

# Head Computed Tomography Scans in Trauma Patients With Seizure Disorder

## Justifying Routine Use

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**Hypotheses:** A majority of trauma patients with known seizure disorder with seizure activity were noncompliant with their medications, normal neurologic examination findings would predict negative results of head computed tomography (CT) scans, and the yield of CT scans would be insufficient to justify their routine use.

**Design:** Retrospective consecutive case series.

**Main Outcome Measures:** Blood levels of antiepileptic drugs, predictive values and receiver operating characteristic curves of Glasgow Coma Scale scores, and findings on head CT.

**Setting:** Urban trauma center.

**Patients:** All trauma patients treated between September 1995 and June 2002 with seizure-related illness.

**Results:** The diagnosis of seizure identified 356 patients. Most (62%) had preexisting seizure disorder. Of

the 101 who had antiepileptic drug levels drawn, 75% of these patients were noncompliant. The negative predictive value of a Glasgow Coma Scale score of 15 for intracranial abnormalities on CT scans was 90%. Receiver operating characteristic curve analyses of Glasgow Coma Scale score vs head CT abnormalities for all patients with seizure activity showed the area under the curve was 0.53, indicating poor discriminating ability. Intracranial abnormality was identified in 27% if the seizure resulted from injury and in 11% if the seizure preceded injury ( $P = .001$ ).

**Conclusions:** Neurologic examination is an unreliable predictor of intracranial injury in patients with seizure disorder. In trauma patients with seizure activity, the yield of CT scans in finding unsuspected intracranial abnormalities justifies its routine use regardless of prior history.

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**A**N ESTIMATED 0.5% TO 2.0% of the population in the United States has a seizure disorder.<sup>1</sup> Not surprisingly, patients with seizure disorder are susceptible to injuries and frequently present as trauma patients. In fact, patients with a seizure disorder have a 2- to 3-times higher mortality rate compared with their age-matched controls and are more likely to die as the result of an accident.<sup>2</sup> Several mechanisms of injury have been identified in this population, including falls, motor vehicle collisions, and drowning. These patients often sustain dental trauma, fractures, burns, and head injuries.<sup>2,3</sup>

Despite the fact that surgeons frequently care for patients with seizure disorder in the setting of acute trauma, guidelines regarding proper care and workup of the postictal trauma patient are not well defined. Many patients with a seizure-related injury have a preexisting seizure disorder.

One report identified that 93% of patients admitted to the trauma service with seizure-related injury had a history of seizure disorder.<sup>4</sup> Another study of 54 patients with seizure-related head injury found that nearly half had preexisting seizure disorder.<sup>5</sup> We

## See Invited Critique at end of article

hypothesized that many of these patients were noncompliant with their medications, resulting in seizure and injury. Furthermore, we suspected that the postictal neurologic examination without focal findings may not necessitate a computed tomography (CT) scan. Finally, we hypothesized that the yield of an emergency head CT scan in a trauma patient with seizure disorder who had seized with normal neurologic examination findings would be insufficient to justify its routine use.

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The purposes of this study were (1) to determine the incidence of preexisting seizure disorder among trauma patients with seizure activity, (2) to ascertain the compliance with antiepileptic medications and the impact of compliance on outcome among trauma patients with seizure disorder, (3) to evaluate the discriminating ability of a neurologic examination without focal findings in trauma patients with seizure disorder, and (4) to examine the frequency of intracranial abnormalities on CT scans in trauma patients with seizure activity.

## METHODS

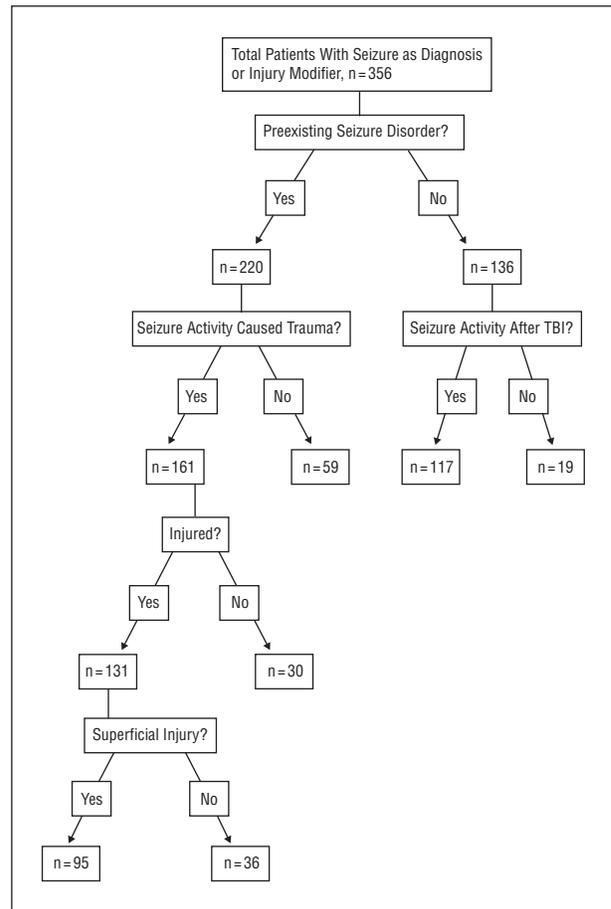
This retrospective consecutive case review was completed at the Alameda County Medical Center, a university-based trauma center in Oakland, Calif. The review was performed according to health information privacy guidelines and with the approval of the hospital institutional review board. All trauma patients admitted to the emergency department under the care of the trauma service between September 1, 1995, and May 31, 2002, were entered for analysis. Inclusion criteria included patients with seizure as the diagnosis, injury modifier, or comorbidity in the trauma registry database. Demographic information, clinical history, laboratory values, and outcome information were obtained by medical-record review.

Injury was attributed to seizure activity if (1) a seizure was witnessed to have preceded the traumatic injury or (2) the patient had all 3 of the following: postictal state, a history of seizure disorder, and no other apparent cause of injury. Noncompliance with treatment was defined as absent or subtherapeutic blood levels of antiepileptic medication. Neurologic examination results were considered normal if (1) there was no focal neurologic deficit recorded on the admission physical examination and (2) the initial hospital Glasgow Coma Scale (GCS) score was 15. An attending radiologist reviewed head CT scans for the presence of intracranial bleeding or skull fracture, and either of these findings was considered positive for abnormalities. Soft tissue hematomas and facial fractures were not included in the abnormality group. Statistical comparisons of groups were performed using a *t* test and 2-tailed Fisher exact test. Logistic regressions, predictive values, and receiver operating characteristic (ROC) curves were calculated for each level of the GCS and compared with findings on head CT scans in all patients as well as in the subgroups of patients with seizure disorder and first-time seizure. Receiver operating characteristic curve analyses were determined using SigmaPlot software (SPSS Inc, Chicago, Ill).

## RESULTS

### DEMOGRAPHICS AND INCIDENCE

Of the 12 870 trauma patients seen during the study period, 220 (1.7%) had a preexisting seizure disorder, and 136 (1%) had new-onset seizure activity. The flow-chart in **Figure 1** depicts these groups and their subgroups. The patients with a preexisting seizure disorder were between 15 and 93 years old (mean, 43.7 years). In 161 patients (73%) with known seizure disorder, the seizure disorder was implicated as the initiating factor for injury. Fifty-nine (27%) of the 220 patients with history of seizure disorder were identified by clinical history only, with no seizure activity identified during that admission.



**Figure 1.** Flow diagram outlining subgroups of trauma patients with seizure as their diagnosis or injury modifier. TBI indicates traumatic brain injury.

The 136 patients with no history of epilepsy or seizure disorder had a seizure either in the field or in the emergency department. These patients with new-onset seizure activity ranged from 14 to 91 years in age (mean, 39.7 years), and a large majority (117/136, 85%) had seizure activity following closed head injury.

### MECHANISM AND PATTERN OF INJURY

Among patients with preexisting history of seizure disorder, in whom seizure activity preceded injury, all suffered blunt trauma ( $n = 161$ ). In the group of patients with new-onset seizure disorder ( $n = 136$ ), blunt trauma also predominated, but there were 3 penetrating injuries resulting in seizure: a gunshot to the head, a gunshot wound to the neck with resultant carotid artery injury, and a stab wound to the neck, also with a carotid artery injury. A summary of the mechanisms of injury in trauma patients with seizure activity is depicted in **Table 1**.

Injuries resulting from seizure activity were identified in 131 of 161 patients with seizure disorder. Of these, 95 patients (73%) had superficial abrasions and lacerations requiring local wound care or closure. The vast majority of soft tissue injuries were to the scalp (95%). Thirty-six patients sustained more serious injuries, including long-bone fractures, facial fractures, skull fractures, intracranial bleeding, and abdominal injuries. The abdominal in-

**Table 1. Mechanisms of Injury of the 297 Trauma Patients With Seizure Activity\***

Mechanism of Injury	Preexisting Seizure Disorder (n = 161)	New-Onset Seizures (n = 136)
Fall	100 (62)	71 (52)
"Found down"; not otherwise specified	32 (20)	0
Motor vehicle collision	22 (14)	17 (13)
Blunt assault	0	31 (23)
Bicycle crash	7 (4)	10 (7)
Pedestrian vs motor vehicle	0	4 (3)
Penetrating injury	0	3 (2)

\*Results are shown as number of patients (percentage of total).

injuries were bladder rupture requiring open repair in 1 patient and 2 liver injuries, both treated nonoperatively. The injuries sustained as a result of seizure activity and need for operative interventions are summarized in **Table 2**.

#### COMPLIANCE WITH ANTIPILEPTIC MEDICATION AND IMPACT ON OUTCOME

Laboratory values to verify compliance with prescribed antiepileptic drugs were collected and reported on 101 of the patients with history of seizure disorder. Non-compliance was documented in 76 patients (75%), and seizure activity resulting in trauma was identified in 62 of these 76 patients. Five of these noncompliant patients required an operation for orthopedic injuries, 1 required emergency craniotomy and died of a closed head injury, and a second died of respiratory failure. These 62 noncompliant patients required 86 hospital days of care (average length of stay, 1.39 days per patient), including 31 days in intensive care (average intensive care unit stay, 0.5 days per patient) and 13 days of ventilator support (average ventilator time, 0.2 days per patient).

Only 14 of the 101 patients in whom drug levels had been collected were compliant with their medications and had adequate serum levels but experienced breakthrough seizures that resulted in traumatic injury. One of these patients required a craniotomy and 1 patient died of sepsis. None of these 14 patients were under the influence of alcohol or illicit drugs on admission.

#### PREDICTORS OF ABNORMAL HEAD CT SCAN

The patients with first-time seizure activity presented to the hospital with a mean  $\pm$  SEM GCS score of  $12.6 \pm 0.3$  vs  $13.5 \pm 0.2$  in patients with established seizure disorder ( $P = .01$ ). The 52 patients with known seizure disorder who did not undergo head CT scans had a mean  $\pm$  SEM GCS score of  $14.6 \pm 0.1$ . None of these 52 established patients with seizure disorder had untoward events due to undiagnosed brain injury.

All patients with first-time activity underwent head CT. The frequency of intracranial abnormality vs GCS score is depicted in **Table 3**.

**Table 2. Injuries Sustained as a Result of Seizure Activity**

Injury	Patients (n = 131), No. (%)	Patients Requiring Operative Intervention (n = 12), No.
Scalp laceration or abrasion	91 (69)	0
Other superficial laceration or abrasion	5 (4)	0
Extremity fracture	11 (8)	7
Spinal fracture	1 (<1)	0
Facial or skull fracture	5 (4)	0
Intracranial bleeding	16 (12)	4
Intra-abdominal injury	3 (2.2)	1

The ROC curve for GCS scores in predicting abnormal CT scans among all trauma patients with seizure activity is depicted in **Figure 2**. The area under the curve is 0.53, representing the poor discriminating ability of the GCS score in determining intracranial abnormality in this population.

**Figure 3** shows the ROC curve for patients with history of seizure disorder. The area under the curve is 0.59, again indicating no useful sensitivity threshold for GCS scores in this patient population.

The negative predictive value and specificity of a GCS score of 15 in patients with seizure disorder were 90% and 47%, respectively. If only patients with a GCS score of 14 or less had undergone head CT scan, 8 intracranial bleeds in 80 patients (10%) would have been missed.

#### CT SCAN FINDING

Patients were significantly more likely to have intracranial abnormality on CT scans when seizure resulted from injury rather than preceded injury. Thirty-seven (27%) of 136 patients with new seizure activity had evidence of acute intracranial abnormality vs 19 (11%) of 168 with preexisting seizure disorder ( $P = .001$ ). The results of these CT scans in patients with new seizure activity are shown in **Table 4**.

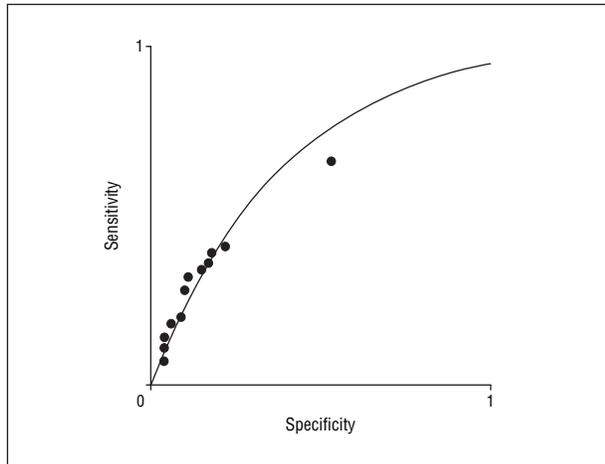
#### COMMENT

Our bias was that we were obtaining unnecessary head CT examinations in trauma patients with a history of seizure disorder who had normal neurologic examination findings. We hypothesized that a large number of trauma patients with known seizure disorder were noncompliant with their antiepileptic medications and that a neurologic examination might help determine the need for a head CT scan. The major findings were that 75% of patients were noncompliant with their treatments, signifying a large number of preventable injuries. We also found that the neurologic examination is unreliable as a predictor of cranial abnormality. Finally, we discovered that although patients with recurrent seizures are less likely to have intracranial abnormality on CT scan than patients with new-onset seizures, the yield of CT scan and likelihood of missed injury justify its routine use in this population.

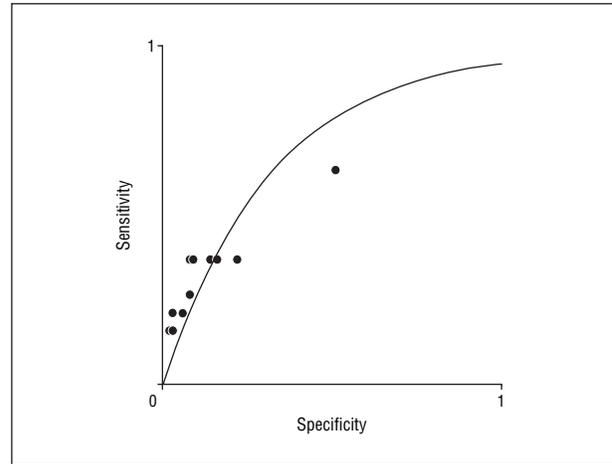
**Table 3. Abnormal Head Computed Tomography Findings vs Glasgow Coma Scale Score**

Group	Glasgow Coma Scale Score				Total
	3-12	13	14	15	
New-onset seizure: abnormal CT scans/total CT scans performed, No. (%)	15/35 (43)	1/4 (25)	10/42 (24)	11/55 (20)	37/136 (27)
Preexisting seizure: abnormal CT scans/total CT scans performed, No. (%)	7/31 (23)	0/8	4/49 (8)	8/80 (10)	19/168 (11)
All abnormal CT scans/total CT scans performed, No. (%)	22/66 (33)	1/12 (8)	14/91 (15)	19/135 (14)	56/304 (18)

Abbreviation: CT, computed tomography.



**Figure 2.** Receiver operating characteristic curve of Glasgow Coma Scale score in predicting intracranial findings for all trauma patients (n=304) with seizure activity. The area under the curve is 0.53, indicating poor discriminating ability.



**Figure 3.** Receiver operating characteristic curve of Glasgow Coma Scale score in predicting intracranial findings for 168 trauma patients with history of seizure disorder. The area under the curve is 0.59, indicating poor discriminating ability.

It is well known that seizures can cause head injury or can result from head injury. Desai et al<sup>5</sup> concluded that seizure activity indicated increased severity of injury only when the seizure results from injury, rather than when the seizure causes injury. The authors found decreased incidence of focal neurologic examination, need for neurosurgical intervention, skull fracture, and intracranial hematoma among patients with preexisting seizure disorder as compared with patients who had a seizure for the first time following head injury. We observed similar results. We found a significantly lower mean GCS score and higher incidence of intracranial abnormality in patients whose seizure followed injury vs those whose seizure preceded injury.

Trauma patients with preexisting seizure disorder are frequently found to have been noncompliant with their medications. Among patients in whom a seizure resulted in injury, this noncompliance results in half of these patients having preventable injuries.<sup>6</sup> Fallon et al<sup>4</sup> also found that 53% of injured patients with seizure disorder were noncompliant with their medications. In the present study, we found that 75% of patients with seizure disorder trauma had documented noncompliance with medication, higher than that previously reported.<sup>4,6</sup> This number could be biased because antiepileptic drug levels were collected and measured in less than half of the patients with a history of seizure disorder or because of

**Table 4. Abnormal Findings on Computed Tomography Scans in Trauma Patients With Seizure Activity\***

Finding	New-Onset Seizures	Preexisting Seizures
Subdural hematoma	9 (7)	4 (2)
Subarachnoid hemorrhage	6 (4)	3 (2)
Parenchymal hemorrhage	7 (5)	2 (1)
Hemorrhagic contusion	5 (4)	5 (3)
Multiple intracerebral hemorrhages	8 (6)	2 (1)
Skull fracture	2 (1)	3 (2)
Total abnormal computed tomography scans	37/136 (27)	19/168 (11)

\*Results are shown as number of patients (percentage of CT scans performed).

the generally lower compliance levels found in indigent patient populations.<sup>7</sup> Additionally, we included all patients with antiepileptic drug levels below the normal range for our hospital as noncompliant. This definition may overestimate actual noncompliance by including patients in whom a subtherapeutic dose was prescribed or those with drug interactions as noncompliant.

Previous studies support the notion that seizure activity is less ominous if it is recurrent rather than acute.

In a study on 557 emergency department visits prompted by seizure activity, Kirby and Sadler<sup>8</sup> observed that a large majority (78%) of the injured patients had preexisting seizure disorder. Of these, only 11% sustained injuries, the most common being scalp lacerations and superficial contusions. There were no serious intracranial injuries. The authors concluded that most injuries resulting from seizure are minor and require little treatment. The present study contrasts these findings, with 81% of our seizure disorder patients sustaining injuries and 11% sustaining serious intracranial injuries. The higher incidence and severity of injury in our study is likely to be explained by the fact that we enrolled patients who were identified by prehospital personnel to require treatment by a trauma center whereas these authors included walk-in patients and less urgent emergency department visits.

Determining the appropriateness of emergency brain imaging for trauma patients at time of presentation can be challenging. Previous studies have investigated the relationship between GCS score and need for diagnostic intervention.<sup>9-13</sup> Most of these authors found an inverse relationship between abnormal head CT findings and hospital GCS score. Shackford et al<sup>9</sup> found that among trauma patients with initial hospital GCS scores of 13, 14, and 15, the incidence of an abnormal head CT scan was 33%, 18%, and 15%, respectively. Other authors report similar findings. A GCS score of 13 correlates with a 27% to 37% incidence of abnormalities, a GCS score of 14 has a 18% to 24% incidence, and 6% to 17% of trauma patients with a GCS score of 15 have abnormal head CT scans.<sup>10-13</sup> In the present study of patients with seizure-related trauma, GCS scores of 13, 14, and 15 correlated with 8%, 15%, and 14% incidence of abnormal CT scans, respectively. The low incidence of intracranial abnormality with a GCS score of 13 is explained by the fact that only 1 patient presented with this GCS score.

Many studies have examined the indication for emergency head CT in seizure patients and results have varied. In an attempt to identify patients who may not require emergency CT scans, several authors have investigated the negative predictive value of normal neurological examination findings and found that it is between 85% and 98%.<sup>14-17</sup> The negative predictive value of normal neurologic examination findings was significant enough for Reinus et al<sup>14</sup> to conclude that seizure patients with "an abnormal neurologic exam or a history of malignancy were most likely to benefit from CT." These authors also found that among 71 patients with neurologic deficits that had resolved prior to hospital presentation, only 1 had evidence of abnormality on emergency head CT scans.<sup>18</sup> We were also interested in the predictive value of GCS score in patients with known seizure disorder who presented after seizure-induced injury. We questioned whether normal results of neurologic examinations in patients with a history of seizure disorder precluded need for head CT. The negative predictive value and specificity of a GCS score of 15 in predicting intracranial abnormality among patients known to have seizure disorder were 90% and 47%, respectively. We found that if we had relied on a GCS score of 15 as the threshold for unnecessary radiologic intervention, we would have missed a significant number of head

injuries. Our data indicate that normal neurologic examination results in trauma patients with seizure disorder have a negative predictive value (90%) similar to that published by other authors.<sup>14-17</sup> The area under the ROC curve (0.59) in this population with seizure disorder confirms the poor discriminating ability of GCS score in predicting intracranial abnormality.

A recent study found that the total technical cost of noncontrast, enhanced head CT scans, including hospital overhead and radiology costs, was \$152.<sup>19</sup> Given the availability, efficiency, high yield, and relatively low cost of head CT scans, we recommend head CT scans for all trauma patients with seizure activity, regardless of neurologic status or history.

## CONCLUSIONS

A large number of trauma patients with seizure activity have a preexisting seizure disorder and are noncompliant with their antiepileptic medications. Our data show that trauma surgeons will encounter many patients who appear to be uninjured with a logical explanation for seizure activity. This is the case for patients with a history of seizure disorder who are noncompliant with treatment. However, we have identified that neurological examination in this population is unreliable and that it would be unsafe to discharge the patient home without radiographic exclusion of intracranial injury. Additionally, the yield of unsuspected major intracranial abnormality on CT scan justifies a policy of its routine use in trauma patients with seizure or who are postictal, regardless of prior seizure history. We conclude that given the ease and relatively low cost, all trauma patients with seizure activity should undergo emergency noncontrast head CT scans, regardless of neurological examination findings, GCS score, or past medical history.

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## DISCUSSION

**John T. Anderson, MD, Sacramento, Calif:** The authors hypothesize that the majority of trauma patients with a known seizure disorder who had seized were in fact noncompliant with their medications, that a normal neurologic examination would predict a negative head CT, and that the yield of a head CT would be insufficient to justify its routine use. They undertook a retrospective analysis over 81 months. They reviewed charts of patients who were admitted to the emergency department and were cared for by the trauma service. From a total of almost 13 000 patients, the authors identified 220 (1.7%) who had a previous history of a seizure disorder and 136 (1%) with a new-onset seizure following trauma. Of the 220 patients with a seizure disorder, 101 of them had a blood test for the presence of anticonvulsant medications. Noncompliance was documented in roughly three fourths of these patients. The authors found that a third of these noncompliant patients also were under the influence of illicit drugs or otherwise inebriated. However, less than half of the patients were tested. It is unclear what criteria were applied to decide who would be tested. Nonetheless, most would agree with the authors' claim that noncompliance with anticonvulsant medications is common in the trauma population.

Of the 220 patients with a known seizure disorder, only 161 actually had a seizure as the precipitating event of the trauma. This is the focus group to test the authors' hypothesis. One hundred thirty-one of these patients had an identifiable injury, and 12 required surgery. Of the 220 patients, 168 had a head CT. Intracranial pathology, defined as either intracranial bleeding or a skull fracture, was identified in 19 patients, 4 who required further neurosurgical interventions, presumably a craniotomy. Fifty-two patients, however, did not have a head CT and reportedly did fine.

Receiver operating curves were derived to assess the use of GCS to discriminate patients with intracranial pathology. The area under the curve for this subgroup was 0.59, arguing that GCS was not a whole lot better than merely flipping a coin. One hundred thirty-six patients were identified with first-time seizures as a result of trauma. Intracranial pathology was identi-

fied in 37 of these patients (27%). This was higher than the prevalence in patients with known seizure disorders.

Ultimately the authors note that in the combined group, namely all patients with seizures with or without a prior history of seizures, restricting head CT scans to patients with a GCS of 14 or less would have missed 8 intracranial bleeds in 80 patients (10%).

I have several questions for the authors. Why do you think that your initial hypothesis proved incorrect, namely, that a normal neurologic examination did not predict a negative head CT and that the yield of CT scan did justify its routine use? Did you choose the right denominator? Is the presence of a seizure a criterion for trauma activation at your hospital? Were there patients with seizures who were not taken care of by the trauma surgeons, who were sent home by the emergency department doctors without a head scan and, in fact, did fine? Were patients in your study just more severely injured? A total of 4 patients in the group with a known seizure required neurosurgical intervention, presumably a craniotomy, to treat the intracranial pathology. How many patients with a normal examination and a GCS of 15 required a craniotomy, admission to the ICU, or otherwise had their treatment altered?

In the patients who had a history of a seizure disorder, you identified 52 patients who were evaluated by the trauma service and did not have a head CT scan. These patients presumably did well. Not all of them had a GCS of 15. Could it be that your residents were able to readily identify patients at high risk for intracranial injury? Was there some other factor that was unmeasured in this study but apparent to everyone evaluating the patient? Is this akin to pornography where the definition is elusive but everyone knows it when they see it?

You report in the paper that most patients with a seizure disorder who are seen at your trauma center are noncompliant with their medications. Further, you note that these noncompliant patients consume substantial resources. Is your trauma center doing anything to address this public health issue that you have identified?

Finally, I would like to finish with a philosophical question and an observation. First the question: what number would the authors have accepted as low enough to skip routine head CT scans in trauma patients with a seizure disorder? Would it have been different than 0? Have we reached a point in medicine where the need to restrict access to a resource is so great and the availability of resources is so limited that we would accept a small but finite harm to a patient? If a head CT scan were to cost \$15 000 instead of the \$152 that the authors quote, would the conclusion of this paper have been different?

**Dr Victorino:** Your first question was why was our hypothesis incorrect? The reason we became interested in this study was that over a several-week period, some of our group noticed that we were seeing a preponderance of seizure activity in our trauma patients. We were obtaining head CT scans on all of them; however, we weren't finding any pathology on the CT scans. We felt that maybe obtaining a CT scan in everyone was a waste of time and money in this patient population. So our hypothesis was based on anecdotal experience. This really emphasizes the need for a more objective review of data instead of basing practice on just our anecdotal experience. I think that's probably the major reason why our hypothesis was incorrect.

To answer your second question, seizure activity is not a criterion for activation in our trauma center. And you are correct: there may have been a few patients who had a seizure but were managed by the emergency department and sent home. However, the ED usually contacts us if they find any pathology or diagnose an injury that would require admission. It is true, however, that they may have seen a few people who didn't have any pathology on CT scan and then subsequently were sent home.

The next question was about the patients with a normal exam and GCS of 15 and how many of those patients had a craniotomy. None of those patients had a craniotomy. However, 8 of those patients (these are patients with a normal exam and a GCS of 15) had pathology on head CT scan and required admission to the ICU.

Your next question was about the 52 patients who did well and who did not get a CT scan. We believe that all of these patients did well. Although our follow-up is not 100%, some of these patients may have gone home, gotten into trouble, and then presented to another area hospital. However, we do not have any evidence that this has occurred. Usually our prehospital personnel are pretty astute and pick up on the patient's recent treatment in our emergency department. Because of this, these patients are almost always brought back to us, and we are fairly confident that this subset of patients did well.

Also in regards to the 52 patients who did well but did not get a CT scan, you asked whether the residents could readily identify patients at high risk for intracranial injury. This is an interesting thought and I think it is difficult to say. Most trauma systems have built into the system "over" triage of the injured patient, and we are very conservative in that we will admit patients rather than send them home. I think the residents know

about our conservative approach and have a low threshold for admitting trauma patients.

You asked what our trauma system was doing to address this public health issue, and this is an excellent point. I think this is one of the major take-home points and is an issue that this study has raised within our group. Our injury prevention program is getting together with the neurologists and the primary care people to see if we can get closer follow-up of our seizure patients to try to educate them and make sure that they are taking their medications. Hopefully this will cut down on the injuries occurring in this patient population and decrease health care costs.

As for your philosophical question, I don't really have a good answer to that. I know that missing 10% of intracranial injuries is too much. Zero, ie, scanning everything that comes in through the trauma department, may be too much as well. I think that a 0 rate for missing intracranial injuries might be too impractical. I would be happy with a miss rate of less than 1%. I do know that if the price of a head CT was \$15 000 and was exorbitant, we probably would be admitting more patients and that our trauma service would probably increase in size. In the beginning when CT scan technology first came out, this was the case. Not every hospital had a scanner, and so there was definitely a limitation of which patients received a head CT.

### Invited Critique

**I**t is often difficult to evaluate the postictal patient presenting after a concurrent seizure and traumatic event. Which came first, the chicken or the egg? Did the seizure cause the trauma, or did the trauma cause the seizure? Does the patient have a preexisting seizure disorder, or is this a true posttraumatic seizure due to new brain injury? Neidlinger and colleagues retrospectively examined this important, common clinical scenario in a review of 356 trauma patients presenting with the additional diagnosis of seizure. Their data reinforce previous findings of lower GCS scores and higher likelihood of CT-proven brain injury in patients in whom the seizure resulted from an injury vs those in which the seizure preceded the trauma.

It should come as no surprise that in patients with a seizure history, three quarters of those tested were noncompliant with their prescribed antiseizure medications. These noncompliant patients had significant injuries (and 2 deaths), requiring a large expenditure of health care resources (including hospital admission, operations, and intensive care unit care). The need for education and prevention should be stressed to the neurologists and primary care physicians treating these patients for seizures before their injury.

The authors offer a cogent plea for the routine use of CT in the postseizure trauma patient population. Other authors have shown that normal GCS scores and neurologic examination findings do not predict normal head CT scans in patients with mild head injury. The current study shows that trauma patients with seizure activity are no different. Considering the "availability, efficiency, high yield, and relatively low cost of head CT scans," a 14% positive head CT rate for the neurologically normal postseizure trauma patient must not be overlooked.

Will the data presented here change the current practice of trauma care? No. Many practitioners have been getting head CT scans in these patients all along and will continue to do so. However, at a time in which evidence-based medicine and cost-effectiveness often drive practice, the study gives credence to this custom. The authors present a well-done retrospective study with ample data to show the utility of these scans, even in neurologically normal patients.

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