Oral Contrast Solution and Computed Tomography for Blunt Abdominal Trauma

A Randomized Study

Renae E. Stafford, MD; Michael D. McGonigal, MD; John A. Weigelt, MD; Thomas J. Johnson, MD

Hypothesis: Oral contrast solution (OC) is unnecessary in the acute computed tomographic (CT) evaluation of the patient with blunt abdominal trauma.

Design: Randomized controlled clinical trial.

Setting: Level I trauma center at a university-affiliated teaching hospital.

Patients: Five hundred adult patients sustaining blunt abdominal trauma and requiring urgent resuscitation and CT evaluation of the abdomen were eligible for the study. Those patients who were younger than 18 years, pregnant, or in police custody were excluded. One hundred six patients were excluded from the analysis (15 for inappropriate enrollment, 9 because a CT scan had not been performed, 1 owing to inability to accept a nasogastric tube, and 81 owing to missing or incomplete records). Three hundred ninety-four patients with an average age of 36 years, an average Revised Trauma Score of 10, and an average Glasgow Coma Scale score of 12 are included in the analysis.

Interventions: Patients were randomized via computer-generated assignment to 1 of 2 groups either receiving OC or not receiving OC (no OC) after placement of a nasogastric tube. All patients received intravenous contrast solution and then underwent helical CT scan of the abdomen and pelvis using the GE HiSpeed Advantage CT scanner (GE Medical Systems, Milwaukee, Wis).

Main Outcome Measures: Abnormal CT results, need for laparotomy, missed gastrointestinal tract and solid organ injuries, nausea, and vomiting.

Results: There were 199 patients in the OC group and 195 patients in the no OC group. Vomiting occurred in 12.9% of patients and the incidence was not different between groups. One hundred five abnormal scans (50 OC and 55 no OC) were obtained and 33 patients with abnormal scans (19 OC and 14 no OC) underwent laparotomy. There was 1 nontherapeutic laparotomy in each group. There was 1 missed small-bowel injury in the OC group (sensitivity, 86%) and no missed small-bowel injuries in the no OC group (sensitivity, 100%). Six bowel injuries were identified at laparotomy in the OC group. Two of the injuries were perforations without contrast extravasation but with pneumoperitoneum in 1. Three bowel injuries were identified in the no OC group, none of which were perforations. Seven of the 9 patients with bowel injury at laparotomy had associated intra-abdominal injury. Specificity for solid organ injury was 94% in the OC group and 57.1% in the no OC group. Sensitivity for solid organ injury was 84.2% in the OC group and 88.9% in the no OC group. The average time to abdominal CT scanning after placement of a nasogastric tube was 39.02 ± 18.73 minutes in the no OC group and 45.92 ± 24.17 minutes in the OC group (P = .008).

Conclusion: The addition of OC to the acute CT protocol for the evaluation of the patient with blunt abdominal trauma is unnecessary and delays time to CT scanning.

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Oral contrast solution (OC) is recommended by both surgeons and radiologists when computed tomography (CT) is used for evaluation of the abdomen in patients with blunt abdominal trauma. Oral contrast aids in the identification of bowel loops, helps delineate bowel mesentery, and distinguishes opacified intestine from hematoma, hemorrhage, and pancreatic pathologic findings. Finally, extravasation of OC is a specific finding for the diagnosis of hollow viscus perforation. The use of OC for blunt abdominal trauma CT scans does have potential disadvantages. These include vomiting with pulmonary aspiration and interference with subsequent angiographic studies. The effective use of OC also requires additional time for gut opacification, which may delay definitive treatment of injuries. The value of OC for CT scans in patients with blunt trauma has
PATIENTS, MATERIALS, AND METHODS

All adult trauma patients presenting to the St Paul Ramsey Medical Center, St Paul, Minn, a level I trauma center, who required urgent resuscitation and CT evaluation of the abdomen for blunt abdominal trauma between June 1993 and October 1996 were eligible for entry into the study.

Patients who were younger than 18 years, pregnant, or in police custody were excluded from the study. Eligible patients were prospectively randomized to either the OC group or the group not receiving OC (no OC). Randomization was implemented by computer-generated assignment. The study was approved by our institutional review board.

All patients had a nasogastric tube placed prior to randomization. Patients in the OC group received 30 mL of diatrizoate meglumine (Gastrografin Oral; Bracco Diagnostics, Princeton, NJ) mixed with 700 mL of tap water, which was administered via the nasogastric tube in the emergency department. All patients received intravenous contrast by a mechanical injector at 2 mL/s at a maximum dose of 2 mL/kg. Intravenous contrast agents were either diatrizoate sodium (Renografin 76; Bracco Diagnostics) or iopromide (Ultravist; Berlex, Wayne, NJ). Computed tomographic scans were performed using the GE HiSpeed Advantage helical scanner (GE Medical Systems, Milwaukee, Wis). Scans were obtained using 7-mm cuts from the dome of the diaphragm to the pelvic crest and 10-mm cuts from the pelvic crest to the symphysis pubis. Scans were immediately examined by an attending radiologist, staff trauma surgeon, and chief surgical resident. Initial management decisions were based on this reading. Data collected at the time of CT scanning included demographic data, mechanism of injury, Glasgow Coma Scale score, Revised Trauma Score, and a history of aspiration or vomiting. The length of time in minutes for travel from the emergency department to the CT scanner, for scanning of the abdomen and pelvis, and for travel from the CT scanner to the ward, intensive care unit, or operating room was recorded. Patient records were reviewed for abnormal CT results on the final staff radiologist reading, need for laparotomy, and missed gastrointestinal tract injuries and complications. Laparotomy findings were compared with both initial and final preoperative CT results. Statistical analysis was performed using the chi² test, t test, and Fisher exact test where appropriate. P ≤ .05 was considered statistically significant.

been questioned. Despite many reports of the accuracy of CT scans with OC in patients with blunt abdominal trauma, the necessity of OC as part of the CT scanning protocol has never been assessed in a randomized prospective fashion.

To evaluate the necessity of OC in CT evaluation of the patient with blunt abdominal trauma and to assess possible disadvantages of its use, we evaluated 500 consecutive patients who required CT evaluation of the abdomen for blunt abdominal trauma in a randomized prospective study.

RESULTS

Five hundred consecutive patients who fit eligibility criteria were enrolled in the study (Figure). One hundred six patients were excluded from the analysis. Of these 106 patients, 15 patients were inappropriately enrolled in the study, 9 patients required immediate laparotomy obviating the need for abdominal CT scan, 1 patient was excluded because of the inability to pass a nasogastric tube, and the remaining 81 patients had incomplete or missing records. These 81 patients were prospectively identified and had initial data points collected, but final data could not be collated because their medical records could not be retrieved from our institution. Thus, 394 patients are included in the final analysis. There were 278 men (70%) and 116 women (30%). Their average ages were 35.6 and 37.8 years, respectively. Motor vehicle crashes accounted for 60.4% of the injuries; pedestrian vs auto accidents, 9.9%; falls, 9.6%; motorcycle crashes, 7.6%; and other mechanisms, 12.5%. The overall average Revised Trauma Score was 10 (range, 4-12) and the overall average Glasgow Coma Scale score was 12.0 (range, 3-15). These variables were not significantly different between the OC and no OC groups.

There were 199 patients in the OC group and 195 patients in the no OC group. There were 105 abnormal CT scans (50 OC and 55 no OC). Of those patients with abnormal CT scans, 33 (31%) underwent laparotomy. Of the 33 laparotomies performed, 19 were OC patients and 14 were no OC patients. There was 1 nontherapeutic laparotomy in each group. One missed small-bowel injury occurred in an OC patient and there were no missed small-bowel injuries in the no OC patients. Vomiting occurred in 27 OC patients (13.6%) and 24 no OC patients (12.3%). There were 2 witnessed aspiration episodes; however, neither of these were related to administration of OC therapy. None of these differences between the patient groups were statistically significant.

There were 6 bowel injuries confirmed at laparotomy in the OC group (Table 1). Thickening of the bowel wall was noted on CT in 3 of the patients in this group, and free fluid was noted in 2. Two of the injuries involved perforations. Only 1 of the perforations was associated with a pseudoperitoneum. There was no contrast extravasation seen on CT scan in either of the patients who had a perforation. The nontherapeutic laparotomy in this group occurred in a patient who had an initial CT scan that was read as negative except for an acetabular fracture. Because of persistent ileus, a second CT scan was performed that showed free fluid in the pelvis. No injury was found at laparotomy.

In the no OC group, there were 3 bowel injuries identified at laparotomy (Table 1). Two patients had free fluid and 1 patient had a thickened bowel as seen on the preoperative CT scan. There were no perforations in this group. Nontherapeutic laparotomy was performed on a patient who had been in a motor vehicle crash and sustained a pancreatic laceration with peripancreatic fluid
and a liver laceration as seen on CT scan. At laparotomy, no liver or pancreatic injuries were noted, although retroperitoneal edema was seen. The patient was discharged from the hospital 8 days after injury.

A missed small-bowel injury occurred in 1 patient in the OC group who sustained multiple orthopedic injuries by attempting suicide by jumping from a bridge. An abdominal and pelvic CT scan done at admission was read by an attending radiologist as negative for hollow viscous or solid organ injury, although the patient did have multiple pelvic fractures. The hospital stay was marked by an ileus, fever, and urinary tract infection. Despite treatment of the urinary tract infection, the patient remained febrile and subsequent workup revealed free air on a chest x-ray film. An exploratory laparotomy was performed on hospital day 20. At laparotomy, bowel content was noted in the peritoneal cavity. A perforation on the antimesenteric border of the midjejunum was found. The postoperative course was complicated by an anastomotic leak and the patient was discharged 60 days after injury.

Of those patients with bowel injury found at laparotomy, 7 had associated intra-abdominal injuries (Table 2). Most had solid organ injuries, and there were 2 bladder ruptures. Solid organ injury, most commonly of the spleen, was the most prevalent finding at laparotomy in those patients without bowel injury.

There were 11 patients who underwent laparotomy in the OC group who were suspected of having 17 solid organ injuries on the basis of preoperative CT scan. Sixteen injuries were confirmed at laparotomy (specificity, 94%). However, 3 injuries (liver, spleen, and pancreas) were identified at laparotomy that were not identified on the preoperative CT scan (sensitivity, 84.2%). In the no OC group, 12 patients were suspected of having 14 solid organ injuries on the basis of the preoperative CT scan results. Eight injuries were confirmed at laparotomy (specificity, 57.1%). One solid organ injury was found at laparotomy that was missed by the CT scan (sensitivity, 88.9%).

Accurate time data were available for 282 (138 no OC and 144 OC) patients. The average time from placement of a nasogastric tube or orogastric tube to abdominal CT scan was 39.02 ± 18.73 minutes in the no OC patients and 45.92 ± 24.17 minutes in the OC patients (P = .008).

**Table 1. Patients With Abnormal CT Scan and Bowel Injury at Laparotomy**

<table>
<thead>
<tr>
<th>CT Scan</th>
<th>OC Group</th>
<th>Laparotomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small amount of peritoneal fluid</td>
<td>Small-bowel thickening, pneuoperitoneum perforations†</td>
<td>Ileal mesenteric tear, hematoma</td>
</tr>
<tr>
<td>Small-bowel thickening, pneuoperitoneum perforations†</td>
<td>Thickening of the mid small bowel‡</td>
<td>Ileal and cecal</td>
</tr>
<tr>
<td>Free fluid in pelvis</td>
<td>Free fluid in pelvis</td>
<td>Mesenteric tears mid ileum</td>
</tr>
<tr>
<td>Soft tissue density in mesenteric fat near tail of pancreas and thickened bowel wall, soft tissue density at hepatic flexure</td>
<td>Mesenteric tears, hepatic flexure, bowel wall hematoma</td>
<td>Mesenteric tears, hepatic flexure, bowel wall hematoma</td>
</tr>
<tr>
<td>Free intraperitoneal fluid</td>
<td>Free fluid in pelvis, soft tissue stranding adjacent to pancreas</td>
<td>Serosal tears descending colon, bladder perforation</td>
</tr>
</tbody>
</table>

*CT indicates computed tomographic; OC, oral contrast solution; †This patient had no contrast extravasation or pneumoperitoneum seen on CT scan. ‡This patient had no contrast extravasation seen on CT scan.

**Table 2. Associated Findings in Patients With Bowel Injury**

<table>
<thead>
<tr>
<th>CT Scan</th>
<th>OC Group</th>
<th>Laparotomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small amount of pelvic fluid</td>
<td>Splenic laceration, rupture of the abdominal wall</td>
<td>Bilateral pelvic wall lacerations</td>
</tr>
<tr>
<td>Splenic laceration, rupture of the abdominal wall</td>
<td>Transverse process fracture L5</td>
<td>Abdominal wall disruption, transected rectus muscle, splenic laceration</td>
</tr>
<tr>
<td>Intraperitoneal splenic fluid</td>
<td>Soft tissue density in mesenteric fat near tail of pancreas and thickened bowel wall</td>
<td>None</td>
</tr>
<tr>
<td>Soft tissue density in mesenteric fat near tail of pancreas and thickened bowel wall, soft tissue density at hepatic flexure</td>
<td>Sacral fractures with pelvic hematoma</td>
<td>None</td>
</tr>
</tbody>
</table>

*CT indicates computed tomographic; OC, oral contrast solution; L5, fifth lumbar vertebra; and no OC, no oral contrast solution.

Computed tomography has become the radiographic technique of choice in many trauma centers for the evaluation of the hemodynamically normal patient with blunt abdominal trauma. While many authors and investigators have advocated the use of OC in addition to intravenous contrast as part of the abdominal trauma CT scanning regimen, considerable controversy remains regarding its necessity. In particular, there is concern regarding time delay to diagnosis of potentially lethal injuries, aspiration of gastric contents and contrast with subsequent pulmonary toxic effects, interference with evaluation of angiographic studies, and whether OC actually adds information to make the diagnosis of a critical bowel injury. In addition, there are pediatric and adult trauma centers where OC is not routinely used as part of the blunt abdominal CT scan protocol.

The rationale for the use of OC in trauma CT of the abdomen is well delineated in the literature. One of the most commonly cited diagnostic signs of bowel perforation is the extravasation of OC. However, this is a rare event. In fact, the incidence ranges from 0% to 19% in patients who received OC for CT evaluation of blunt abdominal trauma and who had bowel perforation documented at laparotomy. Unfortunately, current data sets do not address a possible time...
bias for contrast extravasation as a positive finding. In a series of 24 patients seen in a 5-year period who had signs of bowel injury on CT, the CT scans were performed anywhere from 1 hour to as many as 6 weeks after injury. Rizzo et al reported 59% undergoing CT within 6 hours of injury and the remainder at varying times after admission and after discharge from the emergency department. There was no contrast extravasation in the 2 patients in this study who had bowel perforations. Both patients underwent scanning within 1 hour after injury and were in the OC group. All of our patients were studied on admission and all except 3 were done within 2 hours after admission, making our data pertinent to the immediate use of OC for diagnosis of bowel injuries.

The optimal use of OC also requires adequate transit time for gut opacification. Theoretically, opacification enables the gut to be distinguished from solid organs and omentum. Recommendations for the optimal time between administration of contrast and starting the abdominal CT scan vary. There are few studies where the amount of contrast in the gut has been quantified or addressed. Tsang et al evaluated 70 CT scans of patients with blunt abdominal trauma and found that only 59% of the scans had adequate small-bowel opacification despite an average time from OC administration to performance of the CT scan of 144 ± 5.9 minutes. Given that many patients with blunt trauma have a history of alcohol use and/or may have associated head injuries. Given that many patients with blunt trauma have a history of alcohol use and/or may have associated head injuries. We considered this subjective data not amenable to explicit review.

Pneumoperitoneum is considered to be another diagnostic sign of hollow viscus rupture. While vomiting and aspiration have been discussed in the literature as potential disadvantages to the use of OC, the incidence of these events and their temporal relationship to OC administration is not always easy to identify. Our study design required placing a nasogastric or orogastric tube in each patient before the administration of OC. Aspiration of gastric contents was also done before OC was given. These steps would explain the 12.9% incidence of vomiting that we saw, which is less than that in a previous report. Our low incidence and no difference between the groups could be related to nasogastric tube or orogastric tube placement.

The sensitivity of CT scan with OC for the diagnosis of blunt bowel injury ranges from 80% and 100% depending on the criteria used. Kearney et al reported a sensitivity of only 80% for detection of bowel injury by CT scan with OC, while Sherck et al reported a sensitivity of 92%. In a center where OC is not used in the protocol for blunt abdominal trauma CT scans, 6 patients with small-bowel injury at laparotomy all had findings on CT that were suggestive of bowel injury and 2 of these only had bowel wall thickening and free peritoneal fluid. Other investigators have determined that OC was unnecessary for the diagnosis of small-bowel injury. In those patients who had bowel injury at laparotomy, we identified 6 of 7 patients in the OC group (sensitivity 86%) and 100% in the no OC group by using the presence of free fluid not explained by solid organ injury and/or thickened bowel wall in addition to pneumoperitoneum and contrast extravasation as criteria for bowel injury. This difference was not statistically significant. Other investigators have found that the addition of these factors increases the sensitivity for detection of bowel injury. Thus, it seems that the sensitivity of CT scan for the detection of bowel injury at centers that use OC does not differ significantly from those centers that do not use OC, and our data concur.

The sensitivity of CT scan with OC varies between 90% and 100% for the diagnosis of solid organ injury. Our data, for both OC and no OC CT scans, is within this range. The significant number of false-positive CT results in the no OC group may be the result of "overreading" by the radiologist because no contrast was used. However, only 1 patient in this false-positive group had a nontherapeutic laparotomy. While the specificity was low, there was only 1 nontherapeutic laparotomy because of concurrent intra-abdominal injuries that were identified on the same no OC CT scans.

While vomiting and aspiration have been discussed in the literature as potential disadvantages to the use of OC, the incidence of these events and their temporal relationship to OC administration is not always easy to identify. Our study design required placing a nasogastric or orogastric tube in each patient before the administration of OC. Aspiration of gastric contents was also done before OC was given. These steps would explain the 12.9% incidence of vomiting that we saw, which is less than that in a previous report. Our low incidence and no difference between the groups could be related to nasogastric tube or orogastric tube placement. That contrast material was added to a full stomach may
be the reason that these patients experienced vomiting. The incidence of aspiration in our series is compatible with the incidence found in retrospective reviews. 9,13

Our study is, to our knowledge, the first randomized, prospective study comparing acute CT scanning of the abdomen with OC with CT scanning without OC in a blunt trauma patient population. All CT scans were done in the same manner and within similar time frames, which removes the time bias associated with previous studies. The primary limitation of this study is the low incidence of small-bowel injuries. Our inability to obtain missed injuries clinically or radiographically removes the time bias associated with previous studies. The prevalence of hollow viscus injury, a large number of injured patients would be needed in each arm of a similarly randomized study to prove that there is no difference in outcomes between the groups. This would require a multicenter trial.

A high index of suspicion for hollow viscus and solid organ injury remains necessary when evaluating the patient with blunt abdominal trauma. Clinical signs and symptoms of peritonitis in addition to CT findings of unexplained free intraperitoneal fluid or pneumoperitoneum, extravasation of OC, streaking of the mesentery, and thickened bowel wall are suggestive of hollow viscus injury. The addition of OC to the acute CT protocol for the patient with blunt abdominal trauma is unnecessary and actually delays time to CT scanning. Our prospective findings are consistent with retrospective reports and we believe this correlation warrants our conclusion until a larger prospective study can refute this growing body of evidence. Subsequent CT examinations of the abdomen and pelvis in this population may not require OC either; however, this issue is not addressed in this study and requires further evaluation.


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REFERENCES


Cleon W. Goodwin, Jr, MD, Fort Sam Houston, Tex: Dr Stafford and her associates have convincingly demonstrated that adding OC agent to intravenous contrast for CT evaluation of blunt abdominal trauma patients has no positive benefit and at best is a nuisance in the management of such patients. This certainly is my experience sitting beside these patients in the CT room as they vomited throughout the procedure. This is a huge and deceptively difficult study carried out in a 3-year period. I have a few questions on how you made this study work. I know that you had institutional review board clearance. Did you have to obtain informed consent from these patients? I suspect you did not because historically up to 50% of such patients choose not to participate in clinical trials. Who carried out the randomization? It seems you had a specific coordinator for this prospective study and, if so, how did you end up with incomplete records from 81 patients presumably with prospectively collected data?

I think you have settled the issue of whether OC must be used with these patients. Richard E. Burney, MD, Ann Arbor, Mich: One of the areas that is hard to see by CT after trauma is the pancreatoduodenal area, and contrast frequently helps to differentiate duodenal and pancreatic injuries. I wondered how many patients had pancreatic or duodenal injury, and did you have any problem in visualizing those injuries?

John Barrett, MD, Chicago, Ill: I wonder if you could expand on the point that you made in your presentation that the total number of patients who have gastrointestinal injuries in...
the study is extremely small. All of these patients had small-bowel injuries and none had duodenal injuries. Since these are the patients who would most commonly benefit from OC, I wondered how you can justify your conclusions.

J. David Richardson, MD, Louisville, Ky: Do your radiologists agree with your findings? We have had very similar results, but our radiologists simply refuse to interpret the CT scan without OC making this point moot for us. We agree with your results and interpretation of them.

Dr Weigelt: Dr Goodwin, as far as our consent issue, we convinced the institutional review board that both methods were standard of care and so we did not have to obtain consent before we enrolled the patient, as long as we approached the patient afterwards. At that time the patient usually agreed to participate.

The randomization was done by our computer. We had envelopes in the room, and once the nasogastric tube was placed, we essentially drew an envelope that assigned the patient to receive OC or not to receive it.

The 81 records that are not available is deceptive. We have the records on those patients from this prospective study. What is not available is basically their medical records, which could not be retrieved from our medical records department. Since our study design demanded these records to be reviewed, we had to exclude these patients. I know anybody who has tried to get a record out of a medical record department realizes that sometimes that is an impossible feat.

Both Dr Burney and Dr Barrett talked about the duodenal injuries. We have very few duodenal injuries in this group but do not believe this detracts from our conclusions. We can say pretty conclusively that there is no difference between the two given the limitations of the injuries that you saw in the study.

As far as the question about will the radiologist agree with this approach, presently we have some enlightened radiologists who do agree with it. We have some others who are still resistant to approach this as our standard. However, Dr McGonigal and the group is working on a practice guideline currently that will include the radiologists. It seems that we have the better data set than they do so we may actually be able to persuade them.

IN OTHER AMA JOURNALS

JAMA

Accuracy of Data in Abstracts of Published Research Articles
Roy M. Pitkin, MD; Mary Ann Branagan; Leon F. Burmeister, PhD

Context The section of a research article most likely to be read is the abstract, and therefore it is particularly important that the abstract reflect the article faithfully.

Objective To assess abstracts accompanying research articles published in 6 medical journals with respect to whether data in the abstract could be verified in the article itself.

Design Analysis of simple random samples of 44 articles and their accompanying abstracts published during 1 year (July 1, 1996-June 30, 1997) in each of 5 major general medical journals (Annals of Internal Medicine, BMJ, JAMA, Lancet, and New England Journal of Medicine) and a consecutive sample of 44 articles published during 15 months (July 1, 1996-August 15, 1997) in the CMAJ.

Main Outcome Measure Abstracts were considered deficient if they contained data that were either inconsistent with corresponding data in the article's body (including tables and figures) or not found in the body at all.

Results The proportion of deficient abstracts varied widely (18%-68%) and to a statistically significant degree (P<.001) among the 6 journals studied.

Conclusions Data in the abstract that are inconsistent with or absent from the article's body are common, even in large-circulation general medical journals. (1999;281:1110-1111) www.jama.com

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