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Computed Tomography / Tomodensitométrie

Reduced Kilovoltage in Computed Tomography−Guided Intervention in a Community Hospital: Effect on the Radiation Dose

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Abstract

Purpose: The purpose of this study was to determine whether low-kilovoltage (80 or 100 kV) computed tomography (CT)-guided interventions performed in a community-based hospital are feasible and to compare radiation exposure incurred with conventional 120 kV potential.
Materials and Methods: Effective doses (ED) received by patients who underwent CT-guided intervention were analysed before and after a low-dose kilovoltage protocol was instituted in our department. We performed CT-guided procedures of 93 consecutive patients by using conventional 120-kV tube voltage (50 patients) and a low voltage of 80 or 100 kV for the remainder of this cohort. Automatic tube current modulation was enabled to obtain the best image quality. Procedure details were prospectively recorded and included examination site and type, slice width, tube voltage and current, dose length product, volume CT dose index, and size-specific dose estimate. Dose length product was converted to ED to account for radiosensitivity of specific organs. Statistical comparisons with test differences in the ED, volume CT dose index, size-specific dose estimate, and effective diameter (patient size) were made by using the Student *t* test.
Results: All but 6 of the procedures performed at 80 kV were successful, for a success rate of 86%. At lower voltages, the ED was significantly ($P < .01$) reduced, on average, by 57%, 73%, and 65% for the pelvic, chest, and abdomen procedures, respectively.
Conclusion: A low-dose radiation technique by using 80 or 100 kV results in a high technical success rate for pelvic, chest, and abdomen CT-guided interventional procedures, although dramatically decreasing radiation exposure. There was no significant difference in effective diameter (patient size) between the conventional and the low-dose groups, which would suggest that dose reduction was indeed a result of kVp change and not patient size.

Résumé

Objectif: La présente étude vise à déterminer s'il est possible de réaliser des interventions guidées par tomodensitométrie (TDM) à faible kilovoltage (80 ou 100 kV) dans un hôpital communautaire et à établir une comparaison entre la radioexposition associée à ce faible kilovoltage et celle associée au kilovoltage classique de 120 kV.
Matériel et méthodes: Nous avons analysé la dose efficace reçue par les patients ayant subi une intervention guidée par TDM, avant et après l'instauration d'un protocole à faible dose (à faible kilovoltage) au sein de notre service. Nous avons pratiqué des interventions guidées par TDM chez 93 patients consécutifs, en utilisant le kilovoltage classique de 120 kV à l'égard de 50 patients et un kilovoltage faible de 80 ou de 100 kV à l'égard des autres membres de la cohorte. La fonction de modulation automatique du courant a été activée afin d'obtenir la meilleure qualité d'image. Les renseignements relatifs à l'intervention ont été consignés de façon prospective. Ils englobaient la partie du corps examinée et le type d'examen pratiqué, l'épaisseur de coupe, le kilovoltage et le courant, le produit dose-longueur, l'indice de dose tomodensitométrique ($CTDI_{vol}$) et les doses estimées d'après la taille. Le produit dose-longueur a été converti en dose efficace afin de tenir compte de la radiosensibilité de certains organes. Des comparaisons statistiques visant les divergences en matière de dose efficace, d'indice de dose tomodensitométrique($CTDI_{vol}$), de dose estimée d'après la taille et de diamètre efficace (taille du patient) ont été réalisées au moyen du test *t* de Student.
Résultats: Toutes les interventions réalisées à 80 kV sauf six ont été couronnées de succès, ce qui représente un taux de réussite de 86 %. La dose efficace a nettement diminué ($P < 0,01$) dans les cas de guidage par TDM à faible kilovoltage, affichant une réduction moyenne de 57 % pour les interventions pelviennes, de 73 % pour les interventions thoraciques et de 65 % pour les interventions abdominales.

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Conclusion: Le recours à une technique à faible dose utilisant un kilovoltage de 80 ou de 100 kV entraîne un taux de réussite technique élevé au chapitre des interventions pelviennes, thoraciques et abdominales guidées par TDM, bien qu'il réduise considérablement la radioexposition. Le diamètre efficace du groupe ayant subi une TDM classique et celui du groupe ayant subi une TDM à faible dose ne présentaient aucune différence notoire, ce qui semble indiquer que cette réduction relève du changement de kilovoltage et non de la taille du patient.

Key Words: Radiation dose reduction; Computed tomography; Computed tomography technique; Interventional Radiology

In recent years, results of epidemiologic studies have indicated that 0.5%-3% of all cancer cases could be attributed to medical radiation exposure [1—3]. Even though computed tomography (CT) accounts for only 15% of all radiologic examinations in the United States, CT is responsible for more than 50% of the total medical imaging radiation exposure [4]. This is alarming in light of 10% annual increase in the use of CT in the United States [4]. Although the radiation exposure during CT-guided interventional procedures forms a small fraction of total CT radiation dose delivered [4], patients can receive considerably high radiation doses during these procedures [5]. Therefore, it is essential to modify protocols used during CT-guided interventions to administer the minimum radiation while maintaining adequate image quality.

The radiation exposure to the patient during CT examination is directly proportional to the x-ray tube current, the square of the tube voltage, and the duration of the procedure [6]. Typically, CT interventions are performed by using the same x-ray tube parameters as those used during diagnostic imaging, even though high-resolution images are not often required. Therefore, modification of these parameters can theoretically reduce radiation exposure at the possible expense of image quality [6]. In fact, Lucey et al [7] demonstrated that reduction of the tube current to 30 mA during CT-guided catheter placements and biopsies allowed for a 6-8—fold decrease in radiation dose without compromising technical success. Similarly, Smith et al [8] showed that reduction of the tube voltage to 100 kV with the fixed current of 15 mA resulted in a 95% reduction in radiation exposure during CT-guided percutaneous lung biopsies. Reducing the tube voltage further, to 80 kV, has been successfully reported in CT-guided periradicular injections in the lumbar spine [9] and in CT-guided lung biopsies [10]. To our knowledge, however, there are no reports of CT-guided interventions with reduced voltage protocols for all performed procedures. Therefore, our aims were first to assess the feasibility of performing all CT-guided interventions in our community-based hospital with reduced tube potential of 80 kV instead of the conventional 120 kV, and second to evaluate the effect of such a technique on radiation exposure to patients.

Materials and Methods

Study Design and Patient Population

This study was approved by our institutional review board, and a waiver of informed consent was obtained in this retrospective analysis (Research Ethics Board approval no. H11-00155). A list of all the patients who underwent clinically indicated CT-guided interventional procedures in the department of radiology in a busy community hospital was obtained from health records. Given the published evidence of the success of performing CT-guided biopsy at lower doses [7—10], we had previously switched our protocol to low dose (80 kV) whenever feasible. For the last 50 patients before we switched our protocol, all the procedures were conducted with the x-ray tube voltage set to the routine value of 120 kV. For the second group of 43 patients, the voltage was set to 80 kV (37 patients), and, if image quality was not adequate to complete a procedure, then voltage was increased to 100 kV (6 patients). Automatic tube current modulation was enabled to allow for best image quality. All the patients had a limited diagnostic study (targeted to the affected area) at 120 kV immediately before the intervention, and each procedure was performed by 1 of 4 general radiologists with 4-15 years of experience. The procedures were done as a conventional CT-guided biopsy and/or intervention, and not as CT fluoroscopy. A radiofrequency ablation procedure and cecostomy were excluded from the final analysis given their more complex nature. All of the interventions were performed on a 16-slice multidetector CT scanner (Lightspeed; GE Healthcare, Buckinghamshire, UK). The scanning parameters were rotation time, 0.8 seconds; beam collimation, 20 mm; section thickness and intervals, 2.5 mm; helical pitch, 1.375 (1.75 for lung biopsy); table movement, 27.5 mm/rotation (35 mm/rotation for lung biopsy); and scanning field of view, 40-52 cm. At 120 kV, the noise index for the abdomen was 14 with a dose step of 4.5 and a minimum/maximum mA of 90/400. For the pelvic cases done at 120 kV, the noise index was 18, with a dose step of 0.08 and minimum/maximum mA of 100/440. For the chest cases performed at 120 kV, the noise index was 23, with a dose step of −5.05 and a minimum/maximum mA of 70/300. When the kV was changed to low dose (80 or 100 kV), the noise index and minimum/maximum mA remained the same for abdomen, pelvis, and chest procedures. We do not routinely record the patient's weight, although the patient's weight is asked for by the technologists before the intervention because patients who weigh more than 200 kg (440 pounds) are not placed on the table due to the table's weight limit.

Data Collection and Statistical Analysis

The following information was collected for each examination: patient sex, age, examination type, slice width, x-ray