Angioembolization is necessary with any volume of contrast extravasation in blunt trauma

Ankur Bhakta, David S. Magee, Matthew S. Peterson, Michael Shay O’Mara

ABSTRACT

Introduction: Reduction of nonessential angiogram and embolization for patients sustaining blunt abdominal and pelvic trauma would allow improved utilization and decreased morbidity related to nontherapeutic embolization. We hypothesized that the nature of intravenous contrast extravasation (IVCE) on computed tomography (CT) would be directly related to the finding of extravasation on angiogram and need for embolization.

Methods: A 5-year retrospective evaluation of trauma patients with IVCE on CT. Demographics, hemodynamics, and IVCE location and maximal dimension/volume were examined for relationship to IVCE on angiography and need for embolization. Primary complications were defined as nephropathy and acute respiratory distress syndrome.

Results: A total of 128 patients were identified with IVCE on CT. Ninety-seven (75.8%) also had IVCE identified on angiography requiring some form of embolization. The size of IVCE on CT was not related to IVCE on angiogram ($P = 0.69$). Location of IVCE was related to need for embolization, with spleen embolization (85.4%) being much more frequent than liver (51.5%, $P = 0.006$). Complication rate was 8.7% in all patients, and was not different between patients undergoing embolization and those who did not ($P = 0.40$).

Conclusion: IVCE volume was not predictive of continued bleeding and need for embolization. However, splenic injuries with IVCE required embolization more frequently. In contrast, liver injuries were found to have infrequent on-going IVCE on angiography. Complications associated with angiogram with or without embolization are infrequent, and CT findings may not be predictive of ongoing bleeding. We do not recommend selective exclusion of patients from angiographic evaluation when a blush is present.

Key Words: Angioembolization, blunt trauma, contrast extravasation, injury, liver, spleen

INTRODUCTION

The ability to accurately predict when nonoperative management (NOM) is safe for patients with blunt trauma has been well studied. However, there have been limited studies to predict the patient type on whom NOM will be most beneficial. While the treatment of solid and nonsolid organ injuries has steadily improved with the introduction of angioembolization (AE),[1] no study has identified which clinical signs distinguish patients requiring embolization from patients that do not. Today, with the improvement in computed tomography (CT) technology, NOM has become the standard. Increasingly, AE is used as nonoperative method to address injury after blunt trauma in hemodynamically stable patients. The advancement in CT technology has allowed physicians to determine solid organ injury with more sensitivity and specificity.[2,3] The improved ability to detect solid organ injury has changed how stable patients are treated in the

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acute care setting. There has been a significant increase in the identification of contrast extravasation (indicating an actively bleeding injury) than previously noted. This contrast extravasation has previously been evaluated as to the relationship between size (diameter) and need for embolization. Diameter is not a strong indicator of need for AE. Patients who once underwent invasive interventions such as surgery or diagnostic peritoneal lavage are now being treated nonoperatively with AE and observation.

This increase in sensitivity of CT scans has improved diagnosis; however, it raises questions about the overuse or over-treatment of patients in which an intravenous contrast extravasation (IVCE) or “blush,” is detected. This study hypothesizes the volume, in addition to the diameter, of contrast extravasation visualized on CT scan is predictive of on-going bleeding identified on angiogram and the decision to use AE.

METHODS

This study was compliant with HIPPA requirements and was approved by the Institutional Review Board of the OhioHealth Research Institute, which governs studies at Grant Medical Center. A retrospective review was conducted using medical records of all trauma patients admitted to Grant Medical Center, a Level 1 Trauma Center in Columbus, Ohio, admitting more than 4000 urban and rural trauma patients per year. Patients included were admitted between January 1, 2008 and December 31, 2012 with blunt traumatic solid organ injury and contrast extravasation on CT scan. The trauma registry database was used to identify patients with International Classification of Diseases-9 diagnosis relating to AE, contrast extravasation, and contrast induced nephropathy. Exclusion criteria were patients who received emergent surgical intervention or patients who died in the trauma bay or within 24 h of presentation. Demographic and basic clinical data were extracted from the trauma registry database and patient medical records.

We collected the following data: Arrival time, age, race, gender, mechanism of injury, injuries, abbreviated injury score (AIS), injury severity score (ISS), embolization or not, start and end time of angiography, length of stay, Intensive Care Unit (ICU) length of stay, ventilator days, vitals at time of admission, complications, presence of IVCE, hemoglobin, hematocrit, coagulation, blood transfusions, American Association for the Surgery of the Trauma solid organ injury grade, and mortality.

All patients during the study time frame that were identified to have contrast extravasation on CT scan all received angiographic evaluation. Evaluation was performed with a board certified interventional radiologists within an hour of consultation. Angiography was performed despite hemodynamic status and embolization was performed for active IVCE or prophylactically at the discretion of the interventional radiologists or trauma surgeon.

All CT images during the study time period were filmless and were reviewed on a digital archival system. Individual CT protocols were varied between patients, but not within any one case. CT scans also included those obtained from referring facilities of patients noted to have blunt solid organ blunt trauma. During the study, the institution did not have a standard algorithm on the management of contrast extravasation on CT scans. Before 2010, the standard for AE was based on clinical findings, with the vast majority proceeding to angiographic evaluation. In years 2010–2012 a standard practice was adopted by the institution that all contrast extravasation seen on CT scan be immediately followed up with angiographic imaging. Patients not undergoing angiographic evaluation before 2010 were not included in the study. Indication for embolization was determined by the interventional radiologists or the trauma surgeon at the time of angiography and this was primarily based on the hemodynamic stability of the patient at that time. Any patient with IVCE identified on angiogram was embolized.

These same set of images were retrospectively reviewed by trauma radiologists to specifically evaluate the size and volume of the extravasation. Diamond et al., had previously shown correlation between need embolization and diameter of extravasation; therefore, our study evaluated if either diameter or volume had any predictive value. Measurements for volume were obtained using 3-dimensional reconstruction. This was completed by two radiologists (DM and MP) with cross-over evaluation to confirm consistency between the two reviewers. Predictive values used were the presence, volume, and diameter of IVCE on preangiogram CT. Outcome measures were the presence of IVCE on angiogram and utilization of AE. Secondary outcomes included complications of pseudoaneurysm at the angiography access site and renal failure.

Analyses were performed using SAS 9.2 (SAS Institute, Cary, NC, USA). Descriptive statistics were reported as mean and standard deviation for continuous variables and frequency (percentage) for dichotomous or categorical variables. Simple comparisons between independent groups were conducted using two-sample t-tests or Chi-square tests, as appropriate. Logistic regression was used to model mortality as a function of a set of predictors; odds ratios are based on these logistic regression models, rather than on simple two-way associations, which do not control for other covariates. ICU length of stay (LOS) was assessed using analysis of covariance; patients who were not discharged alive were excluded from...
the ICU LOS analysis. Means of continuous variables were compared between independent groups using a two-sided, two-sample t-test. To compare proportions between independent groups, Chi-square tests were used; where appropriate (i.e., significant differences), odds ratios were reported. The Bonferroni correction was used to control the overall Type II error rate. Otherwise, \( P < 0.05 \) was used to determine statistical significance.

**RESULTS**

One hundred and twenty-eight patients were identified with twelve patients having two or more solid organ injuries with contrast extravasations between January 1, 2008 and December 31, 2012. Mean ISS score for our patient population was 25. Of the 128 patients, 97 (75.8%) patients had extravasation on angiography requiring embolization with five patients with IVCE in two or more regions. These blushes and angiographic findings were noted in solid organs and the pelvis [Table 1].

No patients with IVCE were excluded based on prestudy criteria. Location of IVCE was predictive of need for embolization (\( P = 0.006 \)). The volume of extravasation on CT was not predictive of need for embolization, [Table 2] or the presence of IVCE on angiography [Table 3].

The 75% of patients during this time were males. The mechanism of injury was varied, but the majority of injuries were sustained from motor vehicle crashes [Table 4]. There was also no correlation between the diameter of the IVCE on CT and the need for embolization [Table 5]. The AIS was predictive of which patients would need embolization [Table 6]. Interestingly, patients with larger volumes of extravasation on CT did not require embolization [Table 7] No statistically significant difference was identified in complication rates for patients who had IVCE on angiogram than those who did not. The incidence of renal failure was greater in the group with IVCE on angiography, with four patients (6.3%) with renal failure, versus one patient (1.6%) in the non-IVCE group (not significant. No events of pseudoaneurysm at the access site were identified.

**DISCUSSION**

Our study was undertaken to determine if the volume and size characteristics of IVCE on CT was directly related to finding ongoing extravasation on angiography. One hundred and twenty-eight patients over a 5 years period had IVCE; however, we could not find any direct relationship of IVCE on CT and continued extravasation at the time of angiography. Specifically, the size of the IVCE was not related to IVCE on angiography. Volume and diameter of the IVCE and need for embolization was not correlated; however, the location of the IVCE was related to need for embolization at the time of angiography. The spleen was more likely to have ongoing bleeding at the time of angiography and require embolization compared to the liver.

The identification of the IVCE, the diameter, organ and grade of injury has an impact on success or failures of NOM. According to the Diamond et al.,[8] patients that had a larger dimension of extravasation (mean of 23 mm) were found needing more intervention comparatively.

| Table 1: Contrast extravasation blush location |
|-----------------|----------------|----------------|
| Region          | Fraction embodied (%) | \( P \) (Chi-square test) |
| Liver           | 11/23 (47.8)       | 0.0008         |
| Spleen          | 48/53 (90.6)       |                |
| Pelvic          | 27/38 (71.1)       |                |
| Kidney/other    | 11/14 (78.6)       |                |

| Table 2: Computed tomography volume of extravasation and presence of extravasation on angiogram |
|-----------------------------------------------|----------------|----------------|
| Contrast Extravasation | \( n \) | Volume of IVCE on CT (mL) | \( P \) |
| IVCE on angiography    | 67             | 5.01             | 0.69          |
| No IVCE on angiography | 62             | 4.33             |               |

| Table 3: Computed tomography volume of extravasation and need for embolization on angiogram |
|-----------------------------------------------|----------------|----------------|
| Angiogram Intervention | \( n \) | Volume of IVCE on angiography (mL) | \( P \) |
| Embolization         | 99             | 3.96             | 0.17          |
| No embolization      | 31             | 6.89             |               |

**Table 4: Mechanism of injury**

| Mechanism | Percentage (%) |
|-----------|----------------|
| MVC       | 55 (45.8)      |
| FALL      | 20 (16.7)      |
| MC        | 12 (10.0)      |
| PED       | 11 (9.2)       |
| Other (unknown) | 22 (18.4) |

MVC: Motor vehicle crashes, MC: Motorcycle, FALL: All level falls, PED: Pedestrian struck by vehicle

**Table 5: Embolization versus largest diameter on intravenous contrast extravasation**

| Embolized on | \( n \) | Mean (SD) | Minimum, maximum | \( P \) (two-sample t-test) |
|--------------|---------|-----------|------------------|-----------------------------|
| No           | 30      | 26.3 (21.23) | 4, 100          | 0.27 (NS)                   |
| Yes          | 96      | 21.7 (14.59) | 6, 80           |                             |

SD: Standard deviation, NS: Not significant

**Table 6: Abbreviated Injury Score (AIS)**

| AIS | Embolized | \( P \) (Chi-square test) |
|-----|-----------|-----------------------------|
| 0   | 0/31 (0)  | 1/97 (1.0)                  |
| 2   | 3/31 (9.7)| 5/97 (6.2)                  |
| 3   | 10/31 (32.3)| 35/97 (36.1)               |
| 4   | 10/31 (32.3)| 31/97 (32.0)               |
| 5   | 6/31 (19.4)| 14/97 (14.4)               |
| 6   | 2/31 (6.5) | 11/97 (11.3)               |

NS: Not significant
to those that had a significantly smaller dimension of extravasation (mean of 11 mm). We did not find similar findings in our study. Although not statistically significant we found that those patients with larger IVCE CT did not get embolization. Supporting the idea that volume and diameter do not have any predictive value in determining who needs angiographic evaluation and embolization.

Among the solid organs with IVCE that would require AE, the spleen was found to most commonly needing an intervention when compared to the liver. We were not able to find any other direct relationship, clinically knowing that the liver is less likely need to any intervention can contribute to decision for conservative management. There was also a trend in our data noting pelvic and renal injuries resulting in IVCE although no statistically significant had a greater than seventy percent embolization rate. Therefore, it would be prudent to perform a diagnostic angiogram despite the stability of the patient to circumvent any deterioration of the patient at a later time.

Furthermore, the idea of contrast induced nephropathy has to be addressed in patients receiving contrast dye loads during their screening CT’s, and during angiography. Contrast nephropathy has typically been defined as acute renal failure occurring within 48 h of exposure to intravascular contrast material that is not attributable to other causes.[8] Despite the advances in medical care, contrast-induced nephropathy is the third most common cause of morbidity in hospital acquired renal failure.[9,10,11] Contrast-induced nephropathy is higher in elderly patients as well as those patients who have baseline renal disease, such as diabetes, ingestion of nephrotoxic drugs, and hypovolemia.[8] According a study by van der Vlies et al.,[9] the most common complication from AE in their patient population was contrast induced nephropathy. van der Vlies et al.[9] found a failure rate of 21% which is significantly higher than the national rate of <2%. In addition, van der Vlies et al.[9] study determined a direct correlation between the number of solid organ injuries and with a higher risk of contrast induced nephropathy.

In our study, we did not find any statistical significance in complication of angiography. There were more patients with renal failure with AE than those who did not undergo AE. Furthermore, we did look for other complications associated with AE such as pseudoaneurysm at the catheter site.[12,13] There was not statistical significance for any of the above complications; however, the 90% of the patients had no complications from undergoing either AE or angiographic evaluation. In addition to size and volume of the IVCE, information such as time to angiography, admitting hemoglobin, transfusion requirement, age, gender were compared and there were no statistical significance for those who underwent AE and does who did not.

Limitations to our study was that it was not a prospective trial which limited our ability make a direct correlation between IVCE size and diameter, active bleeding at the time of angiography, and the decision to perform embolization. In addition, our sample size was relatively small. Therefore, a large multi-center prospective trial would be needed to address parameters such as time to angiography, hemoglobin, transfusions requirements, hemodynamic stability, and type of solid organ injury. An additional limitation to our study was that contrast volume administered during angiography could not be quantified.

**CONCLUSION**

This study was not able demonstrate a direct relationship between the size/volume of IVCE on CT and the need of embolization. The decision to proceed with angiography and angiographic embolization is a very complex one, involving numerous variables. Therefore, we believe that IVCE diameter and volume cannot be used solely to include or exclude those patients who would require angiographic evaluation and/or embolization.[14] This may be one part of the decision process, but it cannot be the sole indicator of need for intervention, as many patients with significant injuries or need for embolization could be excluded if the wrong criteria were implemented.

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**Conflicts of interest**

There are no conflicts of interest.

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