Implementation of a Tertiary Trauma Survey Decreases Missed Injuries

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Background: **Missed injuries (MIs) adversely affect patient outcome and damage physician/institutional credibility. The primary and secondary surveys are designed to identify all of a patient's injuries and prioritize their management; however, MIs are prevalent in severely injured and multisystem trauma patients, especially when the patient's condition precludes completion of the secondary survey. We hypothesized that implementation of a routine tertiary trauma survey (TS) would reduce the incidence of MIs in a Level I trauma center.**

Methods: **In mid 1999, a TS form was created and TS documentation was mandated on all trauma intensive care unit (TICU) patients within 24 hours of admission. Patient data, including TS documentation and injury patterns, were concurrently recorded in an institutional trauma registry. Data were compared for patients admitted in 1997 to 1998 (PRE period) and 2000 to 2001 (POST period) using χ^2 or Student's *t* test.**

Results: **MIs decreased from 2.4% to 1.5% overall, and from 5.7% to 3.4% in TICU patients, after TS implementation. Patients with MIs were slightly older (49 vs. 45 years; $p > 0.05$) and had higher Injury Severity Scores (21 vs. 10; $p < 0.05$) than patients without MIs. Sixty percent of MI patients had brain injuries, 56% were admitted to the TICU, and 26% went directly from the emergency department to the operating room. The large majority of MIs in the POST period were detected in patients not undergoing timely TS.**

Conclusion: **ICU patients—particularly brain injury victims and those undergoing emergent surgical procedures—appear to be at highest risk for MI. Implementation of a standardized TS decreased MIs by 36% in our Level I trauma center, and more timely TS would likely have further reduced MIs. A TS should be routine in trauma centers.**

Key Words: **Tertiary trauma survey, Missed injuries.**

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Missed injuries (MIs) have been referred to as "the trauma surgeon's nemesis."[1,2] Although not frequently life-threatening, they may result in significant long-term disability. Furthermore, a MI may stand out as the most memorable event in a patient's course, overshadowing the heroic efforts of the trauma surgeon and trauma team. In addition to proving embarrassing to the surgeon and institution, MIs are a common reason for litigation.[3,4]

The American College of Surgeons Advanced Trauma Life Support (ATLS) course provides a framework for the systematic evaluation of injured patients.[5] The primary survey is designed to recognize and treat immediately life-threatening problems within minutes of arrival. The secondary survey is described as a head-to-toe examination, including "tubes and fingers in every orifice," and is intended to diagnose all injuries before formulating a definitive management strategy. Unfortunately, it is widely recognized that not every injury is identified at the time of presentation. Several factors contribute to this, including the following: urgent treatment priorities abbreviate the initial assessment; altered sensorium precludes a meaningful secondary survey; clinicians miss or underappreciate physical findings; and radiologic studies are not performed, are inadequate, or are misinterpreted.

In 1990, Enderson and colleagues[6] reported a prospective study of MIs, in which they identified additional injuries in 9% of a blunt trauma population by performing a tertiary survey (TS). Enderson and colleagues recommended routine TS for trauma patients to reduce the risk of patients leaving the hospital with undiagnosed injuries. On the basis of the hypothesis that it would reduce MIs, a standardized TS was implemented in our Level I trauma center. The purpose of this study was to determine whether the performance of a TS reduces MIs.

MATERIALS AND METHODS

Institution

Rhode Island Hospital (RIH) is a 719-bed acute-care hospital. It is the only American College of Surgeons–verified Level I trauma center in the state of Rhode Island and serves as a regional trauma referral center for southeastern New England. The RIH trauma registry has been prospectively maintained since 1991 and contains comprehensive data on all trauma patients admitted to the hospital.

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Table 1 **Demographic Information on Patients with MIs Compared with Those without MIs, before (PRE) and after (POST) Implementation of a Formal Tertiary Trauma Survey**

	PRE (1997–1998)			POST (2000–2001)		
	MI	No MI	Total	MI	No MI	Total
No. of patients	81	3,331	3,412	52	3,390	3,442
Age (yr)	49.1 ± 3.5	44.9 ± 0.5	45.3 ± 0.5	47.7 ± 4.3	44.4 ± 0.5	44.5 ± 0.5
No. of men (%)	53 (65)	2,084 (63)	2,137 (63)	34 (65)	2,180 (64)	2,214 (64)
ISS	20.2 ± 2.1	9.9 ± 0.2*	10.7 ± 0.3	21.8 ± 2.0	10.6 ± 0.3*	10.7 ± 0.3

ISS, Injury Severity Score.
* $p < 0.05$ compared with MI.

Tertiary Trauma Survey

In mid 1999, a standardized TS form was created and a TS policy implemented (see Appendix). The policy mandated documentation of the TS—a complete head-to-toe examination with additional radiographic or other investigation as necessary—on all patients admitted to the trauma intensive care unit (TICU) within 24 hours of admission and before discharge from the TICU. Soon thereafter, the TS began to be performed on all trauma service patients, even if not in the TICU.

The RIH trauma registry was queried to provide data on all trauma patients admitted during the 2 years preceding the adoption of the TS (PRE period, 1997–1998), and the 2 years after its implementation (POST period, 2000–2001). The year 1999 was excluded, as the TS was being "phased in." Missed injuries were prospectively tracked by the trauma registry as a routine quality improvement audit filter. Missed injuries were defined as injuries identified more than 24 hours after admission, or injuries that escaped detection by the TS. Demographic data were collected on patients with and without MIs; additional data were collected on patients with MIs.

Statistical Analysis

Trauma registry data are maintained in TRACS (American College of Surgeons, Chicago, IL). Registry records were reviewed from January 1997 to December 2001. Statistical analysis was performed using GB-Stat version 6.5 (Dynamic Microsystems, Inc., Silver Spring, MD). Dichotomous variables were compared using χ^2 or Fisher's exact test, where appropriate. Continuous variables were compared using Student's *t* test. Significance of statistical differences was defined as $p < 0.05$.

RESULTS

Similar numbers of trauma patients were admitted to RIH in the PRE (3,412 patients) and POST (3,442 patients) periods. The ratio of blunt to penetrating mechanisms has remained fairly constant at 90:10. The majority of patients (64%) were men, and their average age (45 years) and Injury Severity Score (ISS) (10.7) were not different between PRE and POST periods. Patients with MIs were slightly older (48.5 ± 3.8 years vs. 44.6 ± 0.5 years; $p > 0.05$), and had higher ISSs (20.8 ± 2.1 vs. 10.3 ± 0.3; $p < 0.05$) compared with patients without MIs; these differences were consistent from the PRE period to the POST period (Table 1). The incidence of MI was 2.4% in the PRE period, and decreased to 1.5% in the POST period ($p < 0.05$).

In the POST period, as compared with the PRE period, a greater proportion of patients were admitted to the TICU (30% vs. 20%; $p < 0.05$). There was a higher incidence of MIs in the TICU patients (4.3%) than in the non-TICU patients (1.1%) ($p < 0.05$). Those admitted to the TICU in the POST period had a lower mean ISS than those admitted in the PRE period (16.4 ± 0.5 vs. 18.8 ± 0.7; $p < 0.05$) (Table 2). The trends between those with MIs and those without (i.e., slightly higher age and significantly higher ISS) were the same for TICU patients as for the overall population of trauma admissions. The incidence of MIs among TICU patients was lower in the POST period compared with the PRE period (3.4% vs. 5.7%, $p < 0.05$).

Table 2 **Demographic Information on TICU Patients with MIs Compared with Those without MIs, before (PRE) and after (POST) Implementation of a Formal Tertiary Trauma Survey**

	PRE (1997–1998)			POST (2000–2001)		
	MI	No MI	Total	MI	No MI	Total
No. of patients	39	651	690	36	1,012	1,048
Age (yr)	44.9 ± 4.4	43.0 ± 1.2	43.2 ± 1.2	48.2 ± 5.0	42.2 ± 0.9	42.3 ± 0.9
No. of men (%)	29 (74)	448 (69)	477 (69)	22 (61)	703 (69)	725 (69)
ISS	27.9 ± 3.0	18.7 ± 0.7*	18.8 ± 0.7	24.7 ± 2.4	16.4 ± 0.5*	16.4 ± 0.5

ISS, Injury Severity Score.
* $p < 0.05$ compared with MI.

Table 3 Frequency of Various Body Region Injuries before (PRE) and after (POST) Implementation of a Formal Tertiary Trauma Survey

	PRE (1997–1998)	POST (2000–2001)
Extremity fracture	31	27
Spine fracture	16	8
Abdominal injury	16	9
Cervical spine injury	12	4
Brain injury	10	3
Pelvic fracture	5	0
Vascular injury	3	1
Diaphragm rupture	3	0
Total Injuries	96	59

The distribution of MIs is listed in Table 3. All categories of MI were less frequent in the POST period, although numbers were small and differences not statistically significant. Whereas extremity injuries constituted 32% of missed injuries in the PRE period, they accounted for 46% of MIs in the POST period.

In Table 4, factors associated with MIs are reviewed. Brain injury was present in 60% of patients with MIs; 56% of patients with MIs had been admitted to the TICU, and 26% had gone directly from the emergency department to the operating room.

DISCUSSION

The American College of Surgeons ATLS course provides a framework for the diagnosis and treatment of immediate threats to life and for the systematic identification of injuries to formulate a definitive management plan. Although the fundamental tenets of the ATLS course are widely known and practiced, it is recognized that a finite number of injuries escape detection during the initial assessment. It is difficult to determine exactly how often this occurs, but a number of investigators have reported MI rates ranging from 1.4% to 14% in patients with multiple injuries.[6–12] The consequences of MIs range from embarrassment and ill will to long-term disability and death, emphasizing the importance of timely detection.

There are a number of factors that contribute to MIs. The presence of life- or limb-threatening injuries or severe shock may necessitate immediate operative intervention or transfer to the TICU before the completion of the secondary survey. Altered sensorium, because of brain injury, intoxication, or sedation, often precludes a meaningful secondary survey, as patient complaints of pain or tenderness cannot be elicited. Similarly, traumatic or pharmacologic paralysis compromises the physical examination. In addition, factors such as inexperience or low level of suspicion on the part of the clinician, and radiologic errors (e.g., failure to perform studies, inadequate films, misinterpretations), have been implicated in the occurrence of MIs. In the present series, 60% of patients with MIs had head injuries and 26% required emergent surgery. In addition, 56% required TICU admission, indicating the presence of shock, the need for sedation or mechanical ventilation, and/or multiple distracting injuries.

Table 4 Factors Associated with Missed Injuries

	MI (%)	No MI (%)	*p* Value
No. of patients	133	6,721	—
Brain injury	80 (60)	2,094 (31)	< 0.05
TICU admission	75 (56)	1,663 (25)	< 0.05
ED to OR	35 (26)	1,106 (16)	< 0.05
ISS	20.8 ± 2.1	10.3 ± 0.3	< 0.05

ED to OR, direct transfer from emergency department to operating room; ISS, Injury Severity Score.

In 1990, Enderson and colleagues[6] reported that TS identified additional injuries in 9% of their blunt trauma patients, and they proposed that a TS should be performed on every trauma patient to avoid MIs. On the basis of our data, we agree with this assessment. Our policy initially applied only to TICU patients; this subset has the most risk factors for MIs. However, we quickly realized that the TS was effective in identifying new injuries, and the TS policy was generalized to all trauma service patients. In so doing, we have decreased our MI rate by 39% in the TICU and 36% overall. In the POST period, we have noted a shift in the types of MIs such that extremity fractures now constitute nearly one half of all MIs (as compared with 32% in the PRE period). The most significant reductions have been in cervical spine injuries, brain injuries, and pelvic/hip fractures. Unfortunately, the MIs in the POST period largely represent a failure of compliance with the policy. In 2001, 19 of 24 MIs occurred in patients who did not have timely performance of the TS. Of the five patients who had TS, two had intra-abdominal MIs (liver laceration and duodenal injury), and three had missed fractures (clavicle, patella, and radius/ulna). This underscores the importance of performing a thorough TS. It also exposes a potential weakness of our policy: by mandating TS within 24 hours, we examine some patients who are not yet ambulatory and who may still have altered mental status. Thus, an additional TS should be performed when patients are ambulatory and have regained consciousness.

Previous discussions regarding this topic have questioned the significance of many MIs and challenged whether or not patient outcomes are significantly impacted by their detection. We submit that no matter how trivial an injury might seem to the trauma surgeon, the patient may feel quite differently. This could lead to ill will between the patient and the physician or institution, and potentially to litigation. The TS costs nothing but time; it is part of good patient care, and should be performed routinely in trauma patients. It may detect new injuries, avoiding adverse outcomes for both patients and physicians.

APPENDIX

RHODE ISLAND HOSPITAL

TERTIARY SURVEY OF TRAUMA PATIENT

Date: _____ Attending: _____

1. HEAD

a. GCS (circle)

Eye Opening	**Motor Response**	**Verbal Response**
Spontaneous = 4	Obeys commands = 6	Oriented = 5
To voice = 3	Localizes pain = 5	Confused = 4
To pain = 2	Withdraws to pain = 4	Inappropriate words = 3
None = 1	Flexion to pain = 3	Incomprehensible sounds = 2
	Extension to pain = 2	None = 1
	None = 1	

GCS _____

For all boxes checked on right, please address in comment section

COMMENTS

b. Inspect and palpate SCALP for

	none	present
lac/abrasion	☐	☐
swelling	☐	☐
ecchymosis	☐	☐
fractures	☐	☐

c. Inspect and palpate FACE for

	none	present
lac/abrasion	☐	☐
swelling	☐	☐
ecchymosis	☐	☐
fractures	☐	☐

d. Examine EYES. Record:

	unassessible	appropriate	inappropriate
eye movement	☐	☐	☐
pupil size/reaction	☐	☐	☐
visual acuity	☐	☐	☐

e. Inspect MOUTH for

	unassessible	none	present
malocclusion	☐	☐	☐
teeth problems	☐	☐	☐
CSF leak, hemotympanum	☐	☐	☐

2. NECK

a. Inspect for

	none	present
lac/abrasion	☐	☐
hematoma	☐	☐
swelling	☐	☐
subcutaneous air	☐	☐

	unassessible	none	present
b. tenderness	☐	☐	☐

	yes	no
c. C-spine cleared radiographically	☐	☐
d. C-spine cleared clinically	☐	☐

3. CHEST

a. Inspect for

	none	present
lac/abrasion	☐	☐
swelling	☐	☐
ecchymosis	☐	☐
subcutaneous air	☐	☐

b. Palpate for tenderness or deformity

	none	present
ribs	☐	☐
sternum	☐	☐
clavicle	☐	☐
flail	☐	☐
paradoxical movement	☐	☐

c. **CXR**

	none	present
HTX/PTX	☐	☐
mediastinal abnormality	☐	☐

RHODE ISLAND HOSPITAL

TERTIARY SURVEY OF TRAUMA PATIENT

4. ABDOMEN — **COMMENTS**

a. Inspect for

	none	present
lac/abrasion		
swelling		
ecchymosis		

b. Palpate for

	none	present
tenderness/guarding		
masses		

c. **PELVIS**

	stable	unstable
stability		

	none	present
radiographic clearance		

5. BACK (log roll with spinal immobilization)

a. Inspect back of head/entire back for

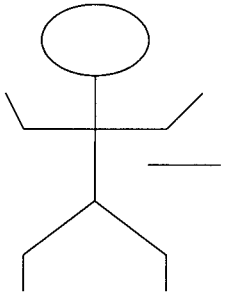
	none	present
lac/abrasion		
swelling		
ecchymosis		

b. Palpate for tenderness and deformity:

	none	present
vertebrae (T-L-S spine)		
ribs		

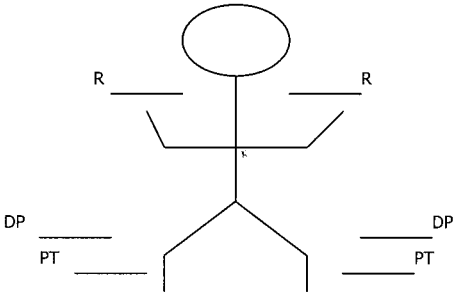
6. EXTREMITIES

Lacs, abrasions, swelling, ecchymosis (number and notate below)

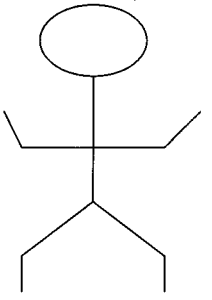


1.) _____
2.) _____
3.) _____
4.) _____

Pulses (+/-)



Tenderness, pain with motor, instability (number and notate below)



1.) _____
2.) _____
3.) _____
4.) _____

7. PERIPHERAL NERVES

	Motor		Sensation	
Nerve	Normal	Abnormal	Normal	Abnormal
ulnar				
median distal				
median, anterior interosseus				
musculocutaneous				
radial				
axillary				
femoral				

	Motor		Sensation	
	Normal	Abnormal	Normal	Abnormal
obturator				
posterior tibial				
superficial peroneal				
deep peroneal				
sciatic nerve				
superior gluteal				
inferior gluteal				

_____ Resident physician name and signature

_____ Date and time of admit

_____ Date and time of survey

_____ Attending physician and signature

_____ Service

REFERENCES

1. Enderson BL, Maull KI. Missed injuries: the trauma surgeon's nemesis. *Surg Clin North Am.* 1991;71:399–418.
2. Scalea TM, Phillips TF, Goldstein AS, et al. Injuries missed at operation: nemesis of the trauma surgeon. *J Trauma.* 1988;28:962–967.
3. 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.
4. 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.
5. American College of Surgeons. Initial assessment and management. In: *Advanced Trauma Life Support Program for Doctors*. 6th ed. Chicago, IL: American College of Surgeons; 1997.
6. Enderson BL, Reath DB, Meadors J, et al. The tertiary trauma survey: a prospective study of missed injury. *J Trauma.* 1990; 30:666–670.
7. Aaland MO, Smith K. Delayed diagnosis in a rural trauma center. *Surgery.* 1996;120:774–779.
8. Born CT, Ross SE, Iannacone WM, et al. Delayed identification of skeletal injury in multisystem trauma: the 'missed' fracture. *J Trauma.* 1989;29:1643–1646.
9. Buduhan G, McRitchie DI. Missed injuries in patients with multiple trauma. *J Trauma.* 2000;49:600–605.
10. Houshian S, Larsen MS, Holm C. Missed injuries in a level I trauma center. *J Trauma.* 2002;52:715–719.
11. Rizoli SB, Boulanger BR, McLellan BA, et al. Injuries missed during initial assessment of blunt trauma patients. *Accid Anal Prev.* 1994;26:681–686.
12. Roberston R, Mattox R, Collins T, et al. Missed injuries in a rural area trauma center. *Am J Surg.* 1996;172:564–568.

DISCUSSION

Dr. Blaine L. Enderson (Knoxville, Tennessee): In 1989, I stood before this Association with some trepidation as I aired our dirty laundry from Tennessee and talked about missed injuries. ATLS protocol with the primary and secondary trauma survey should detect all injuries that a patient has sustained, yet we found that 9% of our patients had injuries that were discovered later, which we classified as "missed injuries." Although there was some debate over the term "missed injury," we did identify factors which could lead them including severe shock, the need for immediate operative intervention, or altered level of consciousness. To overcome this problem, we proposed that a high index of suspicion was necessary to search for missed injuries and that a tertiary trauma survey be done to try to identify these injuries. The authors of this paper demonstrated that 13 years later, missed injuries still occur, but use of a formal tertiary survey can reduce their incidence.

I do have several questions. In your manuscript, you noted that institution of a formal tertiary survey decreased your missed injury rate significantly, both in your intensive care population and your trauma population as a whole. You also show the distribution of missed injuries before and after tertiary survey. Do you have any data on how many and what type of specific injuries were detected by your formal tertiary survey?

Since you collected data prospectively after institution of the tertiary survey you may have had the opportunity to identify this information as well as to identify specific findings on the tertiary survey that are more likely to reveal missed injuries and justify a further work up. Your missed injury rate is lower than ours was, and it was somewhat lower than many rates noted in the literature. Do you think this is related to your definition of missed injury or to a higher baseline suspicion that injury may exist and the search for it?

You note that the mandated tertiary survey at 24 hours may still miss injuries in patients who remain unconscious. Have you instituted a policy to do an additional tertiary survey when patients are ambulatory and have regained consciousness as you suggest in your manuscript? Do you think there may be any role for increased diagnostic testing such as bone scan to provide skeletal surveys in patients with prolonged coma?

I would like to congratulate the authors for their fine work reconfirming the value of tertiary survey.

Dr. Robert C. Mackersie (San Francisco, California): I have a question that relates to the issue of time consumption—just how time consuming doing these surveys are. Have you accounted for the amount of time spent, particularly now in the era of house staff work hour reduction? Who is doing these surveys? Is it the house staff, the nurse practitioners, or Pas, etc.?

Dr. Walter L. Biffl (Providence, Rhode Island): Thank you for the questions. I'll address Dr. Enderson's first. Regarding the question of how many and what type of injuries we detected with the tertiary survey, it was primarily fractures. We made great strides in detecting spinal fractures, in particular, in the later period. This was partially due to spinal survey protocols that were instituted. The low missed injury rate in our series is related in part to the definition. Many groups, including Dr. Enderson's, defined missed injuries as those that were picked up by a tertiary survey. In contrast, we defined missing injuries as those that were missed by a tertiary survey. While we haven't achieved perfection, I think we've come closer.

The comatose or nonambulatory patient is difficult to examine. Consequently, the tertiary survey must be repeated as the patient becomes ambulatory and regains consciousness. It is important to perform the survey within 24 hours, to detect skeletal deformities, investigate drifting hemoglobins, look for intra-abdominal injuries, and so on, but the repeated exams are necessary. The survey takes a little bit of time, but not much more than the daily physical examination.

We have just hired a nurse practitioner and our expectation is that that individual will start to help decompress some of the house staff workload.

Dr. Glen Tinkoff (Newark, Deleware): I applaud the authors on their contribution to this important subject. I'm wondering about the process by which the tertiary exam is performed. How is this different? Who really does it? Who does the documentation? How is it communicated? How is it

acted upon? Is it a separate sheet? Is it a separate document? Also, did you look at which missed injuries were "clinically significant," those that changed the outcome? Lastly, is this a sustainable process?

Dr. Walter L. Biffl (Providence, Rhode Island): The reproduction I showed earlier was a bit blurry, but it is a separate form. It's a check-box form that lists all the body areas with room for notations including the need for x-rays and other studies. It is signed by the house staff as well as the trauma attending.

Dr. Glen Tinkoff (Newark, Deleware): Did you look at clinical significance?

Dr. Walter L. Biffl (Providence, Rhode Island): In 2001, one patient who required a trip to the operating room would have probably benefited from an earlier operation. Otherwise, the large majority were extremity fractures that didn't require operative management.

Dr. Glen Tinkoff (Newark, Deleware): Have you found it sustainable in the process of review?

Dr. Walter L. Biffl (Providence, Rhode Island): Absolutely, in fact, compliance has steadily improved as everybody has recognized its utility.

Dr. Brian Troop (St. Louis, Missouri): Thank you for this important study. I'm surprised your incidence is so low. I suspect it's because you only looked at primarily verifiable injuries and not necessarily soft-tissue injuries such as contusions and abrasions, which sometimes causes some consternation to families when they go home. More specifically, is a definition of a missed injury, if it is found within the first 24 hours, really missed? How about at 48 hours? Last, does your evaluation tertiary survey include a review of all the radiographs that were done the previous night?

Dr. Walter L. Biffl (closing): We defined missed injury as one that was not identified in the first 24 hours or not identified by the tertiary survey, so if the survey was done at 12 hours, anything missed by the survey counted as a missed injury. If the survey wasn't performed, everything identified after 24 hours was counted as a missed injury.

Contusions and abrasions are usually clinically obvious and do not warrant any special treatment. A review of admission radiographs is routine on all patients. New findings are not recorded on the tertiary survey form, but rather, they are entered in the progress notes.