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[UCI]I804:11046-000000522448

Whole Body Bone Scan for Detecting Missed Bone Injuries in Multiple Trauma Patients

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Whole Body Bone Scan for Detecting Missed Bone Injuries in Multiple Trauma Patients

Directed by Professor Man Ki Ju

The Master's Thesis
submitted to the Department of Medicine
the Graduate School of Yonsei University
in partial fulfillment of the requirements for the degree
of Doctor of Philosophy

Hong Yoon Jeong

December 2019

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This certifies that the Master's Thesis of
Hong Yoon Jeong is approved.

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The Graduate School
Yonsei University

December 2019

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ACKNOWLEDGEMENTS

At this moment, I remember when I first started studying medicine. The joy of entering Yonsei university of Wonju medical college and the hard time that I have been studying for almost 15 years. I am grateful for the Yonsei university that brought me here.

Now, I would like to thank my professor and colleagues for the final course of my master's degree. In particular, Man Ki Ju, the thesis supervisor, helped me grow up to be a good surgeon. His advice greatly influenced my growth. For examples, how to care for patients, how to do medical research, and what kind of doctor I should be. I would like to take this opportunity to say thank you again.

Special thanks go to Im-kyung Kim, a teacher and senior for me who helped me a lot for this research. Without her, this research would not have come to this point. I would also like to thank my colleagues who have been with me for four years of training. I could finish the hard process safely because there are wonderful colleagues.

Finally, I would like to express my gratitude and love to my dear wife.

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<TABLE OF CONTENTS>

연세대학교
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LIST OF FIGURES

LIST OF TABLES

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ABSTRACT

Whole Body Bone Scan for Detecting Missed Bone Injuries in Multiple Trauma Patients

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(Directed by Professor Man Ki Ju)

Purpose: Patients with multiple traumas often experience multiple fractures that are missed or overlooked, despite the use of imaging, careful history taking, and physical examinations. This study aimed to evaluate the usefulness of whole body bone scan (WBBS) for detecting missed bone injuries in patients with multiple traumas.

Methods: We evaluated 30 patients with multiple traumas who underwent WBBS at single tertiary referral center between March 2008 and February 2016. We assessed the association of patient demographics with WBBS uptake as a binomial outcome variable.

Results: There were no significant differences in patient demographics by WBBS. The mean injury severity score did not differ by WBBS (18.1 in the WBBS-negative group vs. 18.4 in the WBBS-positive group), and duration from admission to the evaluation of the WBBS was similar (5.4 days in both groups). The most common uptake site in the WBBS was the ribs (n=7), followed by the tibia (n=3), skull (n=2), ankle (n=1), and sternum (n=1). None of the missed injuries required further treatment, such as manual reduction or surgery.

Conclusion: WBBS was useful for detecting missed bone injuries in patients with multiple trauma.

Key words : whole body bone scan, missed injuries, multiple trauma

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Whole Body Bone Scan for Detecting Missed Bone Injuries in Multiple Trauma Patients

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I. INTRODUCTION

Trauma surgeons inevitably treat patients with multiple major traumas, and delays in the diagnosis or treatment of these patients are inexcusable. Therefore, the Advanced Trauma Life Support Course states that the standard of care for these patients should involve a rapid primary survey of life-threatening injuries followed by a head-to-toe secondary survey [1].

However, patients with multiple traumas often experience multiple injuries that are missed or overlooked despite imaging, careful history taking, and physical examinations. Furthermore, during the early phase of multiple traumas, the patient's extreme pain and decreased orientation can make it difficult to detect all of their injuries. Previous studies have reported that standard radiography failed to identify injuries in 0.6～65% of trauma patients [2,3], and in up to 50% of rib fracture cases [4]. Thus, there is growing interest in diagnostic tools that can complement the current imaging modalities. The present study aimed to evaluate the usefulness of whole body bone scan (WBBS) for detecting missed bone injuries in patients with multiple traumas.

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II. METHODS

This study was a retrospective single-center study conducted at a tertiary referral hospital in South Korea from March 2008 to February 2016. This study was approved by the Institutional Review Board of Gangnam Severance Hospital, Yonsei University, Seoul, Korea.

Study population

During the study period, a total of 78 patients with multiple traumas had moderate to severe injuries evaluated by injury severity scores (ISS). The initial diagnoses were made using plain radiography, ultrasonography, computed tomography (CT), or magnetic resonance imaging to examine the region(s) of interest based on patients' symptoms and physical examinations. All patients were initially treated in the emergency room until their vital signs had stabilized.

Whole body bone scan

The WBBS was performed using Tc-99m methylene diphosphonate (20 mCi) at 5～7 days after the admission. Among 78 patients, the WBBS was performed only in 30 patients. Other 48 patients could not undergo WBBS due to critical injuries with unstable hemodynamics. The scanning was performed using a single-lens camera with a high-resolution collimator. Two experienced nuclear medicine physicians reviewed the anteroposterior, oblique, and localized views of the region(s) of interest. The patients were divided into two groups (WBBS-negative vs. WBBS-positive group) based on the presence or absence of uptakes in the WBBS. Areas suspected of bone injuries in the WBBS were finally diagnosed after the performance of additional examinations such as further X-rays or CT scans.

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Statistical analysis

All statistical analyses were performed using IBM SPSS Statistics ver. 19.0 (IBM Co., Armonk, NY, USA). Categorical variables were analyzed using the chi-square test or Fisher's exact test. Continuous variables were analyzed using Student's t-test. p-values of < 0.05 were considered statistically significant.

III. RESULTS

The 30 patients included 12 patients with uptakes in the WBBS (WBBS-positive group) and 18 patients without uptakes in the WBBS (WBBS-negative group). The patients' baseline characteristics are shown in Table 1. We did not identify any statistically significant differences between the two groups, which exhibited similar values for their mean ISS and duration from the admission to the evaluation of the WBBS. The most common mechanism of injury in both groups was the traffic accident. When compared the sites of detected fractures at the initial diagnosis, there was no statistical difference between the two groups. Chest including ribs and clavicle was the most common site of fractures in both groups, and other fractures on face, pelvis, spine and upper and lower extremities were detected at the initial diagnosis (Table 1).

Presence of missed injuries in the whole body bone scan

One example of missed rib fractures is shown in Fig. 1. Plain radiography did not identify any bony lesions, although the WBBS revealed increased uptake in the anterior and right lateral views, which indicated rib fractures. As described in Fig. 1, on the basis of the initial physical examination and X-rays, there was no abnormal findings on the areas suspected injuries in the WBBS. The WBBS detected the missed injuries most commonly on ribs (n=7), followed by tibia (n=3), skull (n=2), ankle (n=1), and sternum (n=1). The newly found lesions using by WBBS were confirmed as fractures according to the presence of

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abnormalities on further area-specific X-rays or CT scans (Table 2). None of the missed fractures required further treatment, such as manual reduction or surgery, and all lesions were successfully treated using conservative care and symptom control.

Table 1. Comparisons of patient characteristics between the two groups

Variable	WBBS-negative (n=18)	WBBS-positive (n=12)	p-value
Gender			1.000
Male	11 (61.1)	8 (66.7)	
Female	7 (38.9)	4 (33.3)	
Age (y)	50.6±17.0	43.2±13.0	0.190
Injury severity score	18.1±7.8	18.4±6.8	0.897
Mechanism of injury			0.372
Fall	4 (22.2)	1 (8.3)	
Passenger TA	3 (16.7)	6 (50.0)	
Pedestrian TA	5 (27.8)	2 (16.7)	
Motorcycle TA	3 (16.7)	1 (8.3)	
Others[a)]	3 (16.7)	2 (16.7)	
Reasons for admission			0.881
Multiple fractures	5 (27.8)	2 (16.7)	
Hemoperitoneum	10 (55.6)	8 (66.7)	
Panperitonitis	2 (11.1)	1 (8.3)	
Others	1 (5.6)	1 (8.3)	
Sites of detected fractures[b)]			0.258
Face	2/26 (7.7)	3 (25.0)	
Upper extremities	1/26 (3.8)	2 (16.7)	
Chest	12/26 (46.2)	5 (41.7)	
Pelvic and sacrum	4/26 (15.4)	2 (16.7)	
Thoracic-lumber spine	3/26 (11.5)	0 (0)	
Lower extremities	4/26 (15.4)	0 (0)	
Hospital stay (d)	10.8±6.9	10.2±5.6	0.802
Duration from admission to evaluation of the WBBS (d)	5.4±2.9	5.4±3.0	0.980

Values are presented as number (%) or mean±standard deviation. WBBS: whole body bone scan, TA: traffic accident. [a)]Blunt traumas due to family violence or physical fight, injuries from sports. [b)]Contains duplication, and "chest" includes ribs and clavicles.

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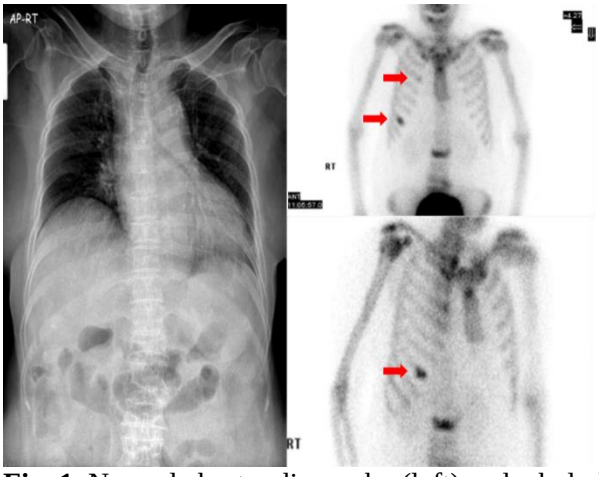

Fig. 1. Normal chest radiography (left) and whole-body bone scanning (right, RT) revealing increased uptake in the right anterior 3rd and 7th ribs (arrows).

IV. DISCUSSION

The current study was performed to reveal the usefulness of WBBS as a screening test for missed bone injuries of the multiple trauma patients. In patients with multiple traumas, the incidence of missed injuries has been reported to 8～65% [1,5,6]. Above all, the musculoskeletal injuries are the most common type of missed injuries. Previous studies demonstrated that repeating imaging or secondary review of previous imaging studies is the most effective method to identify missed injuries [1]. Even though there was no lesion leading to long-term sequelae in this study, trauma surgeons should pay attention that clinical outcomes of missed injuries can range from no harm to prolonged disability or death [6]. From this reason, clinicians have been focused on the various diagnostic imaging tools and the more structured system of imaging review in patients with multiple traumas.

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Table 2. Additional imaging studies for a definitive diagnosis in the WBBS-positive group

Patients (gender/age)	Mechanism	Areas suspected injuries in the WBBS	Initial P/Ex or simple X-rays	Additional studies for confirmation
F/49	Blunt trauma [a)]	Lt. frontotemporal skull	Orbital wall fracture on X-ray (skull series)	Brain CT
M/46	Fall	Rt 6th~7th anterior ribs	Normal	Chest CT
M/31	Blunt trauma [a)]	Rt. 7th anterolateral ribs	Normal	Chest CT
F/63	Pedestrian TA	Rt. proximal tibia	Normal on P/Ex (X-rays were not taken)	X-ray : knee both-oblique, knee standing AP (both) view
F/57	Passenger TA	Lt. 7th~9th anterior ribs	Normal	Chest CT
F/35	Passenger TA	Rt. 7th~8th costochondral junction	Normal	Chest CT
M/29	Passenger TA	Lt. distal tibia	Normal on P/Ex (X-rays were not taken)	X-ray : knee both-oblique, knee standing AP (both) view
M/30	Passenger TA	Lt. 7th~9th anterior ribs	Normal	Chest CT
M/44	Pedestrian TA	Lt. 10th and sternum	Normal	Chest CT
M/63	Motor cycle TA	Parietal skull	Normal	Brain CT
M/44	Passenger TA	Rt. ankle, Lt. distal tibia	Normal on P/Ex (X-rays were not taken)	X-ray : foot AP, lat, both oblique view
M/27	Passenger TA	Multiple bilateral ribs	Normal	Chest CT

WBBS: whole body bone scan, P/Ex: physical examination, F: female, M: male, Lt.: left, Rt.: right, TA: traffic accident, CT: computed tomography, AP: anteroposterior, Lat: lateral.
a)Abdominal traumas.

The WBBS is one of the non-invasive and simple imaging tool. Furthermore, while conventional radiographs often are initially negative, WBBS can identify bone lesions within 48 hours after trauma [7]. However, it is difficult to identify the precise etiology of the injury, as the focally increased uptake can also reflect an osteoblastic response to a local insult (e.g., a bone tumor, metastasis, or infection). In the present study, we performed further evaluations such as CT scans or lesion-specific plain x-rays for a definitive diagnosis to overcome the

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limitation of WBBS.

From previous researches, rib fractures were identified in 7～ 40% of multiple trauma cases [8-11], which are also correlated to our results. A delayed diagnosis of rib fractures may result in severe pain, loss of functional lung capacity, prolonged hospitalization, and higher cost [8]. Although we did not observe a significant difference in the duration of hospitalization between patients with and without uptakes in the WBBS, it would be valuable to analyze the pain scale and total cost of hospitalization to clarify the validity of WBBS.

A Canadian report from a Level I trauma center reported that patients with missed injuries tended to be more severely injured, and to exhibit initial neurological impairment [1]. In the present study, we did not identify differences in the two groups' ISS (18.1 in the non-missed group vs. 18.4 in the missed group, p=0.897). Based on these values, it appears that our patients had moderate-to-severe injuries, although all of our patients were conscious at the time of their admission and were able to undergo WBBS.

The present study has potential limitations. Owing to the nature of retrospective design, this study has risks of bias. As this study included the patients only admitted to the department of surgery, patients with head or chest injuries who were admitted to other departments could be excluded. Most importantly, we could not draw any changes in further treatment plan on the basis of findings from WBBS. From previous report by Lee et al.[8], 61.8% of all patients had missed injuries in WBBS, and 40% of them needed additional operations or immobilization. In this study, no patients with missed injuries in the WBBS required further treatment. This uncorrelated results might be caused by small sample size and homogenous study population mainly including abdominal traumas. Thus, our findings may not generalize to other patient populations, and multicenter clinical studies are needed to validate our findings.

In conclusion, WBBS was useful for detecting missed bone injuries in patients with multiple traumas.

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ABSTRACT(IN KOREAN)

다발성 외상 환자에서 누락된 뼈 손상의 발견을 위한 전신 뼈 스캔

<지도교수 주 만 기>

연세대학교 대학원 의학과

정 홍 윤

목적 : 다발성 외상을 동반한 환자에서 신중한 병력 조사와 이학적 검사 그리고 영상 검사를 시행함에도 불구하고 종종 간과하거나 놓치는 다발성 골절을 경험하게 된다. 이 연구의 목적은 다발성 외상 환자에서 위와 같이 누락되는 뼈 손상의 발견을 위한 전신 뼈 스캔의 유용성에 대해 알아보는 것이다.

방법 : 2008년 3월부터 2016년 2월 사이 단일 3차 의료 기관에 내원한 다발성 외상 환자 중 전신 뼈 스캔을 시행한 30명의 환자를 대상으로 하였다. 본 연구는 이항 결과 변수로 전신 뼈 스캔의 반응과 환자의 인구학적 특성의 연관성을 알아보았다.

결과 : 전신 뼈 스캔의 반응에 따른 두 환자 군에서 인구학적 특징을 비교 하였을 때 통계적으로 유의한 차이는 없었다. 평균 injury severity score는 전신 뼈 스캔 반응에 따라 다르지 않게 나타났으며 (전신 뼈 스캔 음성군에서 18.1 이었으며 전신 뼈 스캔 양성군에서 18.4), 입원부터 전신 뼈 스캔을 시행한 기간도 두 군이 비슷하였다 (양쪽 모두 5.4일). 가장 흔한 전신 뼈 스캔 반응 부위는 갈비뼈 (n=7) 였으며, 그 뒤로 경골 (n=3), 두개골 (n=2), 발목 (n=1), 그리고 흉골 (n=1)이 뒤를 이었다. 누락된 손상 중에 도수 정복이나 수술과 같이 추가 치료를 필요로 하는 경우는 없었다.

결론 : 전신 뼈 스캔은 다발성 외상 환자의 누락된 뼈 손상을 발견하는데 유용하다.

핵심되는 말 : 전신 뼈 스캔, 누락된 손상, 다발성 외상

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PUBLICATION LIST

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