PAPER

Whole Body Imaging in Blunt Multisystem Trauma Patients Without Obvious Signs of Injury

Results of a Prospective Study

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Hypothesis: The use of liberal whole body imaging (pan scan) in patients based on mechanism is warranted, even in evaluable patients with no obvious signs of chest or abdominal injury.

Design: Prospective observational study.

Setting: Academic level I trauma center.

Patients: All patients admitted following blunt multisystem trauma.

Intervention: Pan scan, including computed tomography (CT) of the head, cervical spine, chest, abdomen, and pelvis, with the following inclusion criteria: (1) no visible evidence of chest or abdominal injury, (2) hemodynamically stable, (3) normal abdominal examination results in a neurologically intact patient or unevaluable abdominal examination results secondary to a depressed level of consciousness, and (4) significant mechanisms of injury. Radiological findings and changes in treatment based on these findings were recorded.

Main Outcome Measure: Any alteration in the normal treatment plan as a direct result of CT scan findings. These alterations include early hospital discharge, admission for observation, operative intervention, and additional diagnostic studies or interventions.

Results: One thousand patients underwent pan scan during the 18-month observation period, of which 592 were evaluable patients with no obvious signs of abdominal injury. Clinically significant abnormalities were found in 3.5% of head CT scans, 5.1% of cervical spine CT scans, 19.6% of chest CT scans, and 7.1% of abdominal CT scans. Overall treatment was changed in 18.9% of patients based on abnormal CT scan findings.

Conclusions: The use of pan scan based on mechanism in awake, evaluable patients is warranted. Clinically significant abnormalities are not uncommon, resulting in a change in treatment in nearly 19% of patients.

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SINCE ITS INTRODUCTION IN THE 1970s, computed tomography (CT) has become the mainstay of evaluating hemodynamically stable trauma patients.[1] Advances in CT technology allow for rapid, dependable imaging, and along with later 3-dimensional reconstruction, has proven to be useful in detecting and characterizing various injuries sustained by trauma patients.[2,3] Several authors have advocated for the use of CT as both a screening and diagnostic tool, replacing the use of plain radiography in certain situations.[4-7]

Liberal use of CT scanning has raised concerns ranging from inappropriate resource use to the consequences of radiation exposure.[8,9] Even a new acronym was coined to describe the adverse outcomes resulting from the flood of information from modern technology, VOMIT—victims of modern imaging technology.[10] Several groups have attempted to delineate guidelines for a more selective use of imaging studies.[11-14] However, this remains controversial and not widely accepted.

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It is generally accepted that hemodynamically stable patients with abnormal physical examination results require the use of CT. Similarly, patients with a depressed level of consciousness also require the use of CT since the physical examination is unreliable. Controversy exists with the awake, clinically evaluable patient with no obvious signs of chest or abdominal injury. Even within our own practice group, there exists a wide practice variation in the use of CT scans in this patient population.

The purpose of this study was to evaluate the role of whole body CT imaging in patients with a suspicious mechanism of injury who were hemodynamically stable and had no obvious signs of chest or abdominal injury. We sought to examine the incidence of injury in this patient population as well as the change in treatment that occurred as a result of the CT scan findings.

METHODS

The prospective observational study was performed at the Los Angeles County and University of Southern California Medical Center, a large academic level I trauma center, during the 18-month period from January 2004 through June 2005. All patients with blunt-mechanism multisystem trauma were enrolled if they met the following inclusion criteria: (1) no visible evidence of chest or abdominal injury, (2) hemodynamically stable, (3) normal abdominal examination results in neurologically intact patients or unevaluable abdominal examination results secondary to a depressed level of consciousness, and (4) significant mechanisms of injury as any of the following: (1) motor vehicle crash at greater than 35 mph, (2) falls of greater than 15 ft, (3) automobile hitting pedestrian with pedestrian thrown more than 10 ft, and (4) assaulted with a depressed level of consciousness. All patients underwent a CT scan of the head, cervical spine, chest, abdomen, and pelvis (pan scan) as part of their evaluation. Data regarding patient demographics, mechanisms of injury, physical examination findings, alcohol intoxication status, Glasgow Coma Scale score on emergency department admission, radiologic interpretation of chest and pelvic roentgenograms, injuries sustained, major operative procedures, laboratory data, indications for CT scans, CT scan findings, and changes in treatment based on these findings were recorded.

Computed tomographic examinations were performed with a helical scanner (model 2000; Picker, Cleveland, Ohio) by certified technologists and were supervised by radiology residents, fellows, and staff. Computed tomographic scans of the head and cervical spine were performed first without intravenous contrast. The chest, abdomen, and pelvis CT scans were then performed after injection of 150 mL^3 of nonionic contrast medium at a rate of 3 mL^3 per second. Oral contrast was not administered in all cases. The total time in the scanner was less than 30 minutes in most cases. All images were then reviewed and directly communicated to a member of the trauma team caring for the patients. The official radiologic report as signed by an attending radiologist was used to determine whether the scan was considered abnormal and what injuries, if any, were present.

An abnormal scan was defined as exhibiting any traumatic abnormality. The intrathoracic findings included pneumothorax, hemothorax, pulmonary contusion, mediastinal abnormality suspicious for aortic injury, and rib or sternal fractures. Intra-abdominal abnormalities were solid organ damage and/or any evidence suggesting hollow viscous injury, including pneumoperitoneum, bowel-wall thickening, mesenteric stranding, and isolated free fluid.

Patient treatment changes were defined as alterations in the normal treatment plan as a direct result of the CT scan findings. These changes included early discharge from the emergency department or release to other services, admission for serial examination, performance of additional diagnostic studies or interventions (eg, angiography, diagnostic peritoneal aspiration/lavage), and immediate operative intervention.

Descriptive analyses were performed initially to provide summaries of demographic information, baseline clinical status, frequencies of the findings on physical examination, laboratory results, plain radiographic results, abnormalities on CT scans, and change in patient treatment. Comparisons of CT scan results stratified by indication for study were performed by χ^2 test or Fisher exact test as appropriate. Statistical significance was considered at $P<.05$ for all comparisons. All statistical analysis was performed with SPSS version 13.0 (SPSS Inc, Chicago, Ill). This study was approved by the institutional review board, and the need for informed consent was waived.

Table 1. Demographic and Admission Characteristics of 1000 Patients

Characteristic	No. (%)*
Age, y, mean ± SD	37 ± 19
Male	703 (70.3)
Mechanism	
Motor vehicle crash	562 (56.2)
Pedestrian hit by car	259 (25.9)
Fall	135 (13.5)
Assault	44 (4.4)
Glasgow Coma Scale score	
13-15	808 (80.8)
9-12	80 (8.0)
3-8	112 (11.2)
Alcohol intoxication	240 (24.0)
Positive toxicology screen	84 (8.4)
Visible evidence of trauma	
Head	654 (65.4)
Chest	323 (32.3)
Extremities	589 (58.9)
Back	168 (16.8)
Admitting hemoglobin level, g/dL, mean ± SD	13.9 ± 1.8

*Unless otherwise indicated. Visible evidence of trauma defined as any abrasion, ecchymosed, hematoma, and deformity of extremity or tenderness on palpation.

RESULTS

During the 18-month study period, 1000 consecutive blunt multisystem trauma patients met the study inclusion criteria. **Table 1** summarizes the demographic and admission characteristics of the study population. **Table 2** summarizes the CT results of the 1000 patients who underwent pan scan. All of the patients with a normal chest radiograph and a chest CT scan suggestive but not diagnostic of an aortic injury underwent aortography. Two (50%) of 4 were confirmed to be aortic injuries. Both were repaired: 1 via an open approach, and the other with an endovascular stent. Of the 40 patients with an abdominal CT scan suggestive of hollow viscous injury, 8 (20%) underwent laparotomy. Hollow viscous injury was identified in 6 (15%) of these patients.

Pan scan was obtained in 592 patients (59.2%) based on mechanism of injury. These patients were all clinically evaluable and had normal admission abdominal physical examination results. Pan scan was performed on the remaining 408 patients (40.8%) because of a depressed level of consciousness. These patients also had no visible evidence of chest or abdominal injury. The CT scan results were stratified based on indications and compared. Results are shown in **Tables 3**, **4**, **5**, and **6**. Of the 592 patients evaluated based on mechanism only, 8 patients (1.3%) required laparotomy, 4 for hollow vis-

Table 2. Results of Pan Scan in 1000 Patients

Results	No. (%)
Head CT scan	
Normal	861 (86.1)
Abnormal	139 (13.9)
Subarachnoid	78 (7.8)
Cerebral contusion	77 (7.7)
Subdural hematoma	58 (5.8)
Epidural hematoma	7 (0.7)
Cervical spine CT scan	
Normal	946 (94.6)
Abnormal	54 (5.4)
Fracture	48 (4.8)
Dislocation/subluxation	8 (0.8)
Chest CT scan	
Normal	791 (79.1)
Abnormal	209 (20.9)
Rib fracture	142 (14.2)
Hemothorax/pneumothorax	117 (11.7)
Lung contusion	69 (6.9)
Suspected aortic injury	4 (0.4)
Abdominal CT scan	
Normal	917 (91.7)
Abnormal	83 (8.3)
Liver injury	19 (1.9)
Grade IV	4 (0.4)
Grade III	3 (0.3)
Grade I-II	12 (1.2)
Splenic injury	20 (2.0)
Grade IV-V	6 (0.6)
Grade III	2 (0.2)
Grade I-II	12 (1.2)
Kidney injury	9 (0.9)
Suspicious small-bowel injury	40 (4.0)
Isolated free fluid	30 (3.0)
Small-bowel thickening	7 (0.7)
Free gas	6 (0.6)
Mesenteric stranding	1 (0.1)

Abbreviation: CT, computed tomography.

Table 3. Results of Head Computed Tomography Stratified by Indication for Study

	No. (%)		
Results	Mechanism (n = 592)	Unevaluable (n = 408)	*P* Value
Normal	571 (96.5)	290 (71.1)	<.001
Abnormal	21 (3.5)	118 (28.9)	<.001
Subarachnoid	14 (2.4)	64 (15.7)	<.001
Cerebral contusion	10 (1.7)	67 (16.4)	<.001
Subdural hematoma	6 (1.0)	52 (12.7)	<.001
Epidural hematoma	0	7 (1.7)	<.001

Table 4. Results of Cervical Spine Computed Tomography Stratified by Indication for Study

	No. (%)		
Results	Mechanism (n = 592)	Unevaluable (n = 408)	*P* Value
Normal	562 (94.9)	384 (94.1)	.57
Abnormal	30 (5.1)	24 (5.9)	.58
Fracture	26 (4.4)	22 (5.4)	.47
Dislocation/subluxation	6 (1.1)	2 (0.5)	.36

Table 5. Results of Chest Computed Tomography Stratified by Indication for Study

	No. (%)		
Results	Mechanism (n = 592)	Unevaluable (n = 408)	*P* Value
Normal	476 (80.4)	315 (77.2)	.22
Abnormal	116 (19.6)	93 (22.8)	.22
Rib fracture	89 (15.0)	53 (13.0)	.36
Hemothorax/pneumothorax	60 (10.1)	57 (14.0)	.06
Lung contusion	37 (6.3)	32 (7.8)	.33
Suspected aortic injury	1 (0.2)	3 (0.7)	.16

Table 6. Results of Abdominal Computed Tomography Stratified by Indication for Study

	No. (%)		
Results	Mechanism (n = 592)	Unevaluable (n = 408)	*P* Value
Normal	550 (92.9)	367 (90.0)	.10
Abnormal	42 (7.1)	41 (10.0)	.10
Liver injury	8 (1.4)	11 (2.7)	.13
Grade IV	1 (0.2)	3 (0.7)	.31
Grade III	3 (0.5)	0	.28
Grade I-II	4 (0.7)	8 (2.0)	.08
Splenic injury	10 (1.7)	10 (2.5)	.40
Grade IV-V	1 (0.2)	5 (1.2)	.04
Grade III	1 (0.2)	1 (0.2)	>.99
Grade I-II	8 (1.4)	4 (1.0)	.77
Kidney injury	6 (1.0)	3 (0.7)	.74
Possible HVI	20 (3.4)	20 (4.9)	.23
Free fluid	17 (2.9)	13 (3.2)	.77
Thickening	2 (0.3)	5 (1.2)	.13
Pneumoperitoneum	2 (0.3)	4 (1.0)	.23
Mesenteric stranding	1 (0.2)	0	>.99

Abbreviations: HVI, hollow viscous injury; thickening, bowel-wall thickening.

cous injury. Six of the 8 patients were taken to the operating room based on CT scan findings only. Four patients had a splenic injury and the remaining 2 patients had a hollow viscous injury.

We compared the findings of the chest radiograph with those of the chest CT scan. Of the 1000 patients studied, 809 (80.9%) had a normal chest radiograph. The remaining 191 (19.1%) had an abnormality consisting of rib fractures in 127 patients (12.7%), hemothorax or pneumothorax in 65 patients (6.5%), and a widened mediastinum in 58 patients (5.8%). **Table 7** demonstrates the correlation between the chest radiograph and chest CT results. The sensitivity and specificity of the admission chest radiograph were 69% and 94%, respectively. Of the 809 patients with a normal chest radiograph, 64 patients (7.9%) were found to have an abnormality on chest

Table 7. Correlation Between Chest Radiography and Chest Computed Tomography Results*

	Chest Computed Tomography Results		
	Abnormal (n = 209)	Normal (n = 791)	*P* Value
Chest radiography results			
Normal	64 (7.9)	745 (92.1)	<.001
Abnormal	145 (75.9)	46 (24.1)	<.001

*Values are expressed as number (percentage) unless otherwise indicated.

Table 8. Normal Chest Radiography Results but Abnormal Chest Computed Tomography Results

	Normal Chest Radiography Results, No. % (n = 809)
Abnormal chest computed tomography results	
Occult pneumothorax/small hemothorax	27 (3.3)
Suspicious aortic injury	2 (0.2)
Pulmonary contusion	27 (3.3)
Rib fractures	30 (3.7)
Total	64 (7.9)

Table 9. Change in Treatment Based on Computed Tomography Findings

	No. (%)	
Abdominal Computed Tomography Results	Changed (n = 189)	Unchanged (n = 811)
Abnormal	51 (61.4)	32 (38.6)
Normal	138 (15.0)	779 (85.0)

Table 10. Change in Treatment Based on Computed Tomography Findings for the 592 Patients Evaluated for Mechanism Only

	No. (%)	
Abdominal Computed Tomography Results	Changed (n = 120)	Unchanged (n = 472)
Abnormal	24 (57.1)	18 (42.9)
Normal	96 (17.5)	454 (82.5)

CT. **Table 8** describes these abnormalities. The 2 patients whose CT scan was suggestive of an aortic injury underwent aortography, demonstrating an actual injury in 1 patient.

We examined closely the abnormal abdominal CT results and also examined the normal CT scans for the possibility of missed injuries. Of the 83 patients with an abnormal abdominal CT scan, 13 patients (15.7%) underwent laparotomy directly based on the CT scan findings. Six patients had a hollow viscous injury, while the remaining 7 patients had splenic injuries. Sixty-nine patients (83.1%) were admitted for serial abdominal examinations or further investigations in situations where abdominal examinations could not be performed (depressed level of consciousness). Three patients (3.6%) required a delayed laparotomy during the period of observation. Two cases were from continued bleeding from splenic injuries, and the third was from a patient who developed progressive abdominal distention from a liver injury. None of these patients had hollow viscous injuries. Of the 917 patients with a normal abdominal CT scan, 138 patients were either discharged home based on the normal scan or released to another service. Of the 779 patients who were admitted secondary to associated injuries or for continued observation, 6 patients underwent delayed laparotomy for worsening abdominal signs. Two patients were found to have a hollow viscous injury, 1 patient was found to have a splenic injury missed on CT scan, and the remaining 3 patients underwent a negative laparotomy. The false-negative rate for hollow viscous injuries was 0.22%.

We looked at the effect the pan scan had on the treatment of patients. Treatment changes, as previously described, included prompt hospital discharge or release to other services, admission for serial examination, change of a general admission to further evaluation of injuries (eg, angiography, diagnostic peritoneal aspiration), and immediate operative intervention. A change in treatment from the initial plan occurred in 189 patients (18.9%). **Table 9** presents the changes in treatment, either because of findings on an abnormal scan or because of a normal scan. When we looked at the 592 patients on whom CT was performed based on mechanism only, 120 patients (20.3%) had their treatment changed. **Table 10** presents the effect of an abnormal or normal scan on patient treatment.

COMMENT

Improvements in CT scan technology have brought about new paradigms in the use of CT scans in trauma. Faster, more accurate, and more accessible CT scans have changed the indications for obtaining imaging from being symptom driven to nonsymptom or mechanism driven.[10] This method of CT scanning has both been welcomed and scorned, all at the same time. By instituting a protocol of liberal scanning and studying the results of a mechanism-driven approach for CT scanning, we found that there were clinically relevant findings on the scans in up to 20% of cases and that the results of the CT scan changed the management of patient care in 19% of cases.

Performing whole body imaging on unevaluable patients has been accepted in many trauma centers.[15,16] The fear of missing an injury in a patient who cannot be reliably examined has made pan scanning these patients routine. Even in awake, evaluable patients, liberal scanning is advocated because of the unreliability of physical examination.[17-22] Some would argue that a CT scan has replaced physical examination in trauma.

A policy of liberal CT scanning has also been used as a tool to allow for early hospital discharges. Livingston et al[23,24] have shown that patients can be safely discharged from the emergency department after normal abdominal[23] and normal head[24] scans. Other arguments for liberal scanning include its proven superiority over plain radiography in identifying injuries.[4,5,25-29] It is now increasingly used as a screening tool and has replaced plain radiography in many instances. Finally, advocates of liberal scanning point to the influence on patient treatment that occurs.[4,15,25] Self et al[15] demonstrated that liberal scanning resulted in unexpected findings in 38% of patients, leading to treatment changes in 26% of patients.

While it is clear that CT continues to improve the diagnostic accuracy in trauma and it continues to grow as a screening method for many injuries, there is growing concern that the overuse of CT is creating problems. Hayward,[10] in a letter to the editor, coined the acronym VOMIT (victims of modern imaging technology) to describe the adverse effects of the overreliance on modern imaging studies. Because investigations are now nonsymptom driven, there is a growing concern over the misapplication of the flood of information generated from these investigations. Physicians are now becoming increasingly dependent on CT scans for treatment decisions, possibly even ignoring physical examinations. This may lead to inappropriate intervention, such as a negative laparotomy, or even delayed intervention.

The proliferation of CT scanning also introduces concerns that resources are inappropriately used in this cost-conscious medical era.[8] In a retrospective study looking at the clinical use of imaging in the acute trauma setting, nearly 52% of patients had no clinically significant injuries seen on radiography.[30] Applying stricter guidelines for radiographic evaluation could have resulted in a cost savings of nearly $2000 per patient. Despite the concern of rising costs associated with liberal scanning, a cost analysis has yet to be performed. However, any financial analysis should also take into account the costs, both health-related and legal, associated with missed or delayed diagnoses that can be minimized by routine use of CT.

Besides the cost issue associated with liberal CT scanning, there is a general consensus that the current levels of CT radiation may be associated with an increased risk of cancer.[9] Computed tomography examinations are associated with an organ-specific radiation dose that is much higher than with conventional radiographs.[31] The effective radiation dose to all organs from a single full-body CT examination is 12 to 16 milli-Sieverts (mSv).[30,32] Survivors of the atomic bomb whose radiation dose ranged from 5 to 100 mSv were found to have a statistically significant increase in solid cancer risk.[32] Even the lowest dose in the exposed atomic-bomb survivor population (range, 5-50 mSv; mean, 20 mSv) is associated with an increased cancer mortality risk. Overall, the risks associated with 1 scan are relatively modest, with the estimated lifetime cancer mortality for a 45-year-old adult approximately 1 in 1250, or 0.08%.[32]

The improved accuracy and high sensitivity and specificity of CT scans are unquestioned. There are undoubtedly more findings and more injuries diagnosed after CT scan that may have been missed without such a liberal scanning policy. Several studies have identified significant injuries in as many as 38% of patients undergoing CT scan.[1,15,33] Despite the increased yield in injury identification, intervention or treatment changes based on these findings remain questionable. Rizzo et al[1] found an abnormal scan in 38% of patients studied; however, nearly one third of these were not helpful in the patient care process. Overall, 29% did actually assist in the clinical care of the patient. Gonzalez et al[34] found that additional screening of patients without clinical evidence of abdominal trauma does not impact patient care. Similarly, Fried et al[35] found that although CT demonstrated trauma-related abnormalities in 38% of patients, the clinical course was not altered based on the abnormal findings. They concluded that CT scanning without clinical or laboratory evidence of injury results in an extremely low-yield study and should be discouraged.

We found that the diagnostic yield was significant. Nearly 19% of patients had their treatment altered by the results of the CT scan. Eight patients went to the operating room directly as a result of the findings on CT scan alone, with a bowel injury identified in 6 of these patients. A normal scan proved to be just as helpful. Using the results of CT scans to discharge patients earlier, or even clear them for earlier operative intervention by other services such as orthopedics, makes sense from a patient care as well as an economic standpoint. These often subtle but important changes in treatment are often overlooked or ignored in studies attempting to analyze the utility of screening programs.

An interesting aspect of this study involved the 592 patients who were evaluable whose indication for CT scanning was for mechanism only. Abnormalities were found in this group in 3.5% of head CT scans, 5.1% of cervical spine CT scans, 19.6% of chest CT scans, and 7.1% of abdominal CT scans. With the exception of head injuries, the incidence of injuries diagnosed by CT was not significantly different between evaluable and unevaluable patients. Most importantly, 120 patients (20.3%) had a change in treatment based on findings on the abdominal CT scan. Eight of these patients required a laparotomy, 6 as a result of the findings on CT scan. It is quite concerning that all of these patients had normal abdominal examination results. Certainly, if these patients were not imaged but admitted for observation, their injuries would have been identified eventually. The use of liberal pan scan could avoid the negative outcomes associated with the delay in surgery.[36]

One of the limitations of CT scan is in the diagnosis of hollow viscous injury. False-negative rates have been reported to be 13% to 15%, although several modern series report much lower rates.[37,38] Our false-negative rate was relatively low. Of the 917 patients with a normal abdominal CT scan, 2 patients were found to have a hollow viscous injury, with the false-negative rate of only 0.22%. Our overall incidence of hollow viscous injury was also quite low, with only 8 cases (0.8%) identified. The most likely explanation is that the liberal CT scanning protocol included many patients without significant blunt abdominal trauma.

There are several limitations of this study. Since this was a prospective observational study only, there was no comparison group. For this reason, we could not perform a cost analysis and compare outcomes such as length of stay. Since our general protocol for multisystem blunt trauma, prior to the study initiation, included hospital admission for serial examinations, regardless of the results of the pan scan, many patients who could have been discharged were still admitted. Based on the results of this study, we will implement a liberal CT scanning policy to allow for earlier hospital discharges. Once this is done, we will then be able to perform a cost analysis and determine the benefit of liberal CT scanning.

In summary, we believe that a liberal policy of CT scanning is warranted in patients with blunt multisystem trauma, even among select patients without obvious signs of injury. Although the overall incidence of significant injuries identified by the pan scan was low among evaluable patients, it did prompt immediate intervention in several potentially life-threatening injuries. Of equal or greater importance is the value of a normal pan scan in reliably excluding significant injuries and allowing for earlier discharge or disposition of patients.

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DISCUSSION

James G. Tyburski, MD, Detroit, Mich: The authors have addressed an important concept in the everyday care of the blunt trauma patient. They have studied what appears to be an increasing tendency to whole body imaging. This includes CT scans of the head, cervical spine, chest, abdomen, and pelvis. And they concluded that the use of the "pan scan" based on mechanism is warranted in an awake, reliably evaluable patient.

I have tremendous respect for the trauma service at the University of Southern California. Their expertise, commitment, and contributions to trauma care cannot be overstated. That said, I have some reservations regarding the conclusions of the data, some of which I will try to articulate in a series of 5 questions.

First, the official radiology report signed by the attending radiologist was used to determine whether the CT scans were positive. Was that report immediately available? If it was not immediately available, what percentage of CT scan readings were changed by the final reading of the radiologist?

Second, what percentage of patients that had a Glasgow Coma Scale of 15 at the time of exam had alcohol and/or other drugs on board? Furthermore, what percentage of the people that had a Glasgow Coma Scale of 15 had a loss of consciousness or amnesia to events at the scene, like in a postconcussion syndrome? Both of these subsets may represent patients that are at risk for an unreliable physical exam but would be in your mechanism-only group.

Third, regarding the CT scan of the cervical spine, there were 30 patients, or 5.1%, with fractures and/or dislocation subluxations in the mechanism group vs 24, or 5.9%, in the group that had an unreliable physical exam. This implies that the physical exam was basically useless in the evaluation of the cervical spine, so I want to be clear here. There were no symptoms, pain, or physical signs, tenderness or anything else like that, etc, in these 30 patients that were awake and fully evaluable? Can you comment on this lack of sensitivity in the evaluation of the cervical spine, as this would be at odds with several trauma care guidelines by other organizations?

While we are on the subject of spine, the manuscript makes no mention of thoracic or lumbar fractures. Brandt recently in *The Journal of Trauma* reported the effectiveness of the CT scans of the chest and abdomen in picking up these fractures. Were there any thoracic or lumbar fractures identified? For that matter, how do you clear the lumbar in thoracic spines in blunt trauma patients? The use of the plain radiographs? Or the use of the physical exam?

Regarding the CT scans of the chest, there were 89 rib fractures in the mechanism group alone. And again this implies that none of these patients had pain or tenderness over these ribs. If they did, then that would imply possibly an abnormal physical exam, if it was a physical abdominal exam for their lower rib fractures. Can you comment about that?

Finally, in patients with the occult pneumo- or hemothorax seen on the CT scan but not noticed on the chest x-ray, what differences does that make with these patients? Was your decision influenced by the patient that is on or will be on positive pressure ventilation?

Dr Salim: Thanks, Dr Tyburski. I will try to get through all of your questions.

The first question was regarding the availability of attending radiologists. We do have access to attending radiology readings. They are not in-house, but we can request their readings from home. So basically we do get results from attending radiologists. For the purpose of this study, we did get attending radiologists.

In terms of the percentage of patients with a GCS [Glasgow Coma Scale] of 15 who had a positive toxicology, all the patients in the GCS 15 group (ie, evaluable group) had a negative toxicology. Patients were considered unevaluable if the GCS was 14 or less, if they had loss of consciousness, and if they had a positive toxicology. I do agree that patients who come in with GCS of 15, and if they had loss of consciousness in the past, their physical exam could be unreliable. Again, patients with a GCS of 15 did not have a positive tox.

In terms of pain in the cervical spine, we didn't really address whether they had pain. We were just looking to see if they had any outward signs of trauma. Typically we are just looking at that patient who looks like they don't have anything wrong. It is the typical patient that the ER physician just wants to send home from the ER.

So in terms of cervical spine tenderness, we didn't examine whether tenderness actually correlated with findings on x-ray. We are very, very suspicious with mechanism as well as clinical exam when it comes to cervical spine and lumbosacral spine. Though we didn't address this, we actually are clear based on physical exam at our institution. If they do have tenderness, we work it up with either plain films or CAT [computed axial tomography] scans.

You made a comment in terms of occult pneumothorax. Most of the time these patients, when they were followed, didn't develop any progression of their occult pneumothorax. I don't really have that documented, though, how many actually had an intervention for that, but I know it was extremely low.

In terms of patients with the rib fractures for the GCS of 15, again, we didn't really comment in terms of thoracic tenderness, we just really were focused on their abdominal exam and no outward signs of chest or abdominal trauma. Again, the key was that we were just looking at those patients who didn't really look like they were injured, and we wanted to argue that we should probably work those patients up. And that was really the point of the paper.

Tyler Hughes, MD, McPherson, Kan: I read this abstract with great interest because this is the sort of paper that is going to affect me greatly out in general surgical practice in the community.

The title of the paper and its conclusions may lead people to simply CT everything that walks through the door. And it is not so much in the trauma center where everybody is alert and looking for things but rather in smaller places where there is ignorance of trauma evaluation as an integration of exam, laboratory, and imaging.

I worry when we are going to get involved as surgeons when the trauma victim comes in, and will it be at the end of the report from Australia on the CT scan that everything is okay but yet they miss something on physical exam that could make us want to come in and see the patient sooner? So my question is, at what point does the liberal use of CT meet the liberal use of physical examination of a potential trauma victim?

Dr Salim: And I will tell you, our residents are making fun of trauma when they come on the service. They say, "You know, trauma, there is nothing to it. All you do is CAT scan it."

And I think really the point is you have to respect the mechanism. And I am not saying to not look at the physical exam. Remember the slide that I had in terms of CT scan being better than physical exam—it wasn't me quoting that, I was just saying some people would argue that physical exam is actually better. I think physical exam is probably still the most important aspect. You still have to do your serial exams. But I think you have to respect mechanism. If someone comes in with suspicious enough mechanism, I think you have to work them up appropriately with CT scans.

J. Stephen Marshall, MD, Peoria, Ill: If we use CT with a policy that is this liberal, obviously we are going to increase the cost of our trauma service. Do you think that being able to discharge patients early may offset some of that cost? Or do we risk adding an unwieldy financial burden to the trauma service budget?

Dr Salim: I think the biggest advantage of pan scanning is not finding those little subtle injuries. It is being able to say, you know, this patient doesn't have anything, we can send them home. Unfortunately, we didn't do a cost analysis in our study. But I think that is the next study that needs to be done, to see how much you are actually saving by scanning them and sending them home as opposed to admitting them and watching them.

Karen J. Brasel, MD, Milwaukee, Wis: You talk about mechanism. We certainly know that a fall from 6 ft is different than a fall from 20 ft and a motor vehicle crash at 20 mph is different than a motor vehicle crash at 40 mph. Did you try to separate these out by mechanism at all? Also, could you comment on the accuracy of your CT scan? You had 2 patients who underwent operation for a delayed hollow viscous injury, which I assume was not shown on your CT scan. So I would wonder about the accuracy of the test that you are advocating.

Dr Salim: In terms of mechanism, we actually just looked at all patients with motor vehicle collisions. I think nobody would argue that someone in a significant motor vehicle collision would get worked up. We are just trying to look at those patients on the other side of the curve. And in terms of falls, we pretty much looked at anyone who wasn't a ground-level fall. I think that is why in terms of the number of injuries we found out of 1000 patients, there really weren't that many.

In terms of the delayed CT, those patients actually had negative CT for the abdomen on admission, and they developed hollow viscous injuries or delayed presentation of hollow viscous injury. We know that, unfortunately, for abdominal hollow viscous injuries, there is still a significant false-negative rate. Ours was actually less than 1%, and I think it was this low only because we included some patients that weren't really suspicious for blunt abdominal trauma. It is a little lower than the usual 12% to 13% that most studies quote.

Richard L. Jamison, MD, Portland, Ore: I apologize if I missed it during your presentation, but of the patients whose GCS was 15 and their legs were crossed on the gurney, how many of them had positive CT scans that affected their care that would have otherwise just been sent home?

Dr Salim: I am sorry, I don't have that answer. But for the GCS of 15, we say that 20% changed their management. The majority of the patients that had their management changed was because we were able to send them home.

Baiba J. Grube, MD, Galveston, Tex: In the good old days, we used diagnostic peritoneal lavage in trauma. Many of the cases that you presented that really impacted treatment were intra-abdominal, especially hollow viscous injuries. Is there potentially a role for reinstituting diagnostic peritoneal lavage in this patient group and looking at the cost benefit of doing DPL [diagnostic peritoneal lavage] as opposed to doing CT scans or emergency room ultrasounds?

Dr Salim: Our group has sort of shied away from the DPL, especially in the initial workup. I think there have been studies that have looked at DPL and FAST [focused abdominal sonography for trauma] vs CAT scan and they are arguing that CAT scan is probably more preferential. I think in the patient with a suspicious mechanism, you have a CAT scan that may point toward a hollow viscous injury, and if you watch them and you are not sure of the physical exam, I think that is the ideal patient you may want a DPL. The other alternative is to repeat the CAT scan.