Effective radiation dose reduction in computed tomography-guided spinal injections: a prospective, comparative study with technical considerations

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Abstract

Despite the good general patient acceptance, high patient comfort, safety and precision in the needle placement, exposure to radiation in computed tomography (CT)-guided spinal interventions remains a serious concern, and is often used to argue against its use. The aim of this study was to determine the technical possibilities of reducing the radiation dose in CT-guided epidural and periradicular injections in lumbar spine. We evaluated the possibilities of reducing radiation dose to the patient and operator during CT-guided injections on the lumbar spine using the following steps: significant reduction of the tube current and energy used for the tomogram-acquisition, narrowing the area of interest in spiral CT-mode and reduction of tube current and radiation energy in the final intervention mode.

Fifty-three CT-guided spinal injections were performed on the lumbar spine (34 epidural lumbar, 19 lumbar periradicular) using a low-dose protocol in non-obese patients and compared with 1870 CT-guided injections from the year 2010, when a standard dose protocol was used. Obesity was defined as a body mass index of 30 or over. The protocol consisted of a reduction of dosage for the tomogram acquisition, the spiral scan and the intervention mode, as well as narrowing the area of interest (ARI) to 4-7 scans. Lumbar epidural and periradicular injections were performed using the SOMATOM Emotion CT-scanner (16-slice syngo CT 2009E, Siemens Medical Solutions AG, Erlangen, Germany). To provide the highest safety and precision, in every epidural injection, additional epidurography control was performed before the corticoid-anesthetic-solution was injected. Periradicular injections were performed without contrast solution. The effective radiation doses, number of scans and body mass index of each procedure were documented and compared with dosages of injections in a standard protocol from the year 2010 (n=1870) using SPSS Statistics, version 17.0, IBM, for descriptive statistics and for the comparison of the dosages used.

Materials and Methods

Fifty-three CT-guided spinal injections were performed on the lumbar spine (34 epidural lumbar, 19 lumbar periradicular) using a low-dose protocol in non-obese patients and compared with 1870 CT-guided injections from the year 2010, when a standard dose protocol was used. Technical considerations on radiation dose reduction were provided. An average dose reduction of 85% was achieved using the low-dose protocol in CT-guided epidural and periradicular injections in lumbar spine without showing any effect on safety or precision.

Introduction

Radiography-guided and blind epidural and periradicular application of medications is well described in the literature for the treatment of discogenic and osteoarthritic back pain.1,5 Computed tomography (CT) and fluoroscopy-guided injections allow precise and safe needle placement during the procedures, but are associated with the use of user-dependent radiation dosages to the patient and operator.6 The purpose of this study was to evaluate the possibilities and limitations of a significant reduction in radiation dose in CT-guided interventions without compromising precision and safety.

Technical notes

All injections were CT-guided and were performed using the SOMATOM Emotion CT-scanner (16-slice syngo CT 2009E, Siemens Medical Solutions AG, Erlangen, Germany) according to a standard technique-postero-lateral approach for the interlaminar space and the periradicular injections, well described in literature.5-6 Written permission and informed consent was obtained for all patients at least 24 h before the procedure. Initially, we decreased the energy dose and the tube current for the tomogram acquisition to 80 kV and 100 mA and reduced the scan area. Despite the lower contribution of the tomogram to the overall effective radiation dose, this step provides important information about the possibilities of decreasing dosage at later stages. In obese patients or patients suffering from severe osteoporosis, there is the problem that already the tomogram acquisition (as good as further steps) often needs to be performed with higher energies to achieve an acceptable image quality. In non-obese patients, the above mentioned settings lead to acceptable topograms. In the next step, the ARI for the spiral CT was narrowed as much as possible to reduce the number of scans. In epidural injections, the quadrangular ARI was set in the interlaminar space between two vertebras; in periradicular injections, the upper margin of the ARI was placed onto the proximal border of the bony neuroforamen in lateral topograms. A height of approximately 0.5-1.5 cm (4-7 slices) provided enough information about topographic anatomy for both procedures (Figure 1). In the next step, the ARI was scanned with energies reduced to 80 kV and 80 mA. After the selection of the target point for the injection and planning of the needle trajectory, the operator performs single scans during the puncture with reduced energies (80 kV, 50 mA). An average number of 3-6 scans is needed for each procedure. Image quality is acceptable for periradicular injections because the needle tip has to be placed near to the bony neuroforamen and the osseous structures always have a good visibility in CT-scans (Figure 2). Image quality can become problematic in epidural injections, especially if the interlaminar space is narrowed by degenerative osseous appositions (osteophytes, facet joint arthritis) which reduce the image quality and the visibility/contrast of the dural sack within the spinal canal. Therefore, in epidural injections, we always perform an addition-
al epidurography with 0.5-1 mL SoluTrast (R) contrast solution, injected after the needle tip is confirmed to be in the epidural space (Figures 3 and 4). The visibility of the needle tip is not reduced in the low-dose protocol. After the last scan has confirmed correct needle placement, the medication was injected.

**Results**

A total of 53 CT-guided injections were performed on the lumbar spine with the dose-reduced protocol in non-obese patients (BMI mean 25.55, range 18-30, SD 3.73). There was an average of 5 scans (range 3-6) in the biopsy mode for both epidural and periradicular injections. In all epidural injections, the epidural position could be reached and confirmed by epidurography. There were 3 cases of initial needle misplacement: one inside the ligamentum flavum and 2 intrathecal. These were corrected and the replacement confirmed by a second contrast solution injection during the same interventions without any problems (Figures 5 and 6). One patient reported flushing following the epidural injection. Despite this, no significant complications were registered during or following the procedures while in hospital.

Mean effective radiation doses for epidural injections (n=34) were 0.22 mSv (min
Figure 4. Epidural lumbar injection in a low-dose protocol in a 34-year old male patient. The osseous landmarks, the ligamentum flavum as well as the needle tip can be clearly identified in scans (upper images). Due to a reduced visibility of the thecal sac with cauda roots, epidurography confirms the correct positioning of the needle (lower scans). A dose reduction of 85-90% was achieved in comparison to standard protocols using 5 scans.

Figure 5. Epidural lumbar injection at segment L2/3 in a 50-year old female patient with initial intrathecal needle misplacement and correction (from left to right), verified with contrast solution injection in a low-dose protocol.

Figure 6. Epidural lumbar injection at the segment L3/4 in a 60-year old female patient with osteoligamental spinal stenosis and initial intrathecal needle misplacement, followed by correction with epidurography (from left to right).
0.11, max 0.30, SD 0.042) and for periradicu-
lar injections (n=19) 0.23 mSv (min 0.15, 
max 0.33, SD 0.044). For both procedures 
(n=53, mean 0.22, min 0.11, max 0.33, SD 
0.043, CI95% 0.21-0.24), a significant reduc-
tion in effective radiation dose (average 
85%) could be achieved in non-obese 
patients compared to the standard protocol 
used previously (n=1,870, mean 1.49 mSv, 
min 0.38, max 3.11, SD 0.61, CI95% 1.32-
1.66; Figure 7).

Discussion

A significant effective dose reduction in 
CT-guided spinal injections was observed in 
non-obese patients. The average 85% reduc-
tion in dosage corresponds to the possible 
dose reductions previously described by 
Schmid et al. Further research is needed to 
analyze interventions on facet joints and 
cervical injections, as well as the interven-
tion possibilities in obese patients or 
patients suffering from severe osteoporosis.

Conclusions

A significant reduction in radiation dose 
can be achieved in non-obese patients at all 
stages of CT-guided injections on the lumbar 
spine. Dose reduction remains more limited 
in obese patients. The use of additional 
epidurography in epidural injections is a 
safe compromise between a significant dose 
reduction and image quality.

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