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Original article

Bone scan as a screening test for missed fractures in severely injured patients

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ABSTRACT

Background: In many cases, patients with severe blunt trauma have multiple fractures throughout the body. These fractures are not often detectable by history or physical examination, and their diagnosis can be delayed or even missed. Thus, screening test fractures of the whole body is required after initial management. We performed this study to evaluate the reliability of bone scans for detecting missed fractures in patients with multiple severe traumas and we analyzed the causes of missed fractures by using bone scan.
Hypothesis: A bone scan is useful as a screening test for fractures of the entire body of severe trauma patients who are passed the acute phase.
Material and methods: We reviewed the electronic medical records of severe trauma patients who underwent a bone scan from September 2009 to December 2010. Demographic and medical data were compared and statistically analyzed to determine whether missed fractures were detected after bone scan in the two groups.
Results: A total of 382 patients who had an injury severity score [ISS] greater than 16 points with multiple traumas visited the emergency room. One hundred and thirty-one patients underwent bone scan and 81 patients were identified with missed fractures by bone scan. The most frequent location for missed fractures was the rib area (55 cases, 41.98%), followed by the extremities (42 cases, 32.06%). The missed fractures that required surgery or splint were most common in extremities (11 cases). In univariate analysis, higher ISS scores and mechanism of injury were related with the probability that missed fractures would be found with a bone scan. The ISS score was statistically significant in multivariate analysis.
Discussion: Bone scan is an effective method of detecting missed fractures among patients with multiple severe traumas.
Level of evidence: Level IV, retrospective study.

1. Introduction

Among trauma surgeons who care for patients with poly traumas, it is very important not to delay the life-saving procedures due to missed fractures. However, it is very difficult to diagnose initially all the non-fatal minor injuries in multiple trauma patients brought to the emergency room. It is undesirable to delay resuscitation due to performance of less urgent tests [1]. For musculoskeletal injury, particularly fractures of the extremities, a diagnosis can be made using X-ray, computer tomography (CT), magnetic resonance imaging (MRI) or ultrasound of the suspicious area after vital signs become stabilized. These additional examinations are performed mostly on the areas with symptoms that relate from patients' complaints or on the areas that show abnormal findings on physical examination. In many cases, physicians may be unable to detect all the areas that have injury due to excessive patient pain, decreased awareness of the patient in the emergency room or during the early phases of the hospitalization. Even for mild injuries for which conservative treatment is sufficient, it is important to make accurate diagnosis and be able to determine the treatment period as this will help ensure correct legal and social handling as well as avoid ever-increasing malpractice cases. As such, we investigated the fractures that were detected by bone scan among severe trauma patients during their hospitalization after their treatment in the trauma center of this hospital. Bone scans were examined in terms of their effectiveness as a screening test for missed fractures.

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Table 1
Relationship between missed injuries and the parameters analyzed.

	Diagnosis group	Missed group (treatment group)	*P* (treatment group)
Total number of patients	50	81 (40)	
Sex			
Male	40	65 (32)	NS (0.049)[a]
Female	10	16 (8)	
Age			
Mean ± SD	38.3 ± 20.4	42.5 ± 17.5 (41.1 ± 17.3)	NS (NS)[b]
ISS score (>15)			
Mean ± SD	18.8 ± 3.4	22.7 ± 6.2 (23.2 ± 7.0)	<0.001 (0.007) [b,d]
Conscious state[c]			
Good	40	62 (31)	NS (<0.001)[a]
Moderate	5	9 (5)	
Severe	5	10 (4)	
Mechanism of injury			
Traffic accidents	28	59 (31)	0.049 (<0.001)[a]
Falls	15	14 (7)	
Assaults	1	5 (2)	
Industrial accidents	6	3 (0)	

SD: standard deviation.
[a] χ^2-test, $P < 0.05$.
[b] Independent sample *t*-test, $P < 0.05$
[c] GCS score good, 13∼15; moderate, 9∼12; severe, ∼8.
[d] Statistically significant in multivariate analysis.

2. Patients and methods

The 382 trauma patients who visited the emergency room between September 2009 and December 2010 had an ISS score of 16 or more. One hundred thirty-one patients who underwent bone scan were included in this study. The data were collected from the National Emergency Department Information System (NEDIS), medical records and the results of bone scan interpretation. The subjects' distribution by age and gender, mechanism of injury, time from admission to bone scan, ISS score and the Glasgow coma scale (GCS) score were assessed. For bone scan, intravenous injection of Tc^{99m} - DPD 20 mCi was performed. Urination was allowed four hours later and then an anteroposterior view of the whole body was taken using a gamma camera (dual head gamma, General Electric). In particular, for areas suspected to have a fracture due to increased uptake, magnified and oblique views were taken. Areas suspected of fracture in bone scan were finally diagnosed as a fracture after the performance of additional examinations such as CT and MRI. Among the patients who had been newly diagnosed with fractures, those who had required additional treatments such as splinting or surgery, in addition to conservative care, were identified and grouped into a separate patient group. The collected data were analyzed using SPSS 16.0 for Windows. Statistical analyses were performed using a *t*-test (independent sample *t*-test) and chi-square test; $P < 0.05$ was considered statistically significant.

3. Results

The number of patients who had underwent bone scans and had an ISS score of 16 or more was 131 (105 were men, 26 were women; mean age was 41 years, range of 2–82). There are 6 children patients under 12 but no missed fracture was founded in these children. The mean ISS score was 21.2. For mechanism of injury, traffic accidents accounted for the highest proportion of entire cases, and other proportion was descripted in Table 1. Those with rib fractures (99 patients, 75.6%) accounted for the highest proportion of the entire fracture sites. The frequency of fracture by body area is presented in Table 2.

3.1. Bone scan

After the injury, bone scan was performed between 5 and 89 days (mean of 18 days) after the injury. New fractures were found among 81 patients (61.8%) and the most common area with newly found fractures was the rib area (55 patients, 42.0%). Forty patients (30.5%) required additional treatments such as splinting or surgery, in addition to conservative care or close observation. There was one patient who had a bone scan where three additional fractures were found requiring treatment. Among the 12 cases of spine fractures (thoracic vertebrae, 9; lumbosacral vertebrae, 3) that were found by bone scan, two cases required surgery like decompression and fusion. The immobilizations with braces were needed for 9 cases. And one case was needed only for observation. Of the sternum and rib fractures that were detected by bone scan, none required active treatments in addition to conservative care. All clavicle and scapula fractures that were found by bone scan required active treatments. Two cases of clavicle fracture required surgery like plate fixation and the other 6 cases were immobilized with figure of eight bandage. Four cases of scapula fracture required open reduction and/or internal implantation and the other 6 cases were needed braces. Of the fractures in the extremities that were found by bone scan, five required open reduction and/or internal fixation. And six required closed reduction and splinting without surgery. Conservative care with observation was performed for the other 31 cases (Table 2). There were three cases that fractures were not detected by bone scans. Two fractures were found in a 75-year-old female patient's T and L spine. The remaining fracture was found in the fibular of a 40-year-old male patient. Both patients had no other disease such as HTN and DM. The fracture was accidently found in the outpatient follow up process after discharge.

3.2. Presence or absence of newly found fractures

Although there was no difference between men and women in terms of newly fractures found by bone scan, the frequency of these fractures that required active treatment was significantly higher among women than among men ($P < 0.001$). For classification by mechanism of injury, the frequency of newly found fractures by bone scan was significantly high in vehicular accidents ($P = 0.049$).