Does fluid restriction affect the image quality of skeletal scintigraphy?

Short Communication

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ABSTRACT

Introduction: In Islamic countries in the month of Holy Ramadan many Muslims based on their religious Legislation refuse fluid intake during the fasting time though instructed to drink after injection of Tc-99m Methylene-diphosphonates [Tc-99m MDP] used for skeletal scintigraphy. We aimed to establish whether fluid restriction in Tc-99m MDP skeletal scintigraphy has an impact on its quality.

Methods: One hundred forty-four patients referred for skeletal scintigraphy were studied. Group 1 was well hydrated while group 2 was instructed not to drink till imaging. Image quality was assessed using quantitive measures where by the end of imaging, equal regions of interest (ROI) were drawn over the femoral diaphysis, and the contralateral adductor area. The total number of counts from the bone [B] ROI and soft tissue [ST] ROI was expressed as a ratio [B: ST ratio], and a mean value for each group was established. The image quality was also assessed without knowledge of individual's water intake by a semiquantitative score.

Results: No statistically significant difference was found between the B:ST ratio means [P=0.46] and the semiquantitative scores [P=0.42] in both groups.

Conclusion: Fluid restriction had no impact on the image quality in Tc-99m MDP skeletal scintigraphy though a higher radiation dose to the urinary bladder wall is anticipated.

Key words: Skeletal scintigraphy; Fluid restriction; Tc-99m MDP; Image quality; Bone to soft tissue ratio

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INTRODUCTION

Bone scintigraphy [BS] is one of the most frequently performed radionuclide procedures. Despite its low specificity, its excellent sensitivity makes it useful in screening and diagnosing some conditions not clearly depicted by radiology. Therefore, it remains popular despite advances in magnetic resonance imaging, computed tomography, and positron emission tomography [1]. 50% of Tc-99m Methylene-diphosphonates [Tc-99m MDP] accumulates in bone by 2–6 hours being adsorbed to the osseous mineral phase with relatively little binding to the organic phase. Radiotracer uptake depends primarily on blood flow and rate of new bone formation [2]. In the published quality guidelines for nuclear medicine in skeletal scintigraphy using Tc-99m MDP or similar radiopharmaceuticals; post injection hydration is advocated [3, 4].

The rationale behind a high fluid intake is that the unbound bi- and diphosphonate will be eliminated by renal excretion more rapidly, thus leading to greater bone-to-soft tissue (B: ST) ratios and improved image quality. Also, frequent voiding reduces the radiation burden of the urinary bladder wall [5] however there is no clinical study to support this hypothesis [6]. Additionally, Cronhjort et al. stated that the beneficial effect of hydration on image quality in bone scintigraphy is unproven and a disadvantageous effect cannot be excluded [7]. Hence, it is debatable whether hydration has any influence on the BS quality.

A search of the medical literature [MEDLINE till 2013] revealed three clinical studies concerned with hydration and image quality in skeletal scintigraphy in humans [5-7]. By revising their methodology we found that Klemenz B [6] hydrated all his study group with different hydration levels while Cronhjort M [5] studied a limited number of subjects [10 volunteers] and in Stace et al. study [7] though 200 patients were included but there was no fluid restriction in their patients as they studied the effect of hydration prior to injection of the radiopharmaceutical on image quality and there was a disparity in their study groups related to the physical activity levels of the patients.

Fasting is among the most prevalent activities in the world; many people observe fasting regardless of nationality or religion. Nearly all nations and religions have some kind of fasting festival, although the length of fasting and type of food consumed differ greatly among countries; some regions refrain from eating and drinking for a long period of time, while others observe a short, intermittent fast. Muslims refrain from eating or drinking during daylight hours in the ninth month of the Islamic calendar, the Ramadan festival, which can occur in any season. Investigators all over the world are considering the effects of Ramadan fasting on the physiological and pathological conditions of individuals. The effects of Ramadan on different organs have been extensively studied and reviewed; however, its effect on nuclear medicine field has not been fully acknowledged and thus demands more attention.

In Islamic countries as in Egypt during the month of Holy Ramadan many Muslims based on their religious Legislation refuse to drink after injection of Tc-99m MDP during the fasting time. Hence, in the present study we aimed to face this problem by investigating the impact of fluid restriction after tracer injection on the image quality of Tc-99m MDP skeletal scintigraphy in patients with normal daily activity.

METHODS

The study was approved by the local IRB/Ethics Committee of Cairo University scientific review board [IRB approval number: NEMROCK 60; ARN 19]. Informed consent was obtained from all subjects according to the Declaration of Helsinki; General Assembly, October 2008. 144 patients with normal daily activity as walking or shopping referred for BS were enrolled and classified as: group 1 (G1) was properly hydrated by oral fluids [1 Liter] till 30 to 45 min before the beginning of scintigraphy [8] and group 2 (G2) was restricted from fluid intake till imaging [simulating Holy Ramadan condition].

Both groups had symmetrical characteristics [Age, gender, weight, height, *BMI*, thigh circumference and clinical indications mostly metastatic work-up in approximately 85% or those with bony pains either localized or generalized]. Patients with abnormal serum creatinine, disturbances in urine voiding, those with prosthesis, soft tissue abnormalities especially in the thigh regions as lymphedema and pediatric age groups were excluded. Timed imaging [169 ± 28 minutes] was done using Phillips-Axis gamma camera [Phillips; the Netherlands] mounted with a low energy high resolution collimator [scan speed, 20 cm/min; ventral contour; matrix, 512 × 2,048).

For image quality assessment we adopted the methodology of Klemenz et al [6] that relied on quantitative measures [Bone-to-Soft Tissue Ratio (B: ST) calculation] and semiquantitative score. The latter was based on assessment of the image quality without knowledge of the hydration condition of each patient. The following semiquantitative criteria were visually rated and classified: bone-to-soft tissue contrast, differentiation of single ribs in the anterior and posterior views, lateral processes of vertebrae, visibility of bony details of the pelvis, and filling of

the bladder. The rating scale was as follows: optimal visibility, two points; suboptimal, one point; and inadequate, zero points. Scans with six to eight points were classified as optimal (score 2), three to five points were adequate or suboptimal (score 1), and zero to two points were inadequate (score 0).

For B: ST calculation, the counts over an area of the right femoral diaphysis were determined according to the region-of-interest (ROI) technique. A minimum ROI size of 150 pixels was compared with a similar-sized ROI of the contralateral adductor area. The contralateral medial thigh was used to avoid an overlap with bony structures on the used bony side and putting into consideration absence of significant difference in thigh circumference of each lower extremity. The total number of counts from bone [B] ROI and soft tissue [ST] ROI was expressed as a ratio [B: ST ratio] by the calculated means of anterior and posterior views.

Statistical analysis

Data were described in terms of mean ± standard deviation (±SD), median and range, or frequencies and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student *t* test for independent samples. For comparing categorical data, Chi square (χ^2) test was performed. $P<0.05$ was considered significant throughout.

RESULTS

G1 and G2 comprised 72 patients each [33 males and 39 females] with their mean ages 53.6±12.5 and 55.6 years±10.3 respectively. No statistical significant difference was found between both groups regarding age, gender, weight, height, *BMI*, thigh circumference and clinical indications. Assessment of pelvic osseous details was restricted in 10/72 [13.9%] patients when the urinary bladder was filled as noted in our G1 patients, despite having them void immediately before the scan compared to 2.8% in G2 [*P* 0.04]. The mean semiquantitive score values were 1.26±0.6 and 1.16±0.5 in G1 and G2, respectively [*P* 0.42]. Means of B: ST ratio of G1 and G2 were found to be 2.11 ± 0.8 and 2.17 ± 0.7 respectively with no statistical significant difference [*P* 0.46].

DISCUSSION

This study was addressed to face a common situation in Islamic countries usually in the holy month of Ramadan. This study showed no influence of fluid restriction after IVI of radiopharmaceutical on the B: ST ratio or the image quality of Tc-99m MDP skeletal scintigraphy. In a search of the literature we could not find any previous clinical studies on the adverse effect of fluid restriction on the image quality of Tc-99m bone scans.

Cronhjort et al. had two studies one at animal level [8] and the other on 10 human volunteers [5]. In Klemenz et al. study [6], there was no fluid restriction as they used different hydration volumes in their studied groups. Finally in Stace et al. [7] study they studied the hydration effect prior to tracer injection on image quality and in our opinion their main limitations was the disparity in physical activity in-between the compared groups. So, as far as we know no similar design was used in prior studies to compare the effect of fluid restriction versus hydration post tracer injection on image quality in skeletal scintigraphy in clinically indicated patients with normal level of activity.

It is known that the extracellular fluid volume is increased when patients drink large volumes of fluid and consequently, the enlarged distribution volume of Tc-99m MDP gives rise to lower plasma levels and lower skeletal and renal extraction rates [8]. For this reason, we instructed our patients to drink until 30 to 45 min before the beginning of scintigraphy as in Klemenz et al. study [6].

We found that neither fluid restriction nor hydration had an influence on image quality or B: ST ratio in bone scintigraphy. Cronhjort et al proved in mice [8], then later in humans [5] that change in water balance did not increase the B: ST ratio. Also, Klemenz et al. [6] compared the effect of consumed different fluid quantities post tracer administration of Tc-99m MDP on image quality. They found no significant difference between the group with small amount of fluid intake [0.25 liter] and the other groups [1 and 1.5 Liters]. They stated that water intake does not influence the B: ST ratio ***or*** the quality of bone scan images in a compact bone region. Lastly, Stace et al. study concluded that even hydration prior to bone scintigraphy injection has no significant effect on the B: ST ratio in bone scintigraphy. Also, our obtained semiquantitative scores [1.26±0.6 and 1.16±0.5 in G1 and G2 respectively] were in great concordance with those of Klemenz et al. [6] groups (0.25 L and 1 L fluid hydration) being 1.14±0.6 and 1.28±0.5 respectively.

The mechanism for renal clearance of diphosphonates is not yet fully understood where in normally hydrated patients, less than 5% of the injected dose is evident in plasma three hours after injection. Therefore, it is unlikely that a moderately increased fluid intake would accelerate renal excretion of the tracer to a meaningful degree [8]. Moreover, increased fluid intake will to an extent increase the extracellular fluid volume which will consequently lead to an enlarged distribution volume

of Tc-99m MDP giving rise to lower plasma levels with subsequent lower skeletal and renal extraction rates [5, 6, 9].

Besides, assessment of pelvic osseous details was restricted when the urinary bladder was filled as noted in our G1 patients [13.9% vs. 2.8% in G1 and G2 respectively], despite having them void immediately before the scan. Another major concern with fluid restriction is the radiation burden to the urinary bladder wall being a critical organ in bone scintigraphy that could be partially overcome by encouraging post-scanning hydration at the time of fast-breaking and frequent voiding to reduce the radiation burden to the urinary bladder.

We believe for adult patients with normal activity neither fluid restriction nor hydration has an influential effect on B: ST ratios or image quality. Hence, the findings of our study could be useful for patients instructed for fluid restriction as the case in heart failure.

CONCLUSION

This study revealed that fluid restriction had no influence on image quality of Tc-99m MDP bone scan as proved by quantitative evaluation [B: ST ratios] and semiquantitative scores though a higher radiation dose to the urinary bladder wall is anticipated.

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