and use of DRLs for radio-diagnostic examinations”. Also, it is stated that (Article 58): “whenever DRLs are consistently exceeded, appropriate corrective action is taken without undue delay”. Finally, it states that (Article 83): “the medical physics expert takes responsibility for dosimetry and contribute among others to the optimization of the radiation protection of patients including the application and use of DRLs” [4].
The Greek Atomic Energy Commission (GAEC) reports the national DRLs collecting institutional doses from various hospitals, using data from the dosimetric quantities: volume Computed Tomography Dose Index (CTDI\textsubscript{vol}) and Dose Length Product (DLP). There is a lack of national DRLs regarding various examinations and among them is the Computed Tomography Angiography (CTA). In accordance with the Official J Greek Govern 2014;3176B, the current GAEC guidelines regarding the collection of dosimetric data from CTA examinations, are related with the dosimetric quantities CTDI\textsubscript{vol} and DLP. In this work, the dose delivered to patients during chest CTA examinations at the University Hospital of Patras (UHP), using a 16-slice system, is presented.

2. Patients and Methods
Thirty standard sized patients participated in this study, undertaking chest CTA examinations. The dosimetric data were obtained from the dose report of the system. Additionally, demographic data such as sex, age, weight and height were collected. The body mass index (BMI) was calculated by dividing the patients’ weight by the patients’ height squared (in kg/m\textsuperscript{2}). The patients’ mean age was 62.6 y, the mean weight was 82 kg, the mean height 1.71 m and the mean BMI was 28.1 kg/m\textsuperscript{2}.

All the chest CTA procedures were carried out with a 16-slice CT system (GE Lightspeed 16) with a tube voltage of 120 kVp in helical scan mode, a beam collimation of 16x1.25 mm and a pitch factor of 1.375. The system was under a systematic quality control program, to ensure the correct performance, as well as the reliability and reproducibility of the exposure parameters.

3. Results and Discussion
The mean value of CTDI\textsubscript{vol} was 11.67 mGy, the median value was 12.07 mGy, the minimum value was 9.88 mGy, the maximum value was 12.79 mGy and the 75th percentile was 12.78 mGy. The mean value of DLP was 426.11 mGy\textcdot cm, the median value was 429.66 mGy\textcdot cm, the minimum value was 279.21 mGy\textcdot cm, the maximum value was 567.16 mGy\textcdot cm and the 75th percentile was 455.65 mGy\textcdot cm. The distribution of DLP values is presented in figure 1. The results were compared with the corresponding values reported in the literature and are presented in Table 1.

The median value of CTDI\textsubscript{vol} from our study was comparable to Christensen et al [5] and Ippolito et al [6] and higher than Zhang et al [7] and Beeres et al [8]. Regarding the DLP, the median value of our study was more or less comparable to Cornea et al [9] and Ippolito et al [6] and higher than Zhang et al [7], Manheimer et al [10] and Beeres et al [8].

| Studies          | NxT (slices \times thickness per slice) | kVp | Pitch | CTDI\textsubscript{vol} | DLP   |
|------------------|----------------------------------------|-----|-------|--------------------------|-------|
| Christensen et al [5] | 32x0.6                                 | 120 | 2.4   | 13.9                     | -     |
| Zhang et al [7]   | 64x0.6                                 | 100 | 1.2   | 5.6                      | 191.3 |
| Cornea et al [9]  | 64x0.625                                | 100 | 1.375 | -                        | 648.71|
| Manheimer et al [10]| 64x0.625                                | 120 | -     | -                        | 325.6 |
| Beeres et al [8]  | 128x0.6                                 | 100 | 3.0   | 3.70                     | 273.0 |
| Ippolito et al [6]| 128x0.625                               | 100 | 0.17  | 13.85                    | 490.0 |
| This study        | 16x1.25                                 | 120 | 1.375 | 12.07                    | 429.66|

Table 1. Comparison of the dosimetric data.
The medical physicist, in collaboration with the radiologist and radiographer, should adopt the appropriate corrective actions for optimization of the radiation doses delivered to the patients. An initial investigation, concerning the DLP values that occurred between the 3rd quartile and the maximum value of the distribution, revealed that these were mainly due to the following two reasons: a) incorrect patient positioning with respect to the scan field of view, that led the system to an increase of the tube load during the scanning procedure, and b) increased scanning length in the cranio-caudal direction. The patient dose values that will emerge after the optimization procedure shall contribute in the effort for the establishment of local and national DRLs.

4. Conclusion
The radiation doses delivered to the patients during the chest CTA scan at the UHP were comparable or higher than the values reported in corresponding studies. The values reported could contribute in the effort for the establishment of local and national DRL values.

References

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