Computed tomography scans with intravenous contrast: Low incidence of contrast-induced nephropathy in blunt trauma patients

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BACKGROUND: Computed tomography (CT) with intravenous (IV) contrast is an important step in the evaluation of the blunt trauma patient; however, the risk for contrast-induced nephropathy (CIN) in these patients still remains unclear. The goal of this study was to describe the rate of CIN in blunt trauma patients at a Level 1 trauma center and identify the risk factors of developing CIN.

METHODS: After internal review board approval, we reviewed our Level 1 trauma registry to identify blunt trauma patients admitted during a 1-year period. Chart review was used to identify patient demographics, creatinine levels, and vital signs. CIN was defined as an increase in creatinine by 0.5 mg/dL from admission after undergoing CT with IV contrast.

RESULTS: Four percent of patients developed CIN during their admission following receipt of IV contrast for CT; 1% had continued renal impairment on discharge. No patients required dialysis during their admission. Diabetic patients had an increased rate of CIN, with 10% rate of CIN during admission and 4% at discharge. In multivariate analysis, only preexisting diabetes and Injury Severity Score (ISS) of greater than 25 were independently associated with risk for CIN.

CONCLUSION: The rate of CIN in trauma patients following CT scan with IV contrast is low. Diabetes and ISS were independent risk factors of development of CIN in trauma patients. (*J Trauma Acute Care Surg*. 2014;77: 226–230. Copyright © 2014 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Epidemiologic/prognostic study, level III.

KEY WORDS: Blunt trauma; CT scan; contrast-induced nephropathy.

Computed tomography (CT) with iodinated intravenous (IV) contrast media is central to the evaluation of hemodynamically stable patients with blunt traumatic injuries. CT imaging allows us to quickly and accurately identify injuries, leading to faster final treatment and improved patient care;[1–3] however, this modality is not without risk. The association between the administration of IV iodinated contrast and the subsequent development of acute kidney injury, or contrast-induced nephropathy (CIN), has been well documented.[4–9] The incidence of renal injury after IV contrast administration is highly dependent on the risk profile of the patient, ranging from negligible rates in patients with no risk factors to rates of 5% to 50% reported in patients with diabetes and/or preexisting renal insufficiency. The goal of this study was to assess the risk for CIN in a blunt trauma population, to identify patient risk factors that may contribute to its development, and to evaluate the rate of CIN in high-risk subgroups. We hypothesized that the overall rate of kidney injury after contrast would be low in blunt trauma patients.

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PATIENTS AND METHODS

We performed a retrospective review of all blunt trauma patients admitted during a 1-year period at an American College of Surgeons–verified, community-based Level 1 trauma center. All blunt trauma patients who underwent initial diagnostic or therapeutic radiologic management using IV contrast were included in this study, while patients with a known history of end-stage renal disease or with no follow-up creatinine (Cr) levels after contrast dose were excluded. In addition, patients who had their initial CT scan performed at another facility and were then subsequently transferred to our center were excluded from this study. The study was approved by the institutional review board of North Memorial Hospital, in Robbinsdale, Minnesota.

All data were extracted from the institutional trauma registry and medical records. Baseline demographic data including age; sex; Injury Severity Score (ISS); vital signs at presentation; Cr levels throughout hospital course; and preadmission medical comorbidities, including diabetes mellitus (DM), renal insufficiency, and heart failure, were recorded for all patients. To gain additional insight into CIN, we also studied three high-risk subgroups: (1) blunt trauma patients with DM who underwent CT scanning on admission, (2) blunt trauma patients with renal impairment (Cr > 1.5 mg/dL) on admission who underwent CT scanning on admission, and (3) blunt trauma patients undergoing CT scan, followed by catheter-based angiography to treat areas of active extravasation identified on their initial CT. The patients included in this study were hemodynamically stable, blunt trauma

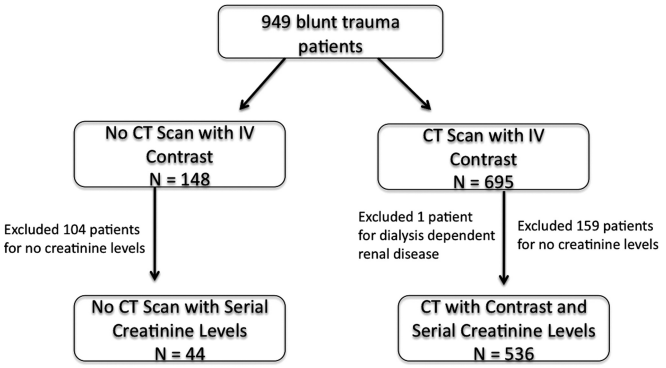

Figure 1. Patient selection.

patients who underwent CT scan of the chest, the abdomen, and the pelvis with a 100-mL bolus of low-osmolar, nonionic iodinate IV contrast (Omnipaque, GE Healthcare, Waukesha, WI) delivered before the chest, abdomen, and pelvis portion of the CT scans. Patients whose only catheter-based intervention was venography for inferior vena cava filter were not included.

Our primary outcome was the incidence of CIN in blunt trauma patients. CIN was defined as an increase in serum Cr of greater than 0.5 mg/dL within 72 hours of admission. We chose not to include an increase of 25% from baseline Cr level in our definition, as this did not change the rate of CIN in our study. Furthermore, recently, Slocum et al.[10] found that the definition of an increase in Cr of greater than 0.4 mg/dL was more predictive of patients at risk for adverse events. SPSS (version 20.0) was used to perform statistical analysis. Categorical variables were evaluated with χ^2 tests, and continuous variables are reported as mean values with SD, unless otherwise noted, and were evaluated with analysis of variance or Student's t test, as appropriate. Variables that were not normally distributed were evaluated using Mann-Whitney U-test. p values of less than 0.05 were considered significant. Logistic regression was used for multivariate analysis. Variables were included in the multivariate analysis if they were identified as risk factors associated with CIN in univariate analysis ($p < 0.05$). Male sex and systolic blood pressure of less than 90 mm Hg were also included, as these have been consistently identified as risk factors of CIN in trauma patients.

RESULTS

Patient Selection

A total of 949 blunt trauma patients were identified via the trauma registry. CT scan using IV contrast was performed in 695 patients. One hundred fifty-eight patients were excluded because of lack serial Cr levels available, and one patient with preexisting end-stage renal disease requiring long-term hemodialysis was also excluded. A total of 536 patients (56%) were included in the CT group data analysis (Fig. 1). Forty-four patients who did not undergo CT with IV contrast and had serial Cr levels were also analyzed. These patients did not have contraindications for CT scan; they did not undergo a contrast CT scan because of isolated injury or injuries that did not necessitate contrast evaluation.

Patient Characteristics

The median age of the patients undergoing CT with IV contrast was 46 years old, reflecting the typical younger trauma patient population. The patients who did not undergo CT with IV contrast tended to be older and had significantly lower ISSs, shorter length of hospital and intensive care unit (ICU) stays, and higher initial systolic blood pressures on admission to the trauma unit. The rates of acute kidney injury during admission were not different between the patients who did and did not undergo a CT scan with IV contrast (Table 1).

Four percent of the patients developed CIN during their admission after undergoing CT scan with IV contrast. No patients required dialysis during their admission. The mean age of the patients who developed CIN was slightly higher than those who did not; however, this difference was not significant

TABLE 1. Demographic Data of Blunt Trauma Patients Who Underwent CT With IV Contrast and Those Who Did Not Receive IV Contrast. (Values reported as mean with standard deviation, unless otherwise noted.)

	All patients (N = 580)	CT with Contrast (n = 536)	CT without Contrast (n = 44)	*p*
Age, median (range), y	46 (1–97)	46 (1–97)	51 (3–90)	0.177*
Sex (male/female)	379/201 (65%/35%)	353/183 (66%/34%)	26/18 (59%/41%)	0.365
ISS, median (IQR)	16 (6–26)	16 (6–26)	5 (5–13)	<0.001*
Hospital length of stay	17 (10)	18 (10)	6 (6)	0.004
ICU stay	5 (8)	5 (8)	3 (6)	0.037
Admission Cr	1.0 (0.4)	1.0 (0.4)	1.0 (0.5)	0.283
Highest Cr	1.1 (0.5)	1.1 (0.5)	1.0 (0.5)	0.335
Cr at discharge	0.9 (0.8)	0.9 (0.8)	0.9 (0.6)	0.341
Admission BP	127 (24)	126 (23)	137 (29)	0.009
Diabetes	50 (9%)	48 (9%)	2 (4.5%)	0.316
CHF	11 (2%)	11 (2%)	0 (0%)	0.337
CIN during admission	24 (4%)	22 (4%)	2 (5%)	0.888
CIN on discharge	6 (1%)	6 (1%)	0 (0%)	0.470

*Using Mann-Whitney U-test.
p value compared demographic data for those undergoing CT and those who did not undergo CT with IV contrast.
BP, blood pressure; CHF, congestive heart failure; ISS, Injury Severity Score; Cr, creatinine; CIN, contract induced nephropathy.

TABLE 2. Univariate Analysis of Risk Factors of Development of CIN

	n	Incidence of CIN, %	*p*
Age			0.001
≥55 y	197	8.1	
<55 y	339	1.8	
Sex			0.814
Male	353	4.2	
Female	183	3.8	
History of DM			0.021
Yes	48	10.4	
No	488	3.5	
History of CHF			0.400
Yes	10	9.1	
No	526	4.0	
ISS			0.014
≥16	277	6.1	
<16	259	1.9	
Initial SBP*			0.256
≥90 mm Hg	413	3.4	
<90 mm Hg	26	7.7	
Initial Cr level			0.387
≥1.5 mg/dL	46	6.5	
<1.5 mg/dL	490	3.9	
Dose of IV contrast			0.050
≥150 mL	40	3.6	
<150 mL	496	10	

*Data not available for all patients.
CHF, congestive heart failure; SBP, systolic blood pressure; DM, Diabetes Mellitus; ISS, Injury Severity Score; Cr, creatinine.

(54 [18] years vs. 45 [21] years; $p = 0.060$). Compared with the patients who did not develop CIN, the patients who developed CIN had significantly higher ISSs (median, 27; interquartile range [IQR], 19–38, vs. median, 16; IQR, 5–25; $p < 0.001$) and longer lengths of hospital and ICU stays (median, 19.5 days [IQR, 2.75–33 days] vs. 6 days [IQR, 3–12 days], $p = 0.022$, and 5 days [IQR, 1–21.5 days] and 2 days [IQR, 0–5 days], $p = 0.006$, respectively). The patients who developed CIN were also more likely to be diabetic (Table 2). Most of the patients who developed CIN returned to baseline renal function. Six patients (1.1%) were discharged with continued CIN. No patients required dialysis at discharge.

TABLE 3. Multivariate Analysis Using a Binary Logistic Regression of Risk Factors of Development of CIN in Blunt Trauma Patients

Variable	Adjusted Odds Ratio	95% Confidence Interval	*p*
Sex (male)	1.73	0.62–4.78	0.295
Age > 55 y	5.63	1.92–16.50	0.002
ISS ≥ 16	3.00	1.00–9.11	0.050
Admission SBP < 90 mm Hg	1.25	0.25–6.35	0.785
DM	6.17	1.10–34.6	0.039
IV contrast dose > 200 mg	1.96	0.48–8.00	0.295

Hosmer-Lemeshow test, $p = 0.822$.
SBP, systolic blood pressure; ISS, Injury Severity Score; DM, Diabetes Mellitus.

TABLE 4. Multivariate Analysis of Risk Factors of Development of Acute Kidney Injury in Blunt Trauma Patients

Variable	Adjusted Odds Ratio	95% Confidence Interval	*p*
Sex (male)	1.72	0.62–4.78	0.295
Age > 55 y	5.48	1.86–16.11	0.002
ISS ≥ 16	3.17	1.02–9.83	0.046
Admission SBP < 90 mm Hg	1.27	0.25–6.41	0.775
DM	6.08	1.09–34.05	0.040
IV contrast	0.507	0.12–2.91	0.579

Hosmer-Lemeshow test, $p = 0.943$.
SBP, systolic blood pressure; ISS, Injury Severity Score; DM, Diabetes Mellitus.

In multivariate analysis, only preexisting DM and ISS of greater than 16 were independently associated with increased risk for developing CIN during the hospital admission (Table 3). A second dose of IV contrast leading to doses higher than 200 mL trended toward an increased risk for CIN; however, this trend did not reach significance. When we analyzed all patients with blunt trauma who had serial Cr levels, including those who did not receive any contrast load, multivariate analysis shows no increased risk for acute kidney injury (Cr increase by >0.5 mg/dL from admission) associated with receiving a contrast dose (Table 4). Only ISS and diabetes remain independent risk factors of acute kidney injury.

We further analyzed these "at-risk" groups, of patients with diabetes, patients with renal insufficiency (Cr ≥ 1.5 mg/dL on admission), and patients who received a second dose of IV contrast, the first for the CT and then again for angiography for either treatment or diagnosis.

Diabetic Patients

Five (10%) of the 48 diabetic patients developed CIN during their admission, with 1 patient (2%) discharged with a continued decrease in renal function. These rates are twice the rate of CIN in our overall patient population. Only four of the diabetic patients had abnormal renal function on admission (Cr > 1.5 mg/dL). No other independent patient characteristics were associated with risk for CIN in the diabetic patients. One of these patients developed CIN after CT scan with IV contrast (25%), compared with 9% of all diabetic patients; however, because of limited numbers in these groups, this difference was not significant ($p = 0.319$).

Patients With Renal Insufficiency

Four (6.5%) of the 46 renal insufficiency (admission Cr ≥ 1.5 mg/dL) patients developed CIN during their admission, with 1 patient (2%) discharged with continued CIN. Although the rates of CIN both during admission and at discharge were higher than those of the general population studied, this difference was not significant. The patients with renal insufficiency on admission were more likely to be male (87% vs. 66% male in the entire cohort; $p = 0.002$). The patients with renal insufficiency on admission who developed CIN tended to be older (mean [SD] age, 55 [21] years, vs. 44 [17] years; $p = 0.022$).

No other patient characteristics were associated with the development of CIN in this study group (data not shown).

Patients Receiving a Second Contrast Dose for Catheter-Based Angiography After CT With Contrast

Forty patients underwent CT scan with contrast followed by catheter-based angiography to treat areas of active extravasation during the period of review. CIN developed during their admission in four patients (10%) and remained at discharge in two patients (5%). These rates were significantly higher than those in the patients who did not receive a second dose of contrast (4% and 1%) ($p = 0.050$ and 0.004). The patients developing CIN tended to be older (53 [8] years vs. 45 [21] years), and ISSs were higher (median, 35 [IQR, 16–35) vs. 23 [IQR, 17–35]), but these differences were not significant. Admission Cr levels were higher in the patients who developed CIN (2.0 [1.9] mg/dL vs. 1.1 [0.4] mg/dL; $p = 0.032$). No other patient characteristics were associated with risk for CIN in this subgroup of patients.

DISCUSSION

CT imaging with IV contrast is a vital aspect of management of a trauma patient, helping to identify injuries and better treat and triage patients. However, the concern of adding iatrogenic insult to already severe injury, via CIN in trauma patients, is a very real concern. Although CIN has been studied extensively in patients following coronary angiography and in unselected hospitalized patients undergoing CT scans, there are limited studies evaluating CIN in trauma patients. Trauma patients have distinct features, in that they have several risk factors of CIN, including hypotension due to blood loss and greater illness at time of contrast load; however, they are typically younger with fewer comorbidities than other populations studied.

In this study, we report an overall incidence of CIN of 4% in blunt trauma patients at a Level 1 trauma center, with 1% of the patients having abnormal Cr levels at discharge. This rate is similar to other similar studies in trauma patients, with a range of CIN rates of 1.9% to 6.6%.[11–13] We found that diabetes, age older than 65 years, ISS of greater than 16, and IV contrast dose of more than 100 mL were all risk factors of CIN in univariate analysis. Interestingly, neither lower systolic blood pressure nor elevated Cr levels at admission were associated with increased risk for CIN. In multivariate analysis, only diabetes and ISS of greater than 15 were found to be independently associated with an increased risk for CIN.

These risk factors are similar to those identified in other studies of trauma patients, as well as of patients receiving contrast for other reasons.[4–7,9,11,13–16] However, none of these studies completely agree on risk factors. Hipp et al.[11] found a significantly increased risk for CIN in trauma patients older than 75 years, whereas others have found that there was no association between increasing age and risk for CIN.[6,17] Similarly, elevated Cr level has been found to be associated with risk for CIN in some studies;[9,11] however, both Matsushima et al.[13] and Tremblay et al.[8] found that there was no association in trauma patients admitted with elevated Cr levels and subsequent development of CIN. Diabetes does seem to increase the risk for CIN in most patients. In most studies reporting the use of multivariate analysis, diabetes remains an independent risk factor of the development of CIN.[4,16,18,19] We found the same result in our work as well. Our further analysis of diabetic patients did not identify other patient risk factors of development of CIN. Renal impairment in the presence of diabetes has been described as an additional risk factor; however, our data were not able to demonstrate this increased risk, likely because of the limited numbers of patients in this specific population. In our study, we did not show an association between renal insufficiency on admission (independent of diabetes status) and an increase risk for CIN; however, this may have been because of the small group size. It is important to note that only one patient in this group had been diagnosed with renal insufficiency before admission; therefore, this may be more indicative of volume status and not true renal insufficiency.

Interestingly, the rate of CIN, defined as an increase in Cr levels by greater than 0.5 mg/dL from admission, was similar between the trauma patients who underwent CT with IV contrast and without. The number of patients who did not undergo CT with IV contrast and also had measured serial Cr levels was small (44 patients), which greatly limits the applicability of this finding; however, this result has been reported in other studies of CIN in trauma patients. Both Matsushima et al.[13] and Kim et al.[14] in single-institution studies reported no difference in rates of acute kidney injury in trauma patients who received IV contrast and those who did not. Similarly, McDonald et al.[5] reported, in a meta-analysis of almost 26,000 patients, no difference in rates of acute kidney injury in patients undergoing CT with contrast and patients with no contrast exposure. In our study, when we included the patients without CT scans, ISS and diabetes remain independent risk factors of CIN during admission, and receipt of contrast is not associated with increased risk.

This study should be interpreted with certain limitations in mind. This is a retrospective study, conducted at a single institution in an urban area. The subgroups of those with diabetes, those receiving two contrast loads, and those without contrast loads are small, which limits the assumptions we can make from the evaluation of these groups. CT scans are a staple in trauma evaluation, especially after blunt injury, so the number of patients who did not undergo CT scan is limited and represents those who had an obvious emergent injury and went directly to the operating room for management or those with minimal or local injury not requiring CT evaluation with contrast. This makes comparing this group with the group that received contrast difficult. In addition, the difference in definitions of CIN limits the comparisons that can be made with other studies. We used an increase in serum Cr levels of 0.5 mg/dL from baseline as our definition, and therefore, our rates can be directly compared only with other studies that used this definition. Our study, as well as the few other studies focusing on trauma patients, offers a unique subgroup analysis of patients at risk for CIN, in that they are substantially younger and likely healthier than hospital and ICU patients who are often studied.

In conclusion, the rate of CIN in our patient population was low, with 4% developing CIN transiently and 1% having residual renal impairment at discharge. Diabetes and ISS were the only independent risk factors associated with CIN in our multivariate analysis. Increased doses of contrast may also increase the risk for CIN in trauma patients. CIN in trauma patients

is obviously of great concern, as no physician wants to add iatrogenic insult to already potentially great injury. We have demonstrated, however, that risk for CIN after CT scan with contrast is low. Imaging studies using IV contrast enable us to better diagnose and treat our patients and should be used as appropriate to optimize patient care, irrespective of concern for contrast-induced injury.

DISCLOSURE

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