OTA ORTHOPAEDIC TRAUMA ASSOCIATION

OTA INTERNATIONAL
THE OPEN ACCESS JOURNAL OF ORTHOPAEDIC TRAUMA

OPEN

Skeletal surveys lack efficacy in obtunded polytrauma patients

Jakub M. Dmochowski, MD*, Cole Wendell, BS, Jennifer L. Bruggers, MD, Stephen J. Becher, MD

Abstract

Objectives: To evaluate if a skeletal survey protocol initiated after 48 hours of intubation will decrease time to diagnosis and the treatment of occult fractures in the obtunded polytrauma patient.

Design: Prospective cohort trial with a retrospective cohort comparison arm.

Setting: A single level 1 trauma center.

Patients: Forty-seven patients were identified prospectively for the skeletal survey protocol to screen for occult fractures. The results of the new protocol were compared to a retrospective comparison arm of 46 patients who would have met the same criteria.

Intervention: A skeletal survey protocol using 2-view x-rays of the patients' extremities to evaluate for any occult injuries after 48 hours of intubation in trauma patients with altered mental status and an unreliable tertiary examination.

Main Outcome Measure: Time to diagnosis of delayed fractures and surgical intervention from date of admission.

Results: The average time to fracture diagnosis and time to surgical intervention in days was not statistically significant between the retrospective and prospective groups [fracture diagnosis: 1.6 ± 5.1 (retrospective) versus 0.5 ± 0.9 (prospective) ($P = .159$); time to initial surgery: 2.7 ± 5.6 (retrospective) versus 1.1 ± 1.7 (prospective) ($P = .064$); time to final surgery: 5.3 ± 8.5 (retrospective) versus 2.4 ± 3.0 (prospective) ($P = .029$)]. In addition, only 24% (4/17) of patients with a delayed fracture diagnosis required surgical intervention making most nonoperative.

Conclusions: Given the inability to have a clinically or statistically significant impact on time to fracture diagnosis or subsequent treatment, we cannot advocate for the routine use of a skeletal survey protocol in obtunded polytrauma patients.

Level of Evidence: Level III

Keywords: obtunded, polytrauma, skeletal survey

1. Introduction

Management of the severely injured polytrauma patient is a clinically challenging task that begins with an accurate diagnosis of the patient's injuries. While life-threatening injuries take precedence during the initial work-up, a delay in diagnosis or a missed injury may lead to changes in treatment, increased morbidity, prolonged length of hospital stay, and increased healthcare costs. In addition, missed injuries are a common reason for litigation.[1,2] Many studies have shown that musculoskeletal injuries, particularly fractures in the extremities, account for a significant percentage of these delayed diagnoses.[3–11]

Initially developed in 1978, the Advanced Trauma Life Support (ATLS) guidelines were created to provide a systematic approach to evaluate the trauma patient. The goal of the primary survey is to detect and prioritize the most life-threatening injuries with a focus on the airway, breathing, circulation, and neurological status. Once stabilized, the patient is then subjected to a secondary survey whose aim is to provide a thorough "head-to-toe" examination that is intended to identify all other injuries.[12] This includes ordering appropriate radiographic studies such as x-rays and computerized tomography (CT) scans as seen fit by the trauma team. Despite this structured approach, not every injury can always be identified during the initial presentation. The exact definitions of missed injuries and delayed diagnoses can vary and as such the incidence rate has been described from 1.3% to 39%, of which between 15% and 22.3% are clinically significant requiring a change in management.[13]

In 1990, Enderson and colleagues introduced the tertiary trauma survey (TTS) as a means to more accurately measure the true incidence of missed injuries in their blunt trauma population. The TTS was able to identify 9% additional injuries missed by the primary and secondary survey with the majority being musculoskeletal in nature. They concluded that the TTS should be a routine examination in the trauma patient population to reduce the risk of missed injuries and delayed diagnoses.[5] The TTS is typically performed within 24 hours of admission and includes a thorough repeat physical examination with additional diagnostic testing as needed. Multiple studies have confirmed the utility of the TTS since its inception with many trauma centers

adopting the TTS into their trauma protocol often using a standardized form to document a thorough examination.[10,14]

Even with the addition of the TTS, missed injuries and delayed diagnoses continue to occur. Several patient characteristics have been identified in the literature as having an association leading to the increased likelihood of missed injuries or delays in diagnosis. They include the unconscious and intubated patient with severe injuries as evidenced by high injury severity scores (ISS) and low Glasgow Coma Scores (GCS).[3,4,6–9,13,15–18] Further cost-effective measures in addition to standard ATLS protocol and the TTS may be beneficial in reducing delays in fracture diagnosis and time to surgical intervention.

The purpose of this study was to determine if such an intervention, a new skeletal survey protocol, would decrease delayed diagnoses of extremity fractures and subsequently the time to surgical intervention in the obtunded polytrauma patient.

2. Patients and methods

The institutional review board approved this single-center prospective cohort trial with a retrospective cohort comparison arm conducted at a level one trauma center in a major metropolitan city. The prospective cohort trial was conducted from July 1, 2016, to July 31, 2017, after the implementation of a new skeletal survey protocol instituted by the trauma team designed to prevent missed and delayed diagnosis of fractures. The data collection end point was selected at 1 year in the prospective arm for comparison to a retrospective arm of the same time frame which corresponded to our institution's incorporation of a standardized electronic medical system. Inclusion criteria for the skeletal survey protocol included trauma patients with: long bone or pelvic fracture(s) discovered upon initial primary and secondary surveys, altered mental status on arrival (GCS<15), 3) intubation for >48 hours consecutively after arrival into the trauma bay, and age ≥16.

Trauma patients qualifying for the skeletal survey protocol received 2-view x-rays of bilateral feet, tibia/fibula, femur, humerus, radius/ulna, and hands after 48 hours of admission unless these x-rays had previously been performed during the trauma work-up. The x-rays were interpreted by orthopaedic surgery residents, one orthopaedic surgery attending, and a formal read by a radiologist.

Injuries detected by the skeletal survey x-rays were classified as a "delayed diagnosis" and tracked to see if they required surgical intervention or conservative management. Patient demographics for those qualifying for the skeletal survey were also recorded including age, sex, injury severity score (ISS), mechanism of injury, initial orthopaedic injuries, presence of open fractures, number of initial fractures, delayed orthopaedic injuries, number of delayed fractures, days to final fracture diagnosis, days to first initial orthopaedic injury surgery, days to final initial orthopaedic injury surgery, and total days intubated.

For the retrospective cohort comparison arm, the trauma registry at Atlanta Medical Center was queried to identify trauma patients meeting the following criteria: pelvic and/or long bone fracture(s), intubated >48 hours, age ≥16, and were alive on their date of discharge from June 1, 2015 to June 30, 2016. This generated a list of 121 patients whose charts were then retrospectively reviewed to see if they would have qualified for the skeletal survey protocol as defined by the prospective guidelines. The same patient demographics were recorded as for the prospective group with summarized results from both displayed in Table 1. Delayed diagnoses were defined as injuries

Table 1

Patient demographics

	Retrospective arm	Prospective arm	P value
Number of patients	46	47	
Average age	37.9±16.5	38.3±17.1	.908
Sex (M/F)	31/15	29/18	.566
Injury severity score	24.4±10.2	23.3±9.0	.585
Mechanism			
MVC	23	28	
PVA	9	7	NS
MCC	4	9	
FFH	6	2	
Other	4	1	
Number of patients with delayed fractures	6 (13%)	11 (23%)	
Total number of delayed fractures	11	12	

FFH = fall from height, MCC = motorcycle accident, MVC = motor vehicle accident, NS = not significant, PVA = pedestrian versus auto.

seen on x-rays taken >24 hours after initial presentation to the trauma bay not otherwise reported in the medical record during chart review. Exclusion criteria included penetrating trauma for both the prospective and retrospective arms of the study.

2.1. Statistical analysis

Statistical calculations were conducted using SAS 9.4 (SAS Institute, Cary, NC). Continuous outcomes were compared across the patient groups by independent sample t-tests: patient demographics, the number of delayed fractures, time to delayed fracture diagnosis, time to initial operative intervention of fractures, and time to final operative intervention of fractures between the prospective and retrospective cohort arms. A Bonferroni-adjusted significance level of 0.0125 was used for determining statistical significance to control for the large number of outcomes in the analyses.

3. Results

There were 121 patients initially identified using the AMC trauma registry database for the retrospective cohort arm of the study. After reviewing patient records, 75 patients were excluded from analysis. Of these, 55 patients had a reliable initial physical exam and were later intubated during their hospital stay or were extubated prior to 48 hours of admission, 7 died prior to 48 hours of admission, 5 had injuries relating to penetrating trauma, 4 had incorrect diagnoses of fractures listed in the registry, 2 were transferred to other facilities prior to 48 hours, and 2 were under the age of 16 upon presentation. This left a total of 46 patients meeting our criteria. There were 31 males and 15 females with an average age of 37.9±16.5 years at the time of presentation. Average ISS score was 24.4±10.2 and the most common mechanism of injury was motor vehicle collision. The average number of initial fractures per patient discovered in the first 24 hours was 3.0±2.3 with a total of 19 open fractures. Of these patients 13% (6) were found to have a delayed diagnosis.

The prospective cohort arm, featuring the skeletal survey protocol, consisted of 47 patients. There were 29 males and 18 females having an average age of 38.3±17.1 years. Average ISS score was 23.3±9.0 with the most common mechanism of injury also being motor vehicle collision. The mean number of initial fractures per patient was 2.3±1.5 with a total of 18 open

Table 2

Retrospective arm delayed fracture characteristics

Patient number	Fracture location	Operative (y/n)
1	Scaphoid waist	n
2	Proximal fibula	n
	Fifth metatarsal shaft	n
	Knee dislocation	y
3	Small finger P1	n
4	Small finger metacarpal neck	n
5	Distal third fibular shaft	n
6	Long finger metacarpal base	n
	Ring finger metacarpal base	n
	Fifth metatarsal base	n
	Proximal third scaphoid with dislocation	y

fractures. Using the skeletal survey protocol, 23% (11) of patients were found to have delayed diagnoses. Demographic data comparing the 2 arms of the study are shown in Table 1, with no statistical significance between the 2 populations of patients. A description of the delayed fractures/injuries for the retrospective and prospective cohort arms are shown in the Tables 2 and 3, respectively. The most common anatomic region for missed fractures was the hand/wrist in both groups. Of all the injuries, 2 required surgical intervention in each group.

We also analyzed the time to delayed fracture diagnosis and treatment as outlined in Table 4. Although the average time to delayed fracture diagnosis and treatment appeared to be shorter in the prospective arm, statistical analysis showed that these results were not statistically significant. The average time to delayed fracture diagnosis was 1.6 ± 5.1 days in the retrospective group and 0.5 ± 0.9 for the prospective group with a P value of .159. The average time to first initial injury surgery was 2.7 ± 5.6 days for the retrospective group and 1.1 ± 1.7 days for the prospective group with a P value of .064. The average time to final initial injury surgery was 5.3 ± 8.5 days for the retrospective group and 2.4 ± 3.0 days for the prospective arm with a P value of .029.

4. Discussion

There have been numerous studies in the trauma literature focusing on missed injuries. Through these efforts many causes for delayed diagnoses have been identified and subsequently aided in the development of standardized protocols to address these issues. Multiple studies have shown that the population at

Table 3

Prospective arm delayed fracture characteristics

Patient number	Fracture location	Operative (y/n)
1	Fibular head	n
2	Humeral shaft	n
3	Small finger P1	y
	Patella	n
4	Radial shaft	y
5	Distal radius	n
6	Distal radius	n
7	Small finger metacarpal shaft	n
8	Tibial plateau	n
9	Radial head	n
10	Distal fibula	n
11	Distal radius	n

Table 4

Timing of fracture diagnosis and treatment

	Retrospective arm	Prospective arm	P value
Average time to delayed fracture diagnosis, days	3.6 ± 5.1	2.5 ± 0.9	.159
Average time to first initial injury surgery, days	4.7 ± 5.6	3.1 ± 1.7	.064
Average time to final initial injury surgery, days	7.3 ± 8.5	4.4 ± 3.0	.029

greatest risk for missed injuries is frequently the multiply injured and obtunded patient unable to participate in their own assessment. Furthermore, some of the most frequently missed injuries involve the musculoskeletal system, particularly fractures of the extremities.[3–11]

Attempts have been made to use radiographic examinations in order to reduce missed or occult fractures. These have included bone scans,[19] whole body CT scans[20] in adults and skeletal surveys in the pediatric population.[21] The use of pelvic CT scans in trauma patients has become standard at many institutions with studies showing a reduction in the incidence of missed pelvic or hip injuries from 1980s to the 2000s.[13] An ideal screening test would be of minimal morbidity and cost to the patient while having a meaningful effect on treatment. The cost at our institution of a skeletal survey as performed in the study is $120 representing minimal increased cost. The dose of radiation for a complete skeletal survey is <3 mSV[22] which represents an extremely low added risk.[23] Thus, the skeletal survey is a low risk, low cost test that could augment the gold standard protocol of primary, secondary and tertiary surveys in the appropriate patient. While not a substitute for a thorough physical exam, it would offer more information, particularly in patients unable to communicate sites of pain.

Our results demonstrated that both groups of patients had similar characteristics as expected in regard to age, sex, ISS scores, and mechanisms of injury. The number of patients with delayed fracture diagnoses was higher in the prospective group (23%) compared to the retrospective group (13%), which is consistent with previous studies that support this finding.[5] Presumably, some fractures may have been missed particularly in patients with serious injuries requiring extended periods of intubation and sedation. We did not have access to clinical records after patients' discharge from the hospital where more fractures could have been discovered.

Interestingly, although the total number of patients with delayed fractures in the prospective group was higher, our results revealed that the retrospective group had a higher number of delayed fractures per patient as seen in Tables 2 and 3. The most common area of delayed fracture diagnosis was the hand/wrist region which is not unexpected, given the smaller size of the bones and increased difficulty in physical examination. Of the delayed fractures, 2 in each group required surgical intervention.

The skeletal survey was not found to have a significant effect on the time to diagnosis of missed fractures or subsequent time to surgical intervention. While there did appear to be a trend showing decreased time to initial and final surgery in the prospective group, this could not be solely attributed to the skeletal survey as there are multiple factors that influence how quickly a patient may be able to go to surgery. Overall, we cannot advocate the use of skeletal surveys as an adjunct to standard physical exam protocols in obtunded polytrauma patients given the lack of significant effect on diagnosis. In addition, the difference between diagnoses in the 2 groups was about 1 day. An

argument can be made that a single day of delayed diagnosis for a fracture will probably not have a major impact on the patients overall course of care. Further screening tests will have to have a much higher impact on the time to diagnosis in order to be clinically relevant. In addition, it took approximately 4 patients being screened for 1 missed fracture to be found, and 24 patients being screened to find one operative missed fracture at a cost of $120 per patient and 3 mSv of radiation exposure per patient. Acceptable levels of cost and radiation exposure are variable across practice settings. Given the lack of clinically significant impact on length of stay, cost, and radiation exposure, these factors did not weigh into our recommendation against the use of the skeletal survey as a screening test.

This study did have several limitations. Firstly, there was no randomization of patients receiving the skeletal survey protocol in the prospective group. Randomization would have created a better comparison group among prospective patients; however, this was not able to be done given our hospital protocol policy. Secondly, our sample size was small and given the low incidence of delayed fracture diagnoses, this resulted in a large range in time to diagnosis, particularly in the retrospective group, which could have skewed our statistical analysis. A larger study may be able to detect a smaller effect size. Lastly, it was difficult to determine if a direct correlation between earlier detection of fractures with delayed diagnosis influenced time to surgical intervention. Obtunded polytrauma patients, by nature, have complex medical and surgical problems that delay surgical intervention unrelated to timing of fracture diagnosis.

5. Conclusions

To our knowledge this is the only study evaluating skeletal surveys as a means to decrease delays in fracture diagnosis. Such delays should always be minimized in order to decrease hospital stay and patient morbidity and mortality. Useful screening tests, in addition to standard physical exam protocols, have not been fully defined and studied. Our use of the skeletal survey in this population represented a novel use of an inexpensive screening test with low radiation exposure. However, given the inability to have either a clinically or statistically significant impact on the time to finding a missed fracture or subsequent treatment, we cannot advocate for its routine use in obtunded polytrauma patients.

Acknowledgments

References

1. Berlin L, Berlin JW. Malpractice and radiologists in Cook County, IL: trends in 20 years of litigation. AJR Am J Roentgenol. 1995;165:781–788.
2. Karcz A, Korn R, Burke MC, et al. Malpractice claims against emergency physicians in Massachusetts: 1975–1993. Am J Emerg Med. 1996;14:341–345.
3. Brooks A, Holroyd B, Riley B. Missed injury in major trauma patients. Injury. 2004;35:407–410.
4. Buduhan G, McRitchie DI. Missed injuries in patients with multiple trauma. J Trauma Injury Infect Crit Care. 2000;49:600–605.
5. Enderson BL, Reath DB, Meadors J, et al. The tertiary trauma survey: a prospective study of missed injury. J Trauma. 1990;30:666–670.
6. Giannakopoulos GF, Saltzherr TP, Beenen LFM, et al. Missed injuries during the initial assessment in a cohort of 1124 level-1 trauma patients. Injury. 2012;43:1517–1521.
7. Houshian S, Larsen MS, Holm C. Missed injuries in a level one trauma center. J Trauma Injury Infect Crit Care. 2002;52:715–719.
8. Janjua KJ, Sugrue M, Deane SA. Prospective evaluation of early missed injuries and the role of tertiary trauma survey. J Trauma Injury Infect Crit Care. 1998;44:1000–1007.
9. Rizoli SB, Boulanger BR, McLellan BA, et al. Injuries missed during initial assessment of blunt trauma patients. Accid Anal Prev. 1994;26:681–686.
10. Biffl WL, Harrington DT, Cioffi WG. Implementation of a tertiary trauma survey decreases missed injuries. J Trauma Injury Infect Crit Care. 2003;54:38–44.
11. Ward WG, Nunley JA. Occult orthopaedic trauma in the multiple injured patient. J Orthop Trauma. 1991;5:308–312.
12. Advanced Trauma Life Support: Student Course Manual. 9th ednChicago, IL: American College of Surgeons; 2012.
13. Pfeifer R, Pape HC. Missed injuries in trauma patients: a literature review. Patient Saf Surg. 2008;2:20.
14. Keijzers GB, Campbell D, Hooper J, et al. A prospective evaluation of missed injuries in trauma patients, before and after formalising the trauma tertiary survey. World J Surg. 2014;38:222–232.
15. Vles WJ, Veen EJ, Roukema JA, et al. Consequences of delayed diagnoses in trauma patients: a prospective study. J Am Coll Surg. 2003;197:596–602.
16. Reid DC, Henderson R, Saboe L, et al. Etiology and clinical course of missed spine fractures. J Trauma. 1987;27:980–986.
17. Kalemoglu M, Demirbas S, Akin ML, et al. Missed injuries in military patients with major trauma: original study. Mil Med. 2006;171:598–602.
18. Robertson R, Mattox R, Collins T, et al. Missed injuries in a rural area trauma center. Am J Surg. 1996;172:564–568.
19. Lee KJ, Jung K, Kim J, et al. Bone scan as a screening test for missed fractures in severely injured patients. Orthop Traumatol Surg Res. 2014;100:953–957.
20. Eurin M, Haddad N, Zappa M, et al. Incidence and predictors of missed injuries in trauma patients in the initial hot report of whole-body CT scan. Injury. 2012;43:73–77.
21. Paine CW, Wood JN. Skeletal surveys in young, injured children: a systematic review. Child Abuse Negl. 2017;76:237–249.
22. Mettler FA, Huda W, Yoshizumi TT, et al. Effective doses in radiology and diagnostic nuclear medicine: a catalog. Radiology. 2008;248:254–263.
23. National Research CouncilHealth Risks from Exposure to Low Levels of Ionizing Radiation. BEIR VII Phase 2. Washington, DC: National Academies Press; 2006.