Contribution of Hybrid SPECT CT Imaging with [99mTc] Tc-MDP in Battered Woman Syndrome: A Case Study

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Abstract

Introduction: *Violence against women is a widespread health problem that knows no racial or social boundaries. It is generally difficult for forensic investigators to obtain medical evidence of violence, particularly in cases where the victims are assessed several months after the event. Bone scintigraphy can be used to identify and document trauma related to acts of torture, and it can also serve as valid evidence in court.*

Case report: *The bone scan revealed multiple areas of tissue uptake in the early phase, associated with bone uptake in the late phase involving both the axial and peripheral skeleton. In addition, several areas of bone uptake were observed in the late phase without corresponding tissue uptake in the early phase. The scintigraphic pattern demonstrated that the patient's bone lesions were of different ages. Based on these findings, early tissue uptake associated with late bone uptake was consistent with recent post-traumatic lesions, whereas late bone uptake without early tissue uptake was consistent with old post-traumatic lesions. The distribution of certain skeletal lesions suggested a defensive posture adopted by the victim.*

Conclusion: *In the context of a forensic investigation, bone scintigraphy is a valuable tool that not only detects bone lesions in patients suspected of physical assault, whether or not they present clinical signs, but also helps to determine when the injury occurred.*

Keywords: *Battered Woman Syndrome, Bone Scintigraphy, Hybrid SPECT/CT, Trauma*

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Introduction

Violence against women, regardless of its cause, is a widespread health problem that knows no racial or social boundaries. It is generally difficult for forensic investigators to obtain medical evidence of violence, particularly in cases where individuals are assessed several months after the physical trauma (1).

Bone scintigraphy, due to its high sensitivity, can be useful as a diagnostic and dating method to reveal recent injuries and even those that occurred several years ago (2-5). It is a diagnostic imaging test that studies the distribution of a radioactive tracer in the skeleton after intravenous injection of a technetium (99mTc)-labeled phosphate molecule (6). Bone scintigraphy is a sensitive method for detecting bone tumors, bone metastases, and metabolic bone diseases (6). It is also useful for assessing skeletal trauma caused by torture (falanga and blows causing bone lesions) (3-5) and child abuse (7). While bone scintigraphy can be used to identify and document trauma related to acts of torture, it

Figure 1: *Planar whole-body acquisition three minutes after intravenous injection of the tracer.*

can also serve as valid evidence in court. The aim of this study is to demonstrate the usefulness of bone scintigraphy for dating bone lesions in battered woman syndrome.

Case Report

This is a 27-year-old female patient referred by her medical examiner for a bone scan to determine the date of injury as part of a forensic investigation. According to the circumstances reported, she had been the victim of repeated assaults by her employer over a period of more than six months, which led to the opening of a judicial investigation.

The clinical examination revealed multiple ecchymotic lesions. The body scan revealed multiple fractures involving the frontal bone, nasal bone, nasal septum, teeth, ribs, and vertebrae.

Examination Protocol

A bone scan was performed after injection of 17 mCi of technetium-99m-labeled methylene diphosphonate ([99mTc] Tc-MDP). The images were acquired using a dual-detector gamma camera equipped with high-resolution low-energy collimators (Siemens SYMBIA-Intervo), combined with a low-dose scanner (SPECT/CT).

After the early phase images were acquired, the patient was asked to drink water and then empty her bladder before the late phase. Plane bone scintigraphy was performed 3 hours after injection, under the following conditions: patient in supine position, 256 × 256 matrix, 1.0 zoom, and examination table speed of 16 cm/min. The examination was completed with static acquisitions and a CT scan focused on the thorax and femurs.

Imaging results

The study revealed, at an early phase **(Fig.1)**, several intense tissue uptakes in the nasal region, the left anterior costal arches (K4 and K5), and the right anterior costal arches (K7 and K8). Moderate uptakes were observed in the right anterior costal arch (K4), left humeral diaphysis, left ulna, and distal third of the left wrist. Discrete uptakes were noted in the left humeral diaphysis and lower third of the left femoral diaphysis. Finally, intense and extensive uptakes were observed in the right ulnar diaphysis, corresponding to a known and treated fracture lesion.

Late images from the bone scan revealed **(Fig.2)** Areas of intense uptake in the left acromion, left scapular spine, and left anterior costal arches (K4 and K5), and less intense uptake in the right anterior costal arches (K4, K7, and K9).

An extensive and intense area of uptake in the bones of the right forearm, corresponding to a known and treated fracture.

An oblong uptake in the left radial diaphysis.
Two less intense areas of uptake in the left humeral diaphysis, as well as uptake in the lower third of the femoral diaphysis, corresponding to a periosteal reaction on the CT images.
Staggered uptake of the spinous processes of the dorsal spine, corresponding to fractures visible on the CT images.
Uptake in the transverse processes of the lumbar vertebrae (L1, L2, and L3), also corresponding to fractures on the CT images.

Given these scintigraphic findings, the uptake observed in the rib cage, nasal bones, and right forearm, combined with early tissue uptake, are consistent with recent post-traumatic lesions dating back less than four

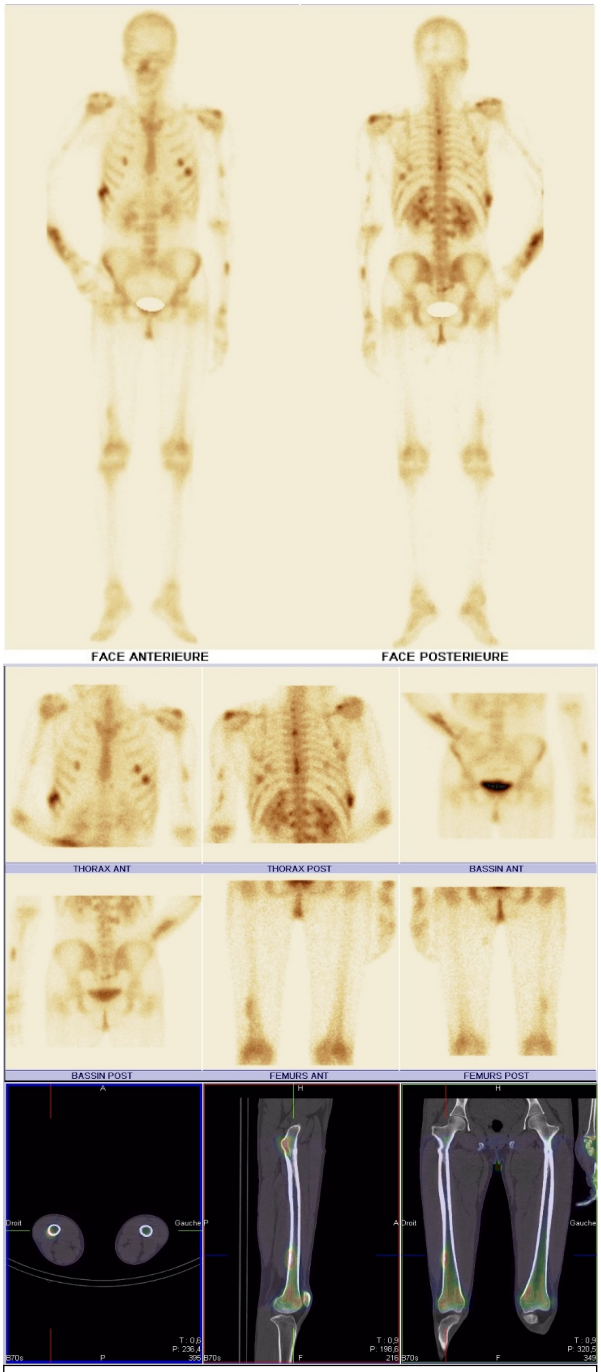

Figure 2: *(A): Planar whole-body acquisition three hours after intravenous injection of the tracer. (B): Delayed static acquisition of the rib cage, pelvis, and femurs, (C): SPECT-CT acquisition focused on the femurs.*

weeks. The injuries affecting the left forearm, the 4th right anterior rib, the spinous processes of the dorsal spine, and the lumbar transverse processes appear to be less recent. These injuries could correspond to a defensive posture adopted by the patient during the assaults. Finally, the uptake without associated tissue uptake at the left acromion, left scapular spine, left humeral diaphysis, and lower third of the femur corresponds to old injuries, dating back more than six weeks.

Discussion

Medical evidence of assault is generally difficult to obtain, and advanced diagnostic methods are sometimes necessary for a complete evaluation. In approximately half of trauma patients, most bone injuries can be detected by morphological imaging (8,9). For lesions that are not visualized, bone scintigraphy is particularly useful in detecting occult fractures and subtle lesions involving the ribs, sternum, or pelvic region. In these areas, bone metabolism is locally increased, and the phosphate complex then binds to 99mTc-MDP (10). Kleinman PK et al. (11) demonstrated the value of bone scintigraphy in identifying occult lesions that are difficult to visualize on radiographs in children who have been abused. Similarly, Ozkalipci O et al. (1) evaluated bone scintigraphy as a tool for detecting the sequelae of torture. Their results showed that the rate of bone lesions detected by scintigraphy was 58%.

Juxta-articular fractures can be visualized earlier than diaphyseal fractures. It allows recent fractures to be diagnosed within 48 hours with 95% sensitivity, and after 72 hours, sensitivity reaches 100% (12, 13). Between 6 and 9 months, the intensity of bone fixation gradually decreases as bone healing progresses (13), but it may remain visible for up to 3 years after the fracture. In one study, Mirzaei et al. evaluated 25 asylum seekers who had been subjected to violent blows between 4 and 24 months after torture. They showed that bone scintigraphy is a highly sensitive and useful tool for documenting trauma consistent with allegations of torture, even 1 to 2 years after the torture.

To assess the age of bone fractures, two scintigraphic phases must be acquired: the early phase (vascular and tissue) and the late phase (bone) (13). In addition, a SPECT/CT scan of the suspected area must be performed to assess morphological and metabolic changes. During the first 4 weeks following the trauma, the fracture shows diffuse tracer uptake during the early and late phases (13). During the following 8 weeks, activity is more concentrated in the late phase images, while activity in the early phase decreases. Our results are consistent with those reported in the literature, in that

bone lesions with hyperfixation associated with tissue hyperuptake appear to be more recent than those with bone hyperfixation alone without tissue hyperuptake in the early phase. However, normalization of the early phase is observed after 6 months and a decrease in late phase activity is visible after 18 months, sometimes persisting for years (14).

Conclusion

In the context of a forensic investigation, bone scintigraphy is a valuable tool that not only detects bone lesions in patients suspected of physical assault, whether or not they show clinical signs, but also helps to determine when the injuries occurred. This technique, which complements forensic evaluation, is a non-invasive, highly useful, and sensitive diagnostic method for mapping injuries and identifying occult fractures.

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Declarations

Consent for publication: The authors clarify that written informed consent was obtained and the anonymity of the patient was ensured. This study submitted to Swiss J. Rad. Nucl. Med. has been conducted in accordance with the Declaration of Helsinki and according to requirements of all applicable local and international standards.

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Bensimimou Hafsa: Formal analysis, Visualization
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Daerqaoui Mohammed Amine: Methodology, Supervision, Writing – review & editing
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