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## An Abdominal CT may be Safe in Selected Hypotensive Trauma Patients with Positive FAST Exam

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### Abstract

**Background**—Positive Focused Assessment with Sonography in Trauma (FAST) and hypotension often indicates urgent surgery. An abdomen/pelvis CT (apCT) may allow less invasive management but the delay may be associated with adverse outcomes.

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**Methods**—Patients in the Prospective Observational Multicenter Major Trauma Transfusion study with hypotension and a positive FAST (HF+) who underwent a CT (apCT+) were compared to those who did not.

**Results**—Of the 92 HF+ identified, 32(35%) underwent apCT during initial evaluation and apCT was associated with decreased odds of an emergency operation, OR 0.11 95% CI (0.001–0.116) and increased odds of angiographic intervention, OR 14.3 95% CI (1.5–135). There was no significant difference in 30 day mortality or need for dialysis.

**Conclusion**—An apCT in HF+ patients is associated with reduced odds of emergency surgery, but not mortality. Select HF+ patients can safely undergo apCT to obtain clinically useful information.

### Keywords

FAST exam; Trauma; Computed Tomography Scan

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### Introduction

Expedient control of hemorrhage is an imperative in high quality trauma care and is associated with improved mortality<sup>1,2</sup>. This imperative to control hemorrhage places a critical emphasis on rapid and accurate diagnosis of injuries. An optimal diagnostic algorithm for abdominal trauma, however, remains in evolution<sup>3–5</sup>.

Traditional diagnosis of intra-abdominal injuries relied upon physical exam and diagnostic peritoneal lavage (DPL), techniques hampered, respectively, by low sensitivity and low specificity<sup>6–10</sup>. Helical computed tomography (CT) has evolved to become a standard evaluation tool for the diagnostic imaging of abdominal trauma but is limited by concerns over radiation and contrast exposure as well as the logistical challenges of transporting an unstable patient to the radiology suite<sup>5,11,12</sup>. The Focused Assessment with Sonography in Trauma (FAST) exam was developed to provide a rapid, inexpensive and repeatable bedside tool to evaluate abdominal injuries. Despite concerns over a low sensitivity and operator dependence, a positive FAST exam is specific for intra-peritoneal fluid and in the setting of hemodynamic instability, has been considered an indication for an immediate laparotomy<sup>5,10,13–18</sup>. Despite this sensitivity for hemoperitoneum, FAST may not correlate well with need for an emergent operation<sup>2</sup>.

The advent of angiography and non-operative management (NOM) of select blunt intra-abdominal injuries along with an evolving understanding of the implications of a non-therapeutic trauma laparotomy has highlighted the importance of balancing speed and accuracy of diagnosis<sup>19–21</sup>. It is no longer necessary to rush every patient with hemoperitoneum to the operating room and it has been suggested that patients who can be transiently stabilized are candidates for CT evaluation<sup>22</sup>. It is unclear if this delay in definitive care is associated with adverse outcomes and if the information obtained from a CT scan alters clinical decision making.

We therefore sought to determine if patients who were initially hypotensive who undergo an abdomen and pelvis CT (CT) scan following a positive FAST exam have similar long term outcomes and less urgent operations than patients who do not undergo a CT.

## Materials and Methods

Data were obtained from a database created by the Prospective Observational Multicenter Major Trauma Transfusion (PROMMTT) study Data Coordinating Center at the University of Texas Health Science Center at Houston. PROMMTT enrolled 1,245 injured patients who required the highest level activation at one of 10 Level I trauma centers and who subsequently received one or more units of red blood cells (RBCs) within 6 hours of hospital admission. Exclusion criteria included age younger than 16 years, transfer from another hospital, pregnancy, more than 20% burn injury, inhalation injury, incarceration, cardiopulmonary resuscitation lasting more than 5 minutes occurring prehospital or in the first 30 minutes after admission, and death within 30 minutes of hospital admission. Data were collected in real time on a wide variety of patient characteristics, including fluid and blood product infusions, diagnostic studies, and surgical interventions. The time of mortality or hospital discharge was recorded. Approval was obtained from the institutional review board at each center and from the US Army Human Research Protections Office<sup>23,24</sup>.

Patients who had a positive FAST along with hypotension, defined as an admission systolic blood pressure (SBP)  $\leq 90$ mmHg were identified. An urgent operation was defined as direct admission to the operating room less than 3 hours from presentation. This longer time was chosen to allow for the inherent delay in obtaining a CT scan during trauma workup. Patients who went to CT were compared to those who did not. Data are presented as medians with 25<sup>th</sup> and 75<sup>th</sup> percentile. Univariable comparisons were made with Fischer's exact test and a Mann-Whitney U test, for categorical and continuous variables, respectively.

Multivariable comparisons were made with binary logistic regression. Variables were selected for inclusion based on clinical feasibility and selected for inclusion in the multivariable model using backwards stepwise elimination to select relevant variables.

In order to control for the fact that this study did not prescribe the management of hypotensive patients with a positive FAST exam and the likely fact that patients who went to CT differed from patients who did not go to CT, we derived a propensity score to undergo CT. This was done by constructing a binary logistic regression model with backwards stepwise elimination to select variables that were independently associated with undergoing CT. The propensity score was a conditional probability, between 0 and 1, that a patient would undergo CT based upon these variables. This allowed collection of confounding variables into a single propensity that was then used as an independent predictor in binary logistic modeling<sup>25</sup>. These propensity scores for CT and splenectomy were then used as independent variables in binary logistic models to determine independent associations with either operative or angiographic intervention. Results are presented with odds ratio (OR) and 95% confidence intervals. Statistical analysis was performed using SPSS (IBM Corporation) v22.0. Significance was set at  $p < 0.05$ .

## Results

We identified 255 patients with a positive FAST exam, of whom 46% subsequently went to CT, demographics of this group are presented in TABLE 1. We subsequently identified 92 patients, 7% of the total population, with admission hypotension and a positive FAST exam. In this group, 32 (35%) underwent CT during their initial trauma evaluation a median of 43 (25–51) minutes after admission to the trauma bay. Importantly, despite setting inclusion criteria for urgent operation at 3 hours, patients taken immediately to the operating room arrived there very rapidly, a median of 25 (17–36) minutes after admission. Initially hypotensive patients who underwent CT following a positive FAST exam were more likely to have a blunt injury, had a higher head Abbreviated Injury Severity (AIS) score and a higher admission platelet count than patients who did not have a CT. There were no significant differences between groups with respect to age, gender, admission hemodynamics, Glasgow Coma Score (GCS), Injury Severity Score (ISS), other AIS regions or admission hematocrit (TABLE 2A).

On univariable comparison of outcomes, patients who underwent CT during their initial trauma evaluation were less likely to undergo an urgent operation though they were more likely to undergo an urgent angiographic intervention. Only one patient who underwent CT proceeded to the OR after 3 hours, and they were in the operating room 3.5 hours after admission. Transfusion volumes of red blood cells, plasma and platelets were lower for patients who underwent CT and while mortality at 24 hours was lower in the CT group, there was no difference in 30 day mortality. Additionally, there was no difference in length of hospital stay for patients who survived and no difference in 30 day need for dialysis (Table 2B).

On multivariable analysis of hypotensive patients with a positive FAST, after controlling for 24 hour red blood cell and plasma transfusion volume, patient age, ISS, admission systolic blood pressure and incidence of urgent operation, there was no independent association between CT and 24 hour or 30 day mortality OR 0.41 95% CI (0.05–3.6) and 1.4 95% CI (0.24–7.7) respectively. In a multivariable model of initially hypotensive patients with a positive FAST exam, controlling for patient age, ISS and admission systolic blood pressure, CT was associated with reduced odds of an urgent operation, OR 0.02 95% CI (<0.01–0.15). In a similar model controlling for admission GCS, ISS, systolic blood pressure, heart rate, patient age and mechanism of injury, a CT scan was associated with increased odds of proceeding to interventional radiology, OR 15.8 95% CI (1.5–133.2). (FIGURE 1A&B)

On binary logistic regression, blunt injury, OR 9.7 95% CI (1.8–51.8), and increasing age, OR 0.95 95% CI (0.92–0.99) were independently associated with propensity to undergo CT in initially hypotensive patients with a positive FAST. (FIGURE 2). Among patients with a similar propensity to undergo CT, actually undergoing a CT was associated with reduced odds of an emergency operation, OR 0.11 95% CI (<0.01–0.12) and an increased odds of proceeding to an angiographic intervention OR 14.3 95% CI (1.5–135).

## Discussion

Hypotensive patients with a positive FAST exam present a management dilemma for the provider. While consensus opinions suggest that this constellation of findings is an indication for an urgent operation<sup>10,18</sup>, this must be balanced against recent findings suggesting that FAST may not correlate well with need for an emergent operation<sup>2</sup> and our evolving understanding of the long term morbidity of a non-therapeutic trauma laparotomy<sup>19–21</sup>. In this study, we demonstrate that initially hypotensive trauma patients with a positive FAST exam who undergo CT have a 30 day mortality that is no different than patients managed without CT. Additionally, we found that undergoing a CT during initial trauma evaluation is associated with increased odds of angiographic intervention and reduced the odds of an urgent operation.

When considering this finding, it is critical to remember that given the limitations of this study design, we cannot infer causation and likely the patients taken to CT are different from patients who are not taken to CT as evidenced by their rapid transport to the operating room, the difference in their mechanism of injury and head AIS as well as by their need for blood product resuscitation. As anticipated, blunt trauma was independently associated with increasing propensity to undergo CT – suggesting that hypotensive patients with penetrating injury are taken directly to the operating room. Interestingly, while not independently associated with CT, HF+ who underwent CT had a higher head and face AIS. This suggests that hypotensive patients who suffered blunt trauma and have some degree of intracranial injury are the population most likely to go to CT following a positive FAST. In addition to these injury factors, it seems likely that some degree of management variation may be related to attending surgeon preference (and thus not captured within this data set) it is also likely that patients found to be responders or transient responders to resuscitation are the ones taken to CT<sup>26,27</sup>. This is one of the most important limitations of this data set and must be kept in mind when applying these results to clinical practice. In order to retrospectively control for this variation in patients, we stratified patients by propensity to undergo CT and found, even within groups of patients with similar propensity to undergo CT, that CT was still independently associated with increased odds of an angiographic intervention and reduced odds of an urgent operation. This finding suggests that the clinical information obtained from CT is altering management decisions and diverting some bluntly injured patients away from operative intervention and to angiography or non-operative management.

Non-operative management of select intra-abdominal solid organ injuries is well established in the trauma literature. The angiographic management of selected injuries is gaining traction<sup>28–30</sup>. While delays in definitive hemorrhage control have been associated with higher mortality in trauma patients, it may be that the additional anatomic information obtained from CT allows for selection of patients that are appropriate for non-operative management or angiographic intervention<sup>2,31</sup>. The findings of this study suggest that an CT in select patients may allow for treatment of appropriate injuries in the angiography suite. This study demonstrates that the time delay inherent in obtaining an CT, at least in some patients, does not result in increased mortality and thus may be a safe decision that yields important information.

These findings must be interpreted carefully as this study is limited by the inclusion criteria of PROMMTT. The database contains only patients who received at least one unit of red blood cells and therefore our findings may not be applicable to all trauma patients. It seems likely, however, that the majority of initially hypotensive trauma patients with a positive FAST exam will receive at least one unit of blood. We are additionally limited by significant missing data in the nature of the operative intervention. While it seems likely that patients with a positive FAST and hypotension on admission who proceed urgently to the operating room are undergoing a thoraco-abdominal operation, this cannot definitely be shown in this data set. In addition, many of the factors that may contribute to variations in trauma bay decision making are not captured in the original PROMMTT database. While propensity score matching attempts to control for this variation in decision making and we hypothesize responders or transient responders are primarily taken to CT, proving this will require additional studies. There is also significant variation in FAST ordering criteria between centers despite its acceptance as a standard diagnostic imaging test and this may introduce variation in patients included within the initially hypotensive, positive FAST cohort<sup>32,33</sup>. Our relatively small numbers as well as the limited data on the specific nature of injuries limited our ability to directly test the hypothesis that patients with injuries not amenable to angiographic intervention might be disproportionately harmed by the delay necessary to obtain a CT, as compared to patients with injuries amenable to angiographic intervention.

We additionally defined initially hypotensive patients as those patients with an admission SBP of  $\geq 90$ mmHg. We did not limit to patients with tachycardia or base deficit abnormalities in order to simulate the clinical situation of an initially hypotensive patient with a positive FAST and admission hypotension in which the trauma surgeon is deciding between immediate operations or further imaging prior to the availability of additional laboratory values.

## Conclusion

In conclusion, we find that some patients with initial hypotension and a positive FAST may be taken to CT without a significant difference in 30 day mortality. We additionally find that undergoing an CT is independently associated with reduced odds of an urgent operation and increased odds of angiographic intervention. This suggests that the information obtained from the CT may impact clinical decisions and that admission hypotension and a positive FAST exam does not mandate laparotomy.

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Figure 1A

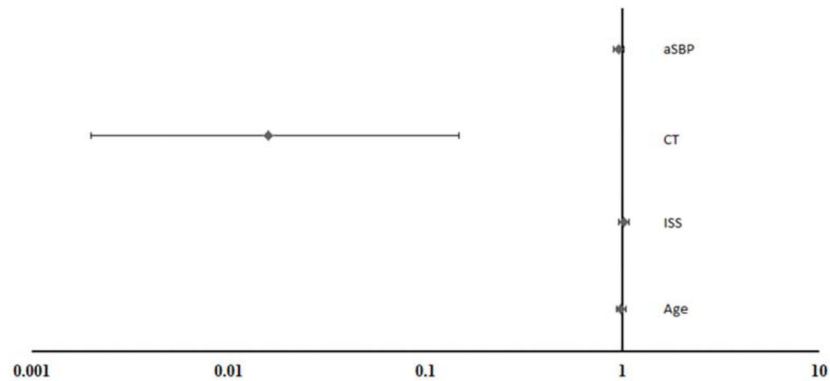


Figure 1B

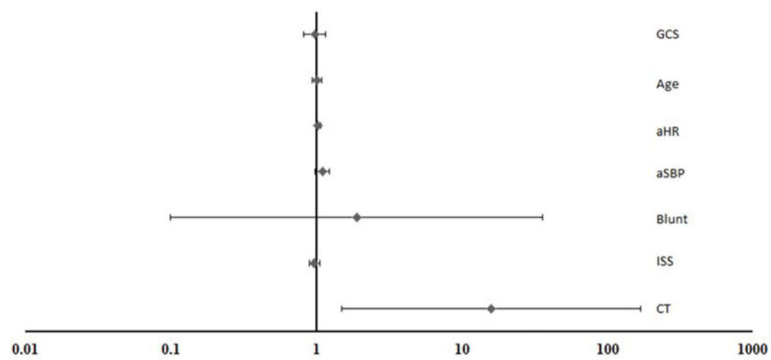
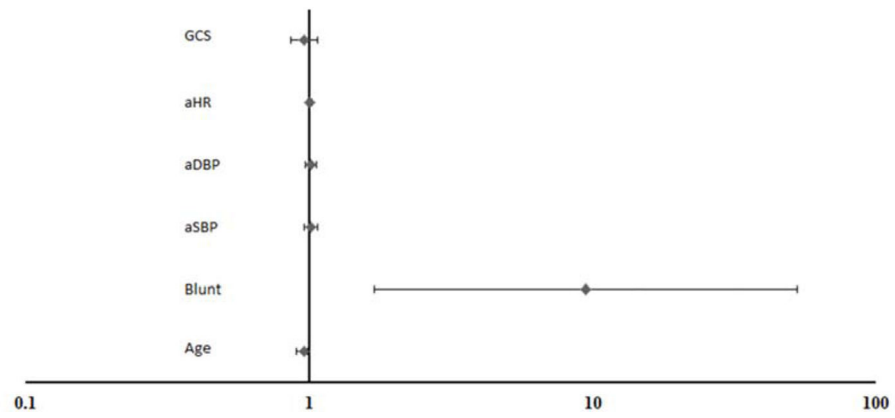
**Figure 1.**

Figure 1A: Multivariable model predicting odds of proceeding to an urgent operation in initially hypotensive patients with a positive FAST. CT: abdominal pelvis CT scan, ISS: Injury Severity Score, aSBP: admission systolic blood pressure.  $R^2 = 0$ .

Figure 1B: Multivariable model predicting odds of proceeding to an urgent angiographic intervention in initially hypotensive patients with a positive FAST. GCS: Glasgow Coma Score, aHR: admission hear rate, aSBP: admission systolic blood pressure, Blunt: blunt mechanism of injury, ISS: Injury Severity Score, CT: abdomen pelvis CT scan.  $R^2 = 0.304$ .



**Figure 2.** Multivariable model predicting propensity for initially hypotensive patients with a positive FAST exam to undergo a CT scan during initial trauma evaluation. GCS: Glasgow Coma Score, aHR: admission hear rate, aDBP: admission diastolic blood pressure, aSBP: admission systolic blood pressure, Blunt: blunt mechanism of injury.  $R^2 = 0.185$ .

**Table 1**

Demographics of patients with a positive FAST.

Patients with a Positive FAST			
	No CT (n=138)	Yes CT (n=117)	p
Age	33(22,48)	33(23,47)	0.66
SBP	98(76,118)	103(88,127)	<0.05
GCS	14(3,15)	11(3,15)	<0.05
ISS	25(16,37)	34(22,41)	<0.01
Urgent Operation	93%	54%	<0.01
Minutes to Operation	25(17,36)	88(57,151)	<0.01
30 Day Mortality	26%	19%	0.18

CT: Abdominal/Pelvis CT scan, SBP: Systolic Blood Pressure, GCS: Glasgow Coma Scale

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**Table 2**

(A) Admission Data and (B) Outcomes of initially unstable patients with a positive FAST exam.

<b>Table 2A</b>			
<b>Patients with a Positive FAST and Hypotension on Admission</b>			
	<b>No CT (n=60)</b>	<b>Yes CT (n=32)</b>	<b>p</b>
Age in Years	41(24,54)	34(24,45)	0.15
sBP	82%	63%	0.08
Blunt Injury	63%	91%	<0.01
SBP	74(65,83)	80(66,86)	0.21
Heart Rate	107(88,128)	118(88,125)	0.62
GCS	13(3,5)	9(4,14)	0.15
ISS	27(16,35)	34(23,41)	0.12
Head AIS	0(0,0.8)	0.5(0,4)	<0.05
Face AIS	0(0,0)	0(0,1)	0.05
Chest AIS	3(1,4)	3(3,4)	0.19
Abdomen AIS	3(2,4)	3(3,4)	0.8
Extremity AIS	2(0,3)	2(0,3)	0.82
External AIS	1(0,1)	1(0,1)	0.62
Admission Plt Count (thousand)	200(164–255)	253(176–327)	<0.05
Admission Hematocrit	34(28,37)	35(31,40)	0.26

<b>2B</b>			
<b>Patients with a Positive FAST and Hypotension on Admission</b>			
	<b>No CT (n=60)</b>	<b>Yes CT (n=32)</b>	<b>p</b>
Urgent Operation	93%	22%	<0.01
Urgent Angiography	2%	22%	<0.01
Minute to Operation	26(19–35)	93(41,121)	<0.01
24 Hour PRBC Volume (Units)	10(6,27)	7(4,11)	<0.05
30 Day PRBC Volume (Units)	8(4,23)	5(3,1)	<0.05
24 Hour FFP Volume (Units)	9(4,20)	6(2,14)	<0.05
30 Day FFP Volume (Units)	7(4,17)	4(2,10)	<0.05
24 Hour Plt Volume (Units)	6(6,12)	0(0,6)	<0.05
30 Day Plt Volume (UnitS)	6(6,12)	0(0,6)	<0.01
Length of Stay	17(11,30)	20(14,37)	0.49
24 Hour Mortality	20%	6%	<0.01
30 Day Mortality	30%	19%	0.32
30 Day Dialysis	6%	8%	1

AIS: Abbreviated Injury Scale score, PRBC: Packed Red Blood Cells, FFP: Fresh Frozen Plasma, Plt: Platelet