Abdominal Computed Tomography for the Diagnosis of Intra-abdominal Sepsis in Critically Injured Patients

Fishing in Murky Waters

George C. Velmahos, MD, PhD; Eman Kamel, MD; Thomas V. Berne, MD; Nabil Yassa, MD; Emily Ramicone, MS; Zhenkai Song, MD; Demetrios Demetriades, MD, PhD

Hypothesis: Abdominal computed tomographic (ACT) scans are useful in the evaluation of sepsis of unknown origin in patients with major trauma.

Design: Prospective case series of consecutive patients.

Setting: Intensive care unit of level I academic trauma center.

Patients: Eighty-five critically injured patients admitted to the intensive care unit in 32 months (6% of all intensive care unit admissions) who developed sepsis of unknown origin.

Interventions: One hundred sixty-one ACT scans.

Main Outcome Measures: Sensitivity and specificity of the ACT scans, number of patients subjected to changes in treatment following an ACT scan.

Results: Forty-nine patients (58%) had an intra-abdominal focus of infection identified on ACT scan. Penetrating trauma and emergent laparotomy were the only independent factors associated with abnormal findings on ACT scan. The sensitivity and specificity of the test were 97.5% and 61.5%, respectively. Overall, 59 patients (69%) benefited from treatment changes after an ACT scan.

Conclusion: Abdominal computed tomographic scans reliably identify intra-abdominal foci of infection in patients with major trauma evaluated for sepsis of unknown origin.

Arch Surg. 1999;134:831-838

INTERRADOMINAL sepsis occurs in 30% to 80% of patients with major trauma.1-3 If not treated rapidly and appropriately, it is associated with high mortality rates. However, its diagnosis in patients who cannot be evaluated clinically remains a formidable task. Critically injured patients who must be admitted to the intensive care unit (ICU) almost always show signs of systemic inflammatory response syndrome. Identifying which patients with systemic inflammatory response syndrome have untreated infection may be difficult, particularly in view of the unreliability of cultures in the presence of antibiotics. Simple bedside radiographic tests, such as plain radiographs or ultrasonography, are difficult to interpret when used for suspected abdominal sepsis in these patients, who are generally edematous and have a distended abdomen.4 Reliance on abdominal computed tomographic (ACT) scans becomes necessary under such conditions.5

Transportation of critically ill patients away from the “safe” environment of the ICU could be harmful. Studies documenting rates of respiratory and hemodynamic deterioration of 5% to 50% during transportation6-7 draw attention to the need for careful scrutiny in selecting patients to be subjected to this risk. Additionally, the cost associated with ACT scans and the personnel who must accompany, monitor, and treat the patient is substantial.8

In our study, we focused on the use of ACT scans in the ICU for critically ill patients with evidence of sepsis. We analyzed the results of ACT scans and their effect on patient treatment. We examined the appropriateness of multiple ACT scans. We recorded complications associated with transport to the radiology suite. Finally, we tried to identify risk factors indicating patients likely to have abnormalities on ACT scan.

RESULTS

Overall, 9258 patients with major trauma were admitted at the Los Angeles County/University of Southern California Medi-
PATIENTS AND METHODS

All patients who were admitted to an ICU after major trauma and then developed signs of sepsis of unknown origin were included in the study prospectively from April 1996 to December 1998. For this study, sepsis was defined by a persistently (>2 days) high temperature (38°C) and a white blood cell count (12 × 10^9/L) occurring later than 3 days after admission to the ICU and usually associated with a hyperdynamic state, as shown by a high cardiac index (4.0 L/min divided by body surface area in square meters) and a low systemic vascular resistance (800 dynessec/cm²). Blood cultures with positive results for sepsis were not necessary for inclusion because most patients were taking antibiotics or decisions on further investigations needed to be made before culture results were returned. The sepsis was thought to be of unknown origin if no other test confirmed an infectious focus that could explain the clinical picture or if signs were not adequately explained by the existing evidence (eg, persistent sepsis despite culture-specific antibiotics with adequate blood levels for known respiratory tract infection).

Patients who had an ACT scan for reasons other than the evaluation of sepsis of unknown origin (eg, bleeding) were excluded from this study. Also, ACT scans that were done after the patient was discharged from the ICU to a regular ward were not included in our database. At that point the improved physiologic status and the ability to communicate with the patient allowed collection of much clinical information that could guide diagnostic workup, and ACT scans were not deemed to be “blind” investigations. Also, the high risk of transportation no longer existed.

The decision to evaluate the abdomen by ACT scan was made at the bedside after thorough examination of all clinical and laboratory parameters by a team of 8 physicians (7 trauma surgeons and 1 medical intensivist) dedicated to trauma and critical care. The patient was escorted to the radiology suite by at least 2 health care professionals (usually a surgical resident and a critical care nurse), and was fully monitored during the procedure. All ACT scans were interpreted by a senior radiologist. A different attending radiologist (N.Y.), blinded to the initial interpretation, reviewed all ACT scans retrospectively to examine intraobserver variability.

Abdominal computed tomographic (CT) scanning was done with a helical CT scanner (Picker PQ 6000; Picker International Inc, Cleveland, Ohio) at 1 cm cuts through the abdomen and pelvis. Intravenous contrast and oral contrast solution were administered through a nasogastric tube to all patients. Intra-abdominal sepsis was confirmed in the presence of abscesses, free bowel perforation, anastomotic leaks, acalculous cholecystitis, or necrotic bowel. When there was a question as to the nature of the fluid, ACT-guided diagnostic aspiration was done and the fluid sent for Gram stain and culture. A localized fluid collection was considered an intra-abdominal abscess when there was low attenuation within parenchymal organs or in extraluminary locations with thick or irregular walls and at least 1 of the following features: intracavitary gas, pus on aspiration, culture-positive aspirate, or aspirate with many white blood cells and no bacterial growth in patients taking multiple antibiotics. Acalculous cholecystitis was diagnosed on imaging of a distended gallbladder with wall thickening, sludge, and pericholecystic fluid. Bowel perforation or anastomotic leak was suspected on finding thickened bowel wall, free intraperitoneal air, or leaking enteric contrast. Bowel necrosis was considered when air was found within the bowel wall, mesenteric veins, or the portal vein.

An abnormal ACT scan was defined as a scan with evidence of intra-abdominal sepsis. An ACT scan was considered true-positive if there was confirmation of the radiographic picture provided at operation, needle aspiration, or autopsy. An ACT scan was considered false-positive if there was no objective confirmation of the radiographic interpretation by the above means. A normal ACT scan was defined as findings that did not identify evidence of intra-abdominal sepsis. A true-negative ACT scan was a scan performed on a patient with normal findings on exploration or autopsy and with no septic loci in the abdominal cavity. An ACT scan was considered false-negative if a subsequent operation or autopsy revealed evidence of intra-abdominal sepsis. Change in treatment was defined as one of the following interventions provoked by the results of an ACT scan: operation, percutaneous drainage, new antibiotics, avoidance of operation, removal of percutaneous drains, or discontinuation of antibiotics.

Data were collected prospectively on demographics, mechanism of injury (blunt or penetrating), severity of injury (aAIS, [Abdominal Abbreviated Injury Score]), operations, parameters of circulatory and respiratory function, laboratory results, radiographic findings, morbidity and mortality, and ICU and hospital stay. Events associated directly with transportation to the radiology suite were noted. Also, changes in treatment based on the results of the ACT scan were recorded. The highest temperature (T_max), highest white blood cell count, highest cardiac index value, and lowest systemic vascular resistance value during the 24 hours preceding the ACT scan were used as general indicators of sepsis.

Patients with and without abnormalities on ACT scan were compared. Categorical variables were compared by χ² or Fisher exact tests. Continuous variables were compared by t test to test the difference in mean values. Variables that had a P<.2 were entered in multiple logistic regression in a stepwise manner to identify factors associated with abnormalities on ACT scan. Variables that had a large volume of missing data were excluded from this analysis. Multiple logistic or stepwise regression analysis was further used to identify risk factors of mortality and prolonged ICU and hospital stay with the specific intent to determine if a abnormalities on ACT scan affected these indicators of outcome. For the analysis of ICU and hospital stay, patients who died were excluded. Statistical significance was determined at a P<.05 for all comparisons. The SAS statistical package (SAS Statistical Package Version 6.12; SAS Institute Inc, Cary, NC) for Windows was used.
and 12 women with an average age of 34 years (range, 10-78 years) and an average Injury Severity Score of 27 (range, 9-75). Forty-three patients (50.5%) had penetrating injuries and 42 (49.5%) had blunt trauma. Emergent operations were performed in 70 (82%) of them. Sixty patients (70.5%) had a laparotomy, 39 (46%) had hollow visceral injuries, and 16 (19%) had colonic injuries associated with clinical deterioration and was taken to the operating room for exploration. His abscess was drained operatively as described above. Four patients described in Table 2 and the previously described patient with the increase in abscess size who underwent an operation. One patient who had 2 normal ACT scans eventually underwent surgical exploration based on clinical evidence of intra-abdominal sepsis (worsening condition and wound dehiscence) and was found to have an abscess next to the right paracolic gutter. Her condition improved gradually after the operation. Twenty (77%) of 26 follow-up ACT scans in patients who had already had 1 previous ACT scan identified a source of sepsis, while only 4 (27%) of 15 were abnormal after a previous normal study.

RESULTS OF FOLLOW-UP ACT SCANS

In 24 of 41 patients who had follow-up ACT scans, a source of intra-abdominal sepsis was identified. Nineteen of the 24 had residual collections that were resolving while being drained (13) or while being treated with antibiotics (6). One had a collection that increased in size and was drained operatively as described above. Four patients had an abnormal follow-up ACT scan in the face of a normal initial ACT scan. These 4 patients are described in Table 1. After the follow-up ACT scan, changes in treatment were made in 15 patients. The ACT-guided drain was discontinued in 3, antibiotic therapy was stopped in 8, and new treatment was instituted in 4 (3 of the 4 patients described in Table 2 and the previously described patient with the increase in abscess size who underwent an operation). One patient who had 2 normal ACT scans eventually underwent surgical exploration based on clinical evidence of intra-abdominal sepsis (worsening condition and wound dehiscence) and was found to have an abscess next to the right paracolic gutter. Her condition improved gradually after the operation. Twenty (77%) of 26 follow-up ACT scans in patients who had already had 1 previous ACT scan identified a source of sepsis, while only 4 (27%) of 15 were abnormal after a previous normal study.

BENEFITS AND HARMs OF ACT SCANS

Overall, 64 (75%) of 85 patients had a change in treatment after the results of the initial ACT scan (49) or the follow-up CT scan (15) were determined. Excluding the 5 patients who had ACT-guided percutaneous drainage for presumed intra-abdominal abscesses but did not develop positive cultures of the drained fluid, 59 (69%) of 85 patients were benefited by this change in treatment. One patient who had 2 false-negative ACT scans but was found to have an intra-abdominal abscess on operation.
Table 1. Status of Four Critically Injured Patients*

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Mechanism</th>
<th>Injury</th>
<th>ACT Scan, No. of Days</th>
<th>Radiographic Diagnosis</th>
<th>Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Gunshot wound to abdomen</td>
<td>Stomach, colon, and liver</td>
<td>Initial: 8, Follow Up: 16</td>
<td>Abscess</td>
<td>Percutaneous drainage</td>
</tr>
<tr>
<td>2</td>
<td>Automobile vs pedestrian</td>
<td>Brain, liver, small bowel, and extremity fractures</td>
<td>Initial: 28, Follow Up: 38</td>
<td>Liver necrosis</td>
<td>Observation</td>
</tr>
<tr>
<td>3</td>
<td>Motor vehicle accident</td>
<td>Multiple rib fractures, lung contusion, and pelvic fractures</td>
<td>Initial: 21, Follow Up: 28</td>
<td>Acalculous cholecystitis</td>
<td>Cholecystectomy</td>
</tr>
<tr>
<td>4</td>
<td>Gunshot wound to abdomen</td>
<td>Kidney, liver, gall bladder, duodenum, small bowel, and lung</td>
<td>Initial: 6, Follow Up: 11</td>
<td>Abscess</td>
<td>Percutaneous drainage</td>
</tr>
</tbody>
</table>

* These 4 patients had an initial normal abdominal computed tomographic (ACT) scan followed by an abnormal ACT scan.

Table 2. Comparison Between Patients With and Without an Abnormal Abdominal Computed Tomographic (ACT) Scan

<table>
<thead>
<tr>
<th>Patients With an Abnormal ACT Scan (n = 49)</th>
<th>Patients With a Normal ACT Scan (n = 36)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>31 ± 14</td>
<td>.03</td>
</tr>
<tr>
<td>Glasgow Coma Score</td>
<td>14 ± 2</td>
<td>.003</td>
</tr>
<tr>
<td>Injury Severity Score</td>
<td>14 ± 20</td>
<td>.12</td>
</tr>
<tr>
<td>Abdominal Abbreviated Injury Score</td>
<td>3 ± 3</td>
<td>.001</td>
</tr>
<tr>
<td>Maximum temperature, °C</td>
<td>38.6 ± 17.2</td>
<td>.68</td>
</tr>
<tr>
<td>White blood cell count, × 10^9/L</td>
<td>18 ± 8</td>
<td>.22</td>
</tr>
<tr>
<td>Cardiac index, L/min per m²</td>
<td>5.2 ± 1.4</td>
<td>.58</td>
</tr>
<tr>
<td>Systemic vascular resistance, dynes/cm²</td>
<td>615 ± 167</td>
<td>.79</td>
</tr>
</tbody>
</table>

FACTORS ASSOCIATED WITH AN ABNORMAL ACT SCAN

Table 2 shows the comparison of different factors between 49 patients with abnormal ACT scans and 36 patients with normal ACT scans. Age, mechanism of injury, Glasgow Coma Scale, aAIS, and the incidence of emergent laparotomy, hollow visceral injury, and colonic injury were found to be significantly different between the 2 groups. The multivariate analysis identified the following variables to be independently predictive of an abnormal ACT scan: penetrating injury (odds ratio, 6.9; 95% confidence interval, 2.2-24.0), emergent laparotomy (odds ratio, 12.7; 95% confidence interval, 3.6-55.2), and Injury Severity Score (odds ratio, 0.9; 95% confidence interval, 0.91-0.99). Paradoxically, Injury Severity Score was associated inversely with findings on ACT scans. The aAIS had a highly significant linear association with findings from ACT scans (P <.001). Twelve (80%) of 15 patients with an aAIS of 5 had an abnormal ACT scan; 15 (75%) of 20 patients with a normal first ACT scan; and 6 (46%) of 13 patients with an aAIS of 2. There were no patients with an aAIS of 1. Interestingly, of 18 patients with an aAIS of 0 (no abdominal injury), 3 had an abnormal first (2) or follow-up (1) ACT scan. Acalculus cholecystitis was diagnosed in all 3 patients. They were treated by percutaneous CT-guided drainage (2) or surgery (1). Except for these 3 patients, all other patients with an abnormal ACT scan had an emergent laparotomy on arrival to the hospital.

SENSITIVITY AND SPECIFICITY OF ACT SCANS

Of 49 patients with abnormal first or follow-up ACT scans, 5 showing intra-abdominal abscesses had an aspirate with no bacteria or white blood cells (false positive), 3 were treated with antibiotics with no objective assessment of the findings on ACT scan, and 1 had liver necrosis and was observed without further confirmation. Therefore, 40 patients were considered to have true-positive findings on ACT scan. Of 36 patients with a normal first ACT scan and with or without a follow-up ACT scan, only 9 had an objective assessment of their abdominal cavity. Eight died and had an autopsy that did not reveal any evidence of intra-abdominal sepsis (true negative) and 1 had an operation that revealed an abscess (false negative). Based on these calculations, the sensitivity of the ACT scan was 97.5% and the specificity was 61.3% (Figure 2).

ADVERSE EVENTS DURING TRANSPORT

Twelve patients (14%) developed mild adverse events during transportation from the ICU to the radiology suite. Three patients had a decrease in their cardiac index and 9 had a decrease in PaO2 by more than 20% of the values they had before transport. No patient had hypotension or desaturation episodes. All events were managed successfully by standard measures.
would not exclude patients from the possibility of hav-

ing an intra-abdominal process as the source of their sep-
sis based on the mechanism of injury.

The need for laparotomy was strongly associated with
an abnormal ACT scan. Three patients (17%) had an ab-
normal ACT scan among 18 patients with no intra-
abdominal injuries. Only 1 of these 18 patients had a la-
parotomy that was nontherapeutic. Acalculous cholecys-
tis was diagnosed on all 3 patients on ACT scan. As this
disease could have been diagnosed by ultrasonography,
we believe that ACT scans are not necessary in most criti-
cally injured patients who have no abdominal injury. If
intra-abdominal sepsis is suspected, it will probably origi-
nate from the gallbladder and an ultrasound scan should
be the diagnostic procedure of choice.

Four patients revealed intra-abdominal foci of sep-
sis on follow-up ACT scans despite the fact that a pre-
vious ACT scan was normal. All 4 patients had severe
intraperitoneal injuries and unresolving sepsis. A fol-
low-up ACT scan was pursued because there was no im-
provement in the patient’s condition despite multiple
therapeutic changes. Although the possibility that find-
ings from the initial ACT scan were false-negative could
explain the paradox, both senior radiologists who re-
viewed the ACT scan blinded to each other’s reading in-
terpreted it as normal. Based on this experience, we be-
lieve that a second ACT scan in the presence of persistent
sepsis in a patient with multiple intra-abdominal inju-
ries is not an unreasonable choice, even if the initial ACT
scan is normal. This should be done after careful scru-
tiny of all potential infectious sources and with the un-
derstanding that this group will be the least likely to show
significant findings on ACT scan.

An abnormal ACT scan was not found to be an in-
dependent risk factor for mortality or increased ICU and
hospital stay. Critically injured patients are complex, and
the isolation of one factor to relate exclusively with over-
all course is unlikely. The good outcome of patients with
abnormal ACT scans could also be attributed to the fact
that a source of sepsis was found and definitively treated.

There is ongoing controversy on the role of ACT
scans for critically ill patients. Some authors believe that
ACT scans are valuable in the diagnosis of intra-
abdominal sepsis,1,3,9 while others believe that it should
not be used to search for a source of sepsis in such pa-
tients.8 According to our study, we would support the
former view. That the risks from transportation were not
substantial and that most adverse events were easily man-
aged encourages us to believe that evaluation by ACT scan
for critically ill patients is safe. Estimation of the cost
is difficult in our county hospital because charges are not
based on individual tests and procedures, but rather on
flat daily fees. In any case, regardless of all expenses re-
lated to ACT scans, calculation of its cost vs benefit would
be almost impossible.

The sensitivity of ACT scans was excellent (97.5%),
but the specificity was low (61.5%). We calculated these
values based only on patients who had an objective as-
essment of results from ACT scans by means of opera-
tion, autopsy, or percutaneous drainage. Obviously, pa-
tients with a normal ACT scan whose condition progres-
sively improved did not have any of these inter-
ventions. Therefore, the sample may be skewed toward

### Table 2. Sensitivity and specificity of abdominal computed tomographic
(ACT) scans to identify intra-abdominal sepsis. TP indicates true positive; FP,
false positive; TN, true negative; FN, false negative.

<table>
<thead>
<tr>
<th></th>
<th>TP</th>
<th>FP</th>
<th>TN</th>
<th>FN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sensitivity</strong></td>
<td>TP = 40</td>
<td>FP = 5</td>
<td>TN = 36</td>
<td>FN = 1</td>
</tr>
<tr>
<td></td>
<td>0.975</td>
<td>0.615</td>
<td>0.62</td>
<td>0.62</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>TP + FN=40</td>
<td>TP + FN=40</td>
<td>TN + FP=40</td>
<td>TN + FP=40</td>
</tr>
<tr>
<td></td>
<td>0.975</td>
<td>0.615</td>
<td>0.62</td>
<td>0.62</td>
</tr>
</tbody>
</table>

### ACT SCAN AS A PREDICTOR OF OUTCOME

From the univariate and multivariate analysis, the fol-
lowing 2 variables were found to be significantly dif-
ferent between survivors and nonsurvivors: age and the in-
cidence of hollow visceral injuries. There were 45 patients
(62%) with an abnormal ACT scan among 73 survivors,
and 4 (33%) among 12 nonsurvivors. The P value was
not significant and ACT scan was not considered to be
a predictor of mortality, even when the incidence of ab-
normalities on ACT scan were examined against all sig-
nificant factors adjusted to each other in a separate mul-
tiple regression analysis. Similarly, there was no difference
between patients with abnormal and normal findings on
ACT scan during a hospital stay (data given as mean ±
SD) (54±34 vs 44.5 ± 25 days; P=.20) or ICU stay (32 ± 26
vs 28 ± 17 days, P = .43).

### COMMENT

The results of this study confirm that ACT scans are a
safe and useful modality to diagnose intra-abdominal sepsis
in critically injured patients. After careful scrutiny and
clinical assessment, only 6% of patients with major trauma
who were admitted to an ICU during the study period
were thought to have sepsis of unknown origin. Of these,
58% indeed had a septic focus in the abdominal cavity and
69% benefited from a change in treatment. Al-
though there were statistically significant differences be-
tween patients who had or did not have hollow visceral
injury (and particularly colonic injury), it was surpris-
ing that these variables were not associated indepen-
dently with a higher probability of identifying intra-
abdominal sepsis on ACT scan according to the mul-
tivariate analysis. This result could be attributed to
rigorous selection of patients who were all at high risk
of developing intra-abdominal sepsis.

The presence of penetrating injury and the need for
a laparotomy increased the chances for having an abnor-
mal ACT scan. However, even among patients with blunt
trauma, the rate of an abnormal ACT scan was 15 (36%)
of 27, which, although significantly lower than the rate
among those with penetrating injuries 34 (79%) of 43,
was by no means negligible. Given these incidences, we
would not exclude patients from the possibility of hav-

Figure 2. Sensitivity and specificity of abdominal computed tomographic
(ACT) scans to identify intra-abdominal sepsis. TP indicates true positive; FP,
false positive; TN, true negative; FN, false negative.
patients who had ongoing problems and were subjected to additional procedures. If we estimate in our sample size, all patients who had a normal ACT scan with no apparent indication that a focus of intra-abdominal sepsis was missed, the specificity improves to 87.5% (35 true negative, 5 false positive).

In conclusion, we recommend the ACT scan as a useful investigation in the evaluation of sepsis of unknown origin in critically ill patients following major trauma. More than half of such studies can be expected to identify a septic focus in the abdomen that can be treated, and approximately two thirds of the patients will benefit from decisions guided by ACT scans. The study is particularly useful in patients who underwent emergent operations following penetrating trauma. Because additional factors predicting an abnormal ACT scan are hard to define, a liberal policy in obtaining ACT scans in such patients is reasonable.

Presented at the 70th Annual Session of the Pacific Coast Surgical Association, San Jose del Cabo, Baja California Sur, February 14, 1999.

Corresponding author: George C. Velmahos, MD, PhD, Los Angeles County + University of Southern California Medical Center, 1200 N State St, Room 9900, Los Angeles, CA 90033 (e-mail: velmahos@hsc.usc.edu).

REFERENCES


DISCUSSION

James J. Peck, MD, Portland, Ore: This is a 32-month prospective case series of 85 consecutive, severely traumatized patients in whom computed tomography was used as a “blind” investigation for sepsis. Only 6% of all ICU admissions for trauma had CT scanning for this indication. In 58% of patients, a septic focus was found and in 69% benefit was achieved by changing treatment style. It was found to be especially useful in patients with penetrating trauma who needed an emergent laparotomy on admission and who subsequently developed sepsis of unknown origin. I compliment the authors for the remarkable 14% mortality in these very sick patients who averaged more than 30 days in the ICU and 50 days in the hospital. Let me reinforce several caveats in this paper. First, computed axial tomographic (CAT) scans for sepsis is of little value before the eighth day after trauma or operation. Nonsuppurative fluid collections and tissue swelling from the trauma itself need to resolve before you can use the CAT scanner. Abscesses less than 3 cm resolve usually with intravenous (IV) antibiotic conservative treatment. There are few pathognomonic signs of an infected collection on CAT scan and needle aspiration is usually required to make the diagnosis. Abscess drainage needs to be complete, and follow-up scans are often necessary. Computed axial tomographic scanning did not improve the survival or shorten the hospital or ICU stays of these patients. Abdominal CAT scan is not the test of choice for patients with an abdominal abbreviated injury score of 0. Three of the 18 patients who had no abdominal injury had acalculous cholecystitis as the source of their sepsis and their conditions would have been better diagnosed by bedside ultrasound.

I do not agree, however, with the authors’ conclusion that a liberal policy in obtaining abdominal CAT scan in such patients is reasonable. Indeed, I agreed with the subtitle of the paper that CT in these patients is “fishing in murky waters.” These are critically ill ICU patients, intubated, paralyzed, and sedated. I fear overuse by recommending a liberal policy. Unfortunately, the objective clinical criteria for ordering these studies has not advanced as rapidly as the availability of the CAT scanner. There is significant hemodynamic and respiratory risk in moving the patient through the corridor and in the elevators to the isolated black hole of the CT scanner. There is a cost to personnel accompanying, monitoring, and treating these patients in the hospital environment. Moreover, the patients who remain in the ICU have fewer caregivers.

The cost of a “blind” investigation is substantial and was not addressed by this paper. One hundred sixty-one CT scans would cost more than a quarter of a million dollars in my hospital for the studies and for the radiologists’ fees to read them. The issue then is, are these patients truly “clinically unevaluable”? The stated criteria for sepsis in this paper is very arbitrary: temperature greater than 38°C; white blood cell count greater than 12 × 10^9/L; Swan-Ganz catheter readings in about half of the patients for cardiac index and peripheral vascular resistance. It appears that more likely these patients were chosen by the 7 trauma surgeons and the medical intensivist based on their clinical acumen. You know what “pornography” is when you see it but you can’t define it.

Our recorder, Dr. Eric Wilson, in the July 1996 issue of Clin Infect Dis, recommended criteria for CAT scan in septic patients based on the Acute Physiology and Chronic Health Evaluation (APACHE) II score between 14 and 25. Patients with scores less than 14 or greater than 25 did not benefit from this technology.

My first question is, have you used an APACHE II score, and are they valuable in this particular subset of critically ill patients. Second, all of your patients were given oral and IV contrast solution. Was there any aspiration, renal failure, or allergic reaction as a complication of these studies? How did your radiologist percutaneously drain these patients? Did they use pig-tail catheters, 8-16 French argyle drains, or 1-step needle aspiration and the lavage technique? Most series report a 3% mortality and a 7% to 10% morbidity with percutaneous drainage due to bowel perforation, contamination of new spaces, or catheter dislodgment or obstruction. What were your complications from percutaneous drainage? Finally, only 2 radiologists read all 161 studies. One is a monk, a man who is a renowned expert at reading CAT scans whose interpretation and whose opinion was never refuted by the second radiologist. Can we reasonably expect that your results can be reproduced in the community by several radiologists who have differing ability to read CAT scans?

In conclusion, I compliment the authors on bringing this important work to our attention. Computed axial tomographic scanning should not be a fishing expedition, but that it is of value in a still-to-be-defined small percentage of critically ill patients with sepsis and trauma.
Samuel Eric Wilson, MD, Orange, Calif: Given your demonstrated accuracy of CT scans, Dr Berne, do you think CT scans should be performed earlier as a screening tool before the onset of gross sepsis, for example, for prolonged ileus, low-grade fever, and other such worrisome signs? Second, how often do you think needle aspiration of fluid collections should be done to confirm the presence of infection before intervention? Third, is there a postoperative day before which CT will not be useful? Do you accept postoperative day 8 as a threshold?

Gil Cryer, MD, Los Angeles, Calif: Dr Velmahef, I think that a little historical perspective is the reason that I would like to ask a question of you. Back in the early 1980s when I was a resident in training, the thing to do with a septic patient was to go to the operating room and explore their abdomen. In those days about 30% of so had an intra-abdominal source of infection. As antibiotics and critical care got better over the next decade, most studies found that CT scans or other diagnostic methodology in septic patients after injury would only yield about a 10% incidence of infectious process in the abdomen. These operations were mostly done for multiple organ failure and severe sepsis. So when we look at your data, about 30% of your patients had an intra-abdominal source of sepsis, which seems very high. One of 2 things must be going on. Either you are using some other criteria to select the patients who are at very high risk who perhaps weren't mentioned today, and I would ask if you think that is possible and what the criteria might be, or the other possibility is that whatever factors have led to our success rate in preventing intra-abdominal sepsis after injury are now failing for some reason. If you think that is the case, I would like to ask what you think the reason might be.

Steve N. Parks, MD, Fresno, Calif: All of us would like to believe that we are great diagnosticians, that we can delay getting extra studies, use routine examinations, and not have to spend the money for CAT scans. It is almost the 21st century and I would like to bring us at least into the 20th century. The CAT scan is one of the best things invented in the last 50 years. It gives us diagnostic material that we never had on the plain chest x-ray film (for the elective thoracic surgeon), on the abdominal x-ray film, or the gastrointestinal study (for the abdominal surgeon). It is a great test, and it has turned out once again to be a great test for sepsis. I do not decry the fact that we are spending money to get the best test we can get. It is papers like this that show us that it is appropriate to do this. In this audience most people are using the CT scan as a way of working up unknown sepsis and abdominal sepsis. It is a good time to have a paper like this that tells us this is good. I warn you about trying to save money; you are going to spend less money if you make the diagnosis and get the patient treated.

Lawrence Way, MD, San Francisco, Calif: I question the appropriateness of the term unnecessary when referring to the negative needle aspirations of collections that did not turn out to be abscesses. The word unnecessary suggests that these aspirations should not have been done. That would only be true, however, if the ability of CT scans to exclude the possibility of an abscess was perfect, which is not the case. Thus, the aspirations in those patients should be considered diagnostic. They were necessary; they largely ruled out abscess formation in those patients, and they did influence the treatment plan.

Larry Gentilello, MD, Seattle, Wash: These patients had multiple CT scans. There were 141 scans performed in 72 patients. But it seems that the second scan was the one that was abnormal in 24 of 41 cases. In other words, out of the 46 abnormal CT scans, 24 of the 46 were abnormal as a result of the second CT scan. So, therefore, couldn’t you conclude that CT scan delays diagnosis because it cannot pick up cases of abdominal sepsis early because its initial sensitivity was very poor?

Maria Allo, MD, San Jose, Calif: I would ask whether there was any correlation between normal and abnormal CT scans and whether the CT scans were performed with oral IV and rectal contrast, oral and IV alone, or no contrast at all.

Lawrence A. Danto, MD, Stockton, Calif: Pus somewhere, pus nowhere, pus under the diaphragm. My concern is that a normal CT scan will keep us from operating on patients when they need to be explored. Our tendency in the age of technology is to forget the value of the exploratory celiotomy, and I wonder what the effect of a negative exploratory celiotomy is on this particular patient group.

Dr Berne: The genesis of this paper was that all of the questions brought up by the discussants are constant points of discussion in our trauma-critical care group when we make rounds in the ICU. We embarked on this study to see if we could shed some light on whether we were getting CTs too often or not often enough and whether we were putting our patients at risk. Dr Peck asked about APACHE scoring. We have been reluctant to apply APACHE measurements to a single patient. I know it is done a lot in cases of infection and sepsis. The validity of that is still, particularly in surgical patients, unclear. So we did not do that. In regard to complications such as allergic reactions or aspiration, we did not have such problems in this group of patients. We occasionally do have problems with oral contrast, and to just answer another question, we gave oral contrast, not rectal contrast, and IV contrast. We did not have particular problems from these agents. These patients' creatinines go up and down and you sometimes think possibly the IV contrast caused that, but there is so much going on in each of these patients that we really couldn’t tell. We did not detect anybody who went into renal failure soon after IV contrast.

The abdominal CT technique in our hospital is that they do the scan, they look at it, and if there is something that they think might be an abscess, they put a needle into it if it is safe. They are very good at knowing what paths are safe to needle and what paths are safe to put catheters through. If they get purulent-looking material, they put a pigtail catheter into it. Then if the catheter doesn’t drain well and if the patient doesn’t do well, we may send the patient down for another CT scan and have that changed occasionally to a larger sump-type catheter.

Another question was were there complications from your percutaneous drainage? In the group of patients in this study, we did not have significant complications—no problems with bowel perforation or bleeding or other potential complications. In our day-to-day care of patients, we occasionally do, but they are very infrequent. It’s amazing how infrequent they are, and I think a lot of it has to do with experienced people who are unwilling to do dangerous things.

Dr Peck’s last question was can you reasonably expect the results to be reproduced by community radiologists? Most of what they identify is fairly straightforward. Well-trained community radiologists in this day and age can come close to reproducing these results.

Dr Wilson questioned whether or not we ought to do CT screening earlier. Maybe we should study that. We have not done it.

How often should you carry out needle aspiration? As I mentioned, this is a standard procedure so it is almost always carried out.

Several people asked a question about what postinjury day should we begin to consider the use of abdominal CT scanning. Dr Way pointed out that it is wrong to put an absolute
date on that. We have had 1 patient who showed significant pathology at 5 days. If we really have a patient we are worried about and we think there might be a problem, we will do it as early as 4 days.

Dr Cryer, you asked about the use of so-called blind exploratory laparotomy. We used to do a lot of blind exploratory laparotomies, but they are rare now. There was a high mortality rate in those patients. There have been studies in recent years pointing out that every time you re-explore such patients, you create a cytokine “storm” to the patient that represents what is talked about in the literature as a “hit.” Our trend has been to move away from that kind of procedure to CT scanning. The way this is done is that we make rounds every day with 3 to 5 trauma surgeons and an intensivist to make rounds in the critical care unit. It is a clinical decision. What we did in this study was to try to see if there are identifiable things that would predict which cases should have CT scans. As you can tell, we really didn’t find any specific criteria to use. Probably just clinical judgment is the best tool for making the decision as to who should go for a CT.

Dr Parks, thank you. I happen to be the “CT nut” in our trauma service, so I agree with you. It has been an extremely important tool for the surgeon, particularly for the trauma surgeon. It has revealed things that we never understood before, and we are still trying to learn how to use this tool. It is expensive and there is a risk to taking patients out of the critical care unit. Everything Dr Peck said about the problems of taking a patient out of the ICU is absolutely true.

Dr Way, I think I addressed your question about the timing. In regard to the use of the term “unnecessary,” you are right. We used the wrong word. It should have been “negative.”

Dr Gentilello suggested that the first CT scan, when negative, actually delays the diagnosis. I hadn’t thought about it in those terms. But, I don’t think so. I believe that it just takes longer in some patients for the pathology to declare itself to a point where it is possible to tell that it is there. Again, it reverts back to the question, what else would you do? The only thing you might do is a blind exploration. I would worry about the harm you would do.

One of the discussants suggested that we should have done ultrasound, particularly early on. Most of these patients have intestinal gaseous distention, and although it might seem reasonable to try ultrasound first, our experience is that it is rarely helpful.