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RADIOGRAPHIC ASSESSMENT OF SPLENIC INJURY WITHOUT CONTRAST: IS CONTRAST TRULY NEEDED?

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Abstract

Introduction—Computed Tomography (CT) has become an essential tool in the assessment of the stable trauma patient. Intravenous (IV) contrast is commonly relied upon to provide superior image quality, particularly for solid organ injury. However, a significant proportion of injured patients have contraindications to IV contrast. Little information exists concerning the repercussions of CT imaging without IV contrast specifically for splenic injury.

Methods—We performed a retrospective analysis using data from our trauma registry and chart review as part of a quality improvement project at our institution. All patients with splenic injury, over a 3 year period (2008–2010), where a CT of the abdomen without IV contrast (DRY) early during their admission were selected. All splenic injuries had to have been verified with abdominal CT imaging with IV contrast (CONTRAST) or via intraoperative findings. DRY images were independently read by a single, blinded, radiologist and assessed for parenchymal injury or ‘suspicious’ splenic injury findings and compared with CONTRAST imaging results or intraoperative findings.

Results—Over the time period of the study 319 patients had documented splenic injury with 44 (14%) patients undergoing DRY imaging which was also verified by CONTRAST imaging or operative findings. Splenic parenchymal injury was only visualized in 38% of patients DRY patients. ‘Suspicious’ splenic injury radiographic findings were common. When these less specific findings for splenic injury were incorporated in the radiographic assessment, DRY imaging had over a 93% sensitivity for detecting splenic injury.

Conclusions—DRY imaging is increasingly being performed post-injury and has a low sensitivity in detecting splenic parenchymal injury. However, less specific radiographic findings suspicious for splenic injury in combination provide high sensitivity for splenic injury detection. These results suggest CONTRAST imaging is preferred to detect splenic injury, however, in those

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patients who have contraindications to IV contrast, DRY imaging may be able to select those who require close monitoring or intervention.

Introduction

Abdominal computed tomography (CT) has emerged as a reliable tool for assessing blunt abdominal injury and is increasingly utilized as an essential component of standard trauma management practice in hemodynamically stable patients.^{1–8} For diagnostic evaluation of traumatic splenic injury, abdominal CT imaging with intravenous (IV) contrast is the preferred method of evaluation as it informs trauma care providers of splenic vascular injury, contrast extravasation and splenic pseudoaneurysms, all which have a significant risk of ongoing bleeding and have been demonstrated to be associated with higher rates of failure of non-operative management and the requirement of more therapeutic procedures including interventional angiography and operative splenectomy.^{9–17} Despite these diagnostic benefits of contrast enhanced abdominal CT imaging, a significant proportion of patients have contraindications to IV contrast due to the inherent risk of allergic reaction or contrast induced nephropathy or do not receive contrast for poorly defined reasons.^{18–23} A paucity of information exists concerning indications for contrast exclusion in the early management of injured patients and the repercussions of abdominal CT imaging without IV contrast for splenic injury management.

We sought to characterize the indications, potential consequences and the efficacy of abdominal CT without IV contrast in the early post-injury period (first 24hrs) in a cohort of splenic injured patients. We hypothesized the exclusion of contrast from abdominal CT evaluation would be secondary to allergic risk and chronic renal insufficiency and result in a high rate of missed splenic parenchymal injuries.

Methods

We performed a retrospective analysis using data derived from our trauma registry and chart review as part of a quality improvement (QI) project at our institution which focused on the potential for missed splenic injuries in patients who underwent abdominal CT imaging without intravenous contrast. All blunt injured patients with documented splenic injury (ICD-9-CM diagnosis codes 865.00–865.99) over a 3 year period (2008–2010) were initially selected. Further selection included those patients where a CT of the abdomen without IV contrast (DRY) early (in initial 24 hours) during their admission was obtained. All patients with registry documented splenic injuries had to have their splenic injury also documented with either concomitant abdominal CT imaging with IV contrast (CONTRAST) or via intraoperative findings deciphered from medical chart and radiographic review during the same initial 24 hours post-injury. All DRY images were independently read by a single, blinded, radiologist and assessed for splenic parenchymal injury, peri-splenic hematoma, abdominal free fluid and left sided rib fractures and compared with CONTRAST imaging or operative findings. This additional radiology read, instead of the primary read was performed and utilized because of the potential risk of bias based upon prior imaging results. Those patients with CONTRAST imaging, in addition to DRY imaging, also underwent splenic injury grading by the same blinded radiologist using the American Association for the Surgery of Trauma (AAST) splenic injury grading system as previously described.^{24,25}

We first characterized the overall splenic injury cohort and then further compared patients who underwent DRY imaging in the first 24 hours relative to the group of patients who underwent early CONTRAST imaging alone. In those splenic injured patients who underwent DRY imaging, potential reasons or indications for excluding IV contrast from each patients radiographic evaluation were investigated (age, mechanism of injury, injury

severity, contrast allergy, presenting creatinine, and recent IV contrast imaging) over the three year period. Finally, assessment of splenic parenchymal injury determination and radiographic 'suspicious' findings for DRY images were compared relative to CONTRAST imaging and operative findings for the determination of splenic injury.

Data were summarized as mean $\pm$ SD, median [inter-quartile range], or percentage (%). Student-t or Mann-Whitney statistical tests were used to compare continuous variables, while Chi-Square or Fischer's Exact test were used for categorical variables. Statistical analyses were performed using SPSS 17 (SPSS, Chicago, IL). $P < 0.05$ was considered significant.

Results

Over the time period of the study 336 patients had documented splenic injury with 159 patients (47.3%) requiring exploratory laparotomy. Of these, 17 patients (10.7%) were taken straight to the operating room without preoperative imaging and were not able to be included in the study cohort. Of the remaining 319 patients representing the study cohort with blunt splenic injury, 44 patients (13.8%) underwent DRY imaging during the initial 24 hours post-injury. All DRY patients were either verified by CONTRAST imaging during the same time period (initial 24 hours post-injury) or operative findings were available. Operative findings alone (without a CONTRAST scan for comparison) were utilized for DRY scan verification in 11 patients (25.0%). There were no patients in this splenic injury cohort with DRY scanning alone who did not have additional splenic injury verification. DRY patients who required diagnostic or interventional angiography ($n=18$, 5.3%) all had concomitant CONTRAST imaging which was utilized to verify DRY imaging reads.

This cohort of splenic injured patients represented a significantly injured trauma cohort with a median injury severity score of 22 [14,33]. They had a mean age of 38 ± 18 , with over 69% being male. Just over 18% of patients were initially hypotensive upon arrival (Systolic Blood Pressure < 90 mmHg) and the entire group had a median abdominal abbreviated injury score (AIS) of 3 [2,4], while head, face, chest, and extremity injuries were less common, as demonstrated by lower median AIS scores. (Table 1.)

Those patients who underwent DRY imaging as compared to CONTRAST alone patients (no DRY imaging during initial 24 hours post injury) were similar in demographics, injury characteristics and presenting vitals, however, DRY patients were less severely injured overall, more commonly suffered from a fall mechanism as compared to motor vehicle or motorcycle collision, had a significantly higher probability of survival, and lower hospital, ICU and operative requirements. (Table 2.)

Characterization of the indications for DRY abdominal imaging in the initial 24 hours post-injury revealed that of the 44 DRY imaging patients, 15 patients (34%) had undergone CT abdominal imaging with CONTRAST at an outside hospital prior to trauma center arrival. There were 5 patients (11%) who underwent CONTRAST followed by repeat DRY abdominal imaging after admission to the trauma center, while the remaining 24 patients (55%) underwent a DRY assessment of their abdomen as their first abdominal imaging, either at the outside hospital or at our trauma center. In those with initial DRY imaging, a proportion of patients each had low severity of injury ($ISS < 9$), a fall mechanism, were older (> 70 years of age), had known IV contrast allergy or had a presenting creatinine 1.2 mg/dL (Table 3.) Interestingly, over 83% of patients had at least one of these plausible indications for DRY imaging while over 29% had greater than one plausible indication. Importantly, 17% patients had no apparent plausible indication for contrast omission.

In those patients who underwent DRY imaging as their first abdominal CT evaluation at either an outside hospital or during their trauma admission, 9 out of 24 patients (38%) required exploratory laparotomy. Of these patients 6 underwent outside hospital DRY imaging and upon arrival underwent CONTRAST imaging and were taken to the operating theatre with 4 requiring splenectomy. The 3 patients who underwent their DRY imaging at the trauma center all had IV contrast allergy and were taken directly to the operating room based upon DRY scan findings. Only a single patient required splenectomy while the other 2 patients had minor splenic injury and did not require splenectomy. There were 3 patients who required interventional splenic angiography and all 3 patients had DRY imaging at an outside hospital which was followed by CONTRAST imaging at our trauma center where pseudoaneurysms were diagnosed and managed appropriately with non-urgent embolization.

When patients with DRY abdominal imaging results in the first 24 hours post-injury were evaluated for splenic parenchymal injury and splenic injury grading by a single blinded radiologist, splenic parenchymal injury was only visualized in 38.6% of DRY imaging patients. In patients who underwent both DRY and CONTRAST abdominal imaging (n=33, 75%), splenic parenchymal injury was more likely to be visualized in higher grade splenic injuries on DRY imaging (Visualized: mean splenic injury grade= 2.6 ± 0.8 vs. Non-visualized: mean splenic injury grade= 2.0 ± 0.8 , $p = 0.03$). Importantly, in those patients without splenic parenchymal injury visualized on DRY imaging, one grade 4 spleen and four grade 3 splenic injuries would have not been visualized and three of these patients initially presented hypotensive (SBP<90 mmHg). In this DRY subgroup where a splenic parenchymal laceration was not visualized there was a 7% mortality (2/27) and 26% patients required an early exploratory laparotomy. Importantly, single, blinded, radiologist reads correlated with initial primary reads in all cases.

When suspicious splenic injury radiographic findings were characterized in patients who underwent DRY imaging, peri-splenic hematoma, free abdominal fluid and left sided rib fractures were relatively common. (Table 4.) When these less specific findings for splenic injury were incorporated in the radiographic assessment, DRY imaging had over a 93% sensitivity for detecting splenic injury. In those DRY patients where splenic parenchymal injury was not visualized, suspicious splenic injury findings were associated with a sensitivity of over 88% for splenic injury. Isolated splenic injury was found radiographically or operatively in over 81% of DRY patients. Concomitant liver injury (n=3), bowel injury (n=2), and retroperitoneal injury (n=4) were apparent on radiographic or operative evaluation and when these non-splenic injured patients were excluded, the sensitivity of suspicious findings and DRY imaging to determine splenic injury remained consistent (94%).

To verify these findings we then characterized these suspicious splenic injury findings in those patients who underwent CONTRAST imaging alone (n=275) for their trauma evaluation. Importantly, splenic parenchymal injury was not included in this specific characterization as these were CONTRAST images and for the vast majority documented splenic parenchymal injury. Suspicious splenic injury findings alone (any of the three) had a sensitivity of 86% for splenic injury, even when splenic parenchymal lacerations were not utilized in the assessment.

Discussion

As imaging technology continues to increase in speed, precision and sensitivity, we will increasingly rely upon diagnostic CT evaluation for the acutely injured patient.^{4,26,27} Utilization of intravenous contrast for CT imaging has become the primary method of screening for multiple types of vascular and solid organ injury, has been incorporated into

algorithms and practice guidelines and has changed the way specific injuries are managed.^{9,28-30} As the population continues to become older with concomitant age-associated comorbidities³¹⁻³³, those injured patients who are at higher risk for complications secondary to contrast administration will likely increase. The results of the current analysis demonstrate the diagnostic importance of IV contrast for splenic parenchymal and vascular injury. Despite the relatively small sample size of the current analysis, the results suggest that those patients who have risk factors for contrast complications and undergo initial non-contrast imaging should have follow-up contrast examinations if able or be closely monitored for missed parenchymal or splenic vascular injury. Importantly, in those non-contrast patients where follow-up contrast images cannot be obtained, suspicious splenic injury radiographic findings are common, have a high sensitivity for splenic injury and should promote heightened concern for splenic injury and appropriate management.

The prevalence of intravenous contrast allergy or prior acute reaction varies in the literature between 0.3% up to 1.5%.^{18,19,21} Risk factors for contrast induced nephropathy have been shown, primarily in the medical population, to include advanced age, diabetes, renal insufficiency and be significantly associated with higher morbidity and mortality.^{20,34-39} Injured patients have additional factors including hypovolemia, shock, renal parenchymal injury and an elevated volume of contrast material when multiple body cavities are evaluated and imaged. Although recent work has demonstrated that the incidence of contrast induced nephropathy following traumatic injury was relatively low with a benign clinical course in a typically aged trauma cohort²⁰, little information exists regarding the significance of this contrast complication in older injured patients where additional risk factors may coincide. The current analysis demonstrated that those patients who underwent initial DRY imaging more commonly suffered falls as compared to motor vehicle collisions, had a lower overall injury severity and had a lower length of stay and requirement for operative intervention. Due to these findings, we included low injury severity and fall mechanism as probable indications for DRY imaging. The current results suggest that low injury severity or the appearance of low injury burden may be one of the more common indications for contrast omission in addition to more standard reasons. Most importantly, these results suggest that multiple potential risk factors and indications were present in almost a third of patients. An unexpected finding was the high rate of DRY imaging which occurred secondary to referral hospital contrast administration. Further evaluation of these types of occurrences is needed due to the increased risk associated with the repeat administration of contrast or delay of such evaluation when the outside radiographic studies are not complete or are insufficient.

This analysis does have several limitations that deserve discussion. First, this study was performed at a single, level I trauma center and may not be generalizable or pertinent to other centers with differing admission demographics, injury characteristics or management practices for splenic injury. As with any retrospective analysis, potential unknown or unmeasured confounding variables may be responsible for the associations described and the conclusions formulated. Our analysis was limited by our sample size and overall statistical power. We were unable to verify what indications for DRY imaging were actually utilized at the time of contrast versus no contrast decision, other than allergy to IV contrast or elevated creatinine, due to the retrospective nature of the analysis. We commonly withhold the administration of CONTRAST when a patient has received recent contrast at an outside hospital or in the last 24 hours from admission as an institutional protocol, unless driven by injury severity or specific injury management. As the study cohort that was selected consisted of all patients with documented splenic injury over a three year period, we were unable to quantitate specificity of suspicious splenic findings for splenic injury and determine if the absence of suspicious splenic injury findings consistently ruled out splenic

injury, as all patients a priori had splenic injury. Similarly, to verify our evaluations of the DRY abdominal images, we utilized CONTRAST images or operative findings. In this study cohort there were no patients with DRY abdominal images that did not have verifiable CONTRAST imaging or operative findings. This is again due to the fact that all patients had documented splenic injury for inclusion. Due to the large number of admissions at our institution, we perform over 1,800 DRY images annually in the first 24 hours for multiple reasons, which limits the ability to characterize the specificity of DRY imaging and suspicious splenic injury radiographic findings via a retrospective approach. All images assessed we obtained in the initial 24 hours post-injury. We were unable to characterize the importance of the timing of DRY imaging (early in the 24 hours versus late in the initial 24 hours) due to the relatively small numbers of patients. Finally, the results and conclusions formulated from this manuscript may not be applicable to patients without similar inclusion characteristics and importantly may not apply to those with additional organ system injuries such as hepatic, renal and bowel injuries or patients who have DRY abdominal evaluation alone.

In conclusion, these results suggest that DRY abdominal imaging has a low sensitivity for detecting splenic parenchymal and vascular injury, particularly for patients with low anatomic grade injuries. Abdominal CT imaging with intravenous contrast is the preferred method of evaluation of blunt traumatic injuries in hemodynamically stable trauma patients. However, in those patients where IV contrast remains contraindicated and follow-up contrast imaging cannot be performed for any reason, suspicious splenic injury radiographic findings on DRY abdominal imaging have a high sensitivity for splenic injury and may be able to select those who require close monitoring, repeat imaging, or intervention for splenic injury. The specificity of suspicious finding was unable to be determined by this analysis, however, the current results suggest they that patients with these finding may benefit from close monitoring. Further investigation into the role of non-contrast imaging for splenic injury and other injury types are needed to determine the role DRY imaging should or should not play in the evaluation of the acutely injured patient.

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Table 1

Classification of injuries for the splenic injury study cohort. (n=319)

	% With Injury	Median [IQR] Component AIS score
Head/Neck	34%	0 [0,2]
Face	24%	1 [0,2]
Chest	46%	2 [0,4]
Abdominal	100%	3 [2,4]
Extremity	50%	1 [0,3]
Skin/Soft Tissue	42%	0 [0,1]

Table 2

Univariate comparison of DRY and CONTRAST only patients

	DRY (n=44)	CONTRAST only (n=275)	p-value
Age (years)	42.6±22	38.1±17	0.319
Gender (%Male)	38.6%	32.1%	0.257
Blunt Mechanism Subtype			
MVC/MCC/Pedestrian	54.5%	75.7%	0.003*
Fall	29.6%	11.3%	
Other	15.9%	13.0%	
Glasgow Coma Score	14.2±7	13.3±8	0.259
Lowest SBP (mmHg)	110±18	104±28	0.159
Hypotension (< 90 mmHg, %)	11.9%	21.2%	0.142
ISS	19 [9,29]	24 [16,34]	0.013*
Abdomen AIS	2 [2,3]	3 [2,4]	0.428
Concomitant Head Injury (%)	22.7%	35.6%	0.092
Concomitant Face Injury (%)	21.5%	24.7%	0.543
Concomitant Chest Injury (%)	39.2%	48.6%	0.294
Concomitant Extremity Injury (%)	38.6%	51.7%	0.106
Concomitant Skin/Subcutaneous Injury(%)	36.4%	43.2%	0.396
TRISS Probability of Survival	0.97±0.1	0.86±0.2	0.005*
Hospital Length of Stay (LOS)	8.6±8	12.7±12	0.037*
ICU LOS	4.0±6	6.5±9	0.078
Exploratory Laparotomy (%)	27.3%	50.9%	0.004*
Diagnostic or Interventional Angiography (%)	9.1%	4.8%	0.246
Mortality (%)	4.5%	5.5%	0.789

Table 3

Probable indications for DRY abdominal imaging in first 24 hours

Any DRY imaging in first 24 hours	% (n=44)
Outside hospital IV contrast	34%
Previous IV contrast at trauma center in first 24 hours	11%
Initial DRY imaging only	% (n=24)
Injury Severity (ISS<9)	38%
Fall mechanism	29%
Elevated presenting creatinine (Cr ≥ 1.2 mg/dL)	25%
Age (> 70 years)	21%
IV contrast allergy	17%
Multiple (> 1) indications	29%
Any indication	83%

Table 4

Suspicious splenic injury findings on DRY abdominal imaging and associated incidence.

Suspicious Splenic Injury Radiographic Findings	% (n=44)
Perisplenic hematoma	72.7%
Intraabdominal free fluid	75.0%
Left sided rib fractures	34.1%
Multiple suspicious findings	77.3%
<u>Any suspicious finding</u>	<u>93.2%</u>