Size-specific institutional diagnostic reference levels for computed tomography of the neck

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Background/introduction

Diagnostic reference levels (DRLs) are an important quality assurance tool in radiology departments (1-2). Today, most DRLs provide a volumetric computed tomography dose index (CTDIvol) and a dose length product (DLP) for each anatomical region and for normal size patients (3, 4) However, the EUROSAFE campaign as well as efforts from the American College of Radiology strive to improve DRLs by analyzing CT dose for specific clinical indications and for different patient sizes (5, 6).

Tailoring DRLs to clinical indications requires an analysis beyond the anatomical region (such as abdominal CT, chest CT or neck CT). And size-specific DRLs require a patient size metric such as weight, body mass index or patient diameter. While current DRLs often use patient weight to quantify patient size, recent studies implemented and evaluated automated tools to acquire patient water-equivalent diameter (6, 7).

Size-specific, indication based DRLs for CT of the neck may help to improve CT quality assurance by detecting additional outliers which then can be further analyzed.

The goal of our study was to develop size-specific DRLs for different CT protocols commonly used in neck CT imaging and to compare the average dose to the current national DRLs.
Description of activity and work performed

Methods

We performed a retrospective study which was approved by the institutional ethics committee. CT examinations of the neck performed between 01/2016 and 05/2017 were included. The included protocols were CT angiography of the carotid arteries, cervical staging CT and CT of the cervical spine. Exclusion criteria were patients with other CT protocols and a water-equivalent diameter (dw) of less than 15 cm and above 24 cm.

CT examinations

CT examinations were performed in clinical routine on four multi-detector CT scanners (scanner 1 = Definition Flash with 128 slices, scanner 2 = Definition AS+ with 128 slices, scanner 3 = Definition AS with sliding gantry with 64 slices, scanner 4 = Definition Edge with 128 slices, all Siemens Healthineers, Forchheim, Germany). CT examinations were performed in accordance to the institutional standard operating protocols with automated exposure control (CareKV and CareDose4D, Siemens Healthineers) in spiral mode. Iterative reconstruction (Safire, Level 3, Siemens Healthineers) was used in scanner 1 - 2, iterative reconstruction (ADMIRE, Siemens, Healthineers) was used on scanner 4 and filtered back projection (FBP) was used on scanner 3.

Assessment of radiation dose and patient diameter

Scanner-indicated CTDIvol was extracted using the radiation dose structured report and the institutional CT dose monitoring system (DoseIntelligence, Pulmokard, Herdecke, Germany). Dw was calculated with a self-developed software tool which has been previously evaluated (7).

All examinations were grouped into size bins according to the patient Dw (one bin per cm Dw). Analysis was performed for each CT protocol separately. Linear regression was used to produce institutional DRLs based on the patient Dw bins. Based on the recommendations of the International Commission on Radiological Protection the 75th percentile was applied as the upper limit and the 25th percentile was applied as the lower limit of the institutional DRLs (8).

Comparison with national DRLs

Mean CTDIvol for each protocol was compared with the national size-independent DRLs which are 20 mGy for cervical CTA, 20 mGy for CT of the cervical spine and 15 mGy for cervical staging CT.
Results

CT examinations

Overall, 9654 CT examinations of the neck were performed during the study period, 5721 of which had to be excluded due to an inadequate protocol or Dw (Figure 1). Thus, 3933 examinations were included in our analysis (2320 carotic CTAs, 855 staging CT examinations, 758 CT examinations of the cervical spine; mean age 66±17 years, 1790 male, 2142 female). Mean CTDIvol was 14.2±8.5 mGy (range 1.6 - 39 mGy) and mean patient Dw was 19.3±20.3 cm (15.0 - 24.9 cm).

Institutional size-specific DRLs

Mean CTDIvol was 15.0±10.5 mGy (range 1.7 - 39.9 mGy) for CT of the carotid arteries; 8.9±2.4 mGy (2.1 - 16.5 mGy) for neck CT and 15.7±4.7 mGy (2.8 - 35.5 mGy) for CT of the cervical spine.

For all CT protocols there was a linear progression of CTDIvol with increasing Dw (Figure 2 - 4). We found very high coefficients of determination in our linear regression analysis (R² = 0.96 for cervical CTA and staging CT; R² = 0.89 für cervical spine CT). On average, CTDIvol increased by 1.3 mGy per patient Dw in cervical CTA, 0.6 mGy in staging CT and 1.1 mGy in CT of the cervical spine.

Linear regression of the 75th percentile Quartile produced the following equations which can be used to calculate the size-specific institutional DRL: cervical staging CT y=0.4315x +2.804; CTA y=1.314x-2.8181 and cervical spine CT y=1.3111x-3.5223.

Comparison to the national DRLs

German national DRLs are 20 mGy for cervical CTA, 20 mGy for CT of the cervical spine and 15 mGy for cervical staging CT. An average size patient as determined by patient Dw was 19.8 cm for CTA, 19.2 cm for staging CT and 17.7 cm for cervical spine CT. Average institutional CTDIvol were lower than the national DRLs (84.3% for cervical spine, 63.0% for cervical staging CT and 80.4% for cervical CTA).
Fig. 1: Figure 1: Flowchart of the patient collective in our study
**Fig. 4:** Institutional size-specific diagnostic reference levels (DRLs) for cervical spine CT. The bold line represents the mean CTDIvol per patient bin. The upper black line represents the 25th and 75th percentile which can be used as size-specific institutional DRLs. The coefficient of determination and the linear regression equation (of the mean) are displayed in the lower right corner.

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**Fig. 3:** Institutional size-specific diagnostic reference levels (DRLs) for cervical CTA. The bold line represents the mean CTDIvol per patient bin. The upper black line represents the 25th and 75th percentile which can be used as size-specific institutional DRLs. The coefficient of determination and the linear regression equation (of the mean) are displayed in the lower right corner.

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**Fig. 2:** Institutional size-specific diagnostic reference levels (DRLs) for cervical staging CT. The bold line represents the mean CTDIvol per patient bin. The upper black lines represent the 25th and 75th percentile which can be used as size-specific institutional DRLs. The coefficient of determination and the linear regression equation (of the mean) are displayed in the lower right corner.

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Conclusion and recommendations

In conclusion, we generated size-specific institutional DRLs based on patient water-equivalent diameter for different CT protocols of the neck. In average size patients, the CTDIvol was lower than the national DRLs in all protocols. The herein developed size-specific DRLs may help to improve the institutional CT quality assurance.
Personal/organisational information


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References


