Increasing time to operation is associated with decreased survival in patients with a positive FAST examination requiring emergent laparotomy

Ronald R. Barbosa, MD, Susan E. Rowell, MD, Erin E. Fox, PhD, John B. Holcomb, MD, Eileen M. Bulger, MD, Herbert A. Phelan, MD, MSCS, Louis H. Alarcon, MD, John G. Myers, MD, Karen J. Brasel, MD, Peter Muskat, MD, Deborah J. del Junco, PhD, Bryan A. Cotton, MD, MPH, Charles E. Wade, PhD, Mohammad H. Rahbar, PhD, Mitchell J. Cohen, MD, *and* **Martin A. Schreiber, MD, on behalf of the PROMMTT Study Group,** *Portland, Oregon*

INTRODUCTION: Focused assessment with sonography for trauma (FAST) is commonly used to facilitate the timely diagnosis of life-threatening hemorrhage in injured patients. Most patients with positive findings on FAST require laparotomy. Although it is assumed that an increasing time to operation (T-OR) leads to higher mortality, this relationship has not been quantified. This study sought to determine the impact of T-OR on survival in patients with a positive FAST who required emergent laparotomy.

METHODS: We retrospectively analyzed patients from the PRospective Observational Multicenter Major Trauma Transfusion (PROMMTT) study who underwent laparotomy within 90 minutes of presentation and had a FAST performed. Cox proportional hazards models including Injury Severity Score (ISS), age, base deficit, and hospital site were created to examine the impact of increasing T-OR on in-hospital survival at 24 hours and 30 days. The impact of time from the performance of the FAST examination to operation (T_{FAST}-OR) on in-hospital mortality was also examined using the same model.

RESULTS: One hundred fifteen patients met study criteria and had complete data. Increasing T-OR was associated with increased in-hospital mortality at 24 hours (hazard ratio [HR], 1.50 for each 10-minute increase in T-OR; confidence interval [CI], 1.14–1.97; $p = 0.003$) and 30 days (HR, 1.41; CI, 1.18–2.10; $p = 0.002$). Increasing T_{FAST}-OR was also associated with higher in-hospital mortality at 24 hours (HR, 1.34; CI, 1.03–1.72; $p = 0.03$) and 30 days (HR, 1.40; CI, 1.06–1.84; $p = 0.02$).

CONCLUSION: In patients with a positive FAST who required emergent laparotomy, delay in operation was associated with increased early and late in-hospital mortality. Delays in T-OR in trauma patients with a positive FAST should be minimized. (*J Trauma Acute Care Surg*. 2013;75: S48–S52. Copyright © 2013 by Lippincott Williams & Wilkins)

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

KEY WORDS: Time to operation; laparotomy; FAST examination; PROMMTT.

Trauma is one of the leading causes of death worldwide.[1] In the last few decades, extensive efforts have been made to develop and improve trauma systems in an effort to improve outcomes after injury.[2–4] It is commonly assumed that the time to definitive surgical care of life-threatening injuries is an important determinant of mortality. This has been demonstrated in patients with subdural hematomas,[5–7] but data for other types of operations are sparse.

Few studies have directly examined the impact of time to operation (T-OR) on survival in patients requiring emergent laparotomy for trauma. A longer T-OR has been shown to increase mortality in patients with traumatic hollow viscus injury

From the Trauma Services (R.R.B.), Legacy Emanuel Hospital and Health Center, Portland, Oregon; Department of Surgery (S.E.R., M.A.S.), Division of Trauma, Critical Care and Acute Care Surgery, School of Medicine, Oregon Health & Science University, Portland, Oregon; Biostatistics/Epidemiology/Research Design Core (E.E.F., M.H.R.), Center for Clinical and Translational Sciences, University of Texas Health Science Center at Houston, Houston, Texas; Department of Surgery (J.B.H., D.J.d.J., B.A.C., C.E.W.), Center for Translational Injury Research, Division of Acute Care Surgery, Medical School, University of Texas Health Science Center at Houston, Houston, Texas; Department of Surgery (E.M.B.), Division of Trauma and Critical Care School of Medicine, University of Washington, Seattle, Washington; Department of Surgery (H.A.P.), Division of Burn/Trauma/Critical Care, Medical School, University of Texas Southwestern Medical Center at Dallas, Dallas, Texas; Department of Surgery (L.H.A.), Division of Trauma and General Surgery, School of Medicine, University of Pittsburgh, Pittsburgh, Pennsylvania; Department of Surgery (J.G.M.), Division of Trauma, School of Medicine, University of Texas Health Science Center at San Antonio, San Antonio, Texas; Department of Surgery (K.J.B.), Division of Trauma and Critical Care, Medical College of Wisconsin, Milwaukee, Wisconsin; Department of Surgery (P.C.M.), Division of Trauma/Critical Care, College of Medicine, University of Cincinnati, Cincinnati, Ohio; Division of Epidemiology (M.H.R.), Human Genetics and Environmental Sciences, School of Public Health, University of Texas Health Science Center at Houston, Houston, Texas; and Department of Surgery (M.J.C.), Division of General Surgery, School of Medicine, University of California San Francisco, San Francisco, California.

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Address for reprints: Ronald R. Barbosa, MD, Trauma Services, Legacy Emanuel Hospital and Health Center, 2801 N. Gantenbein, Suite 130, Portland, OR 97227; email: rbarbosa@lhs.org.

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TABLE 1. Baseline Characteristics Among 115 PROMMTT Patients With Positive FAST Who Underwent Emergent Laparotomy

Age, y	37 ± 16
ISS	29 (17–38)
AIS score head	0 (0–2)
AIS score chest	3 (0–4)
AIS score abdomen	3 (3–4)
AIS score extremity	2 (0–3)
Sex	77.3% male
Mechanism	64.3% blunt

Values are mean ± SD or median (interquartile range).
AIS, Abbreviated Injury Scale.

largely because of delays in diagnosis.[8,9] Clarke et al.[10] published a retrospective study in 2002 that used logistic regression to demonstrate that increasing time in the emergency department increased the probability of death by 0.35% per minute in hypotensive trauma patients. In general, for operations performed in the acute setting, an association between a longer T-OR and increased mortality has been difficult to demonstrate. This may be in part caused by indication bias because patients who have a longer T-OR may have less severe injuries and, therefore, a lower expected mortality.

The recently completed PRospective Observational Multicenter Major Trauma Transfusion (PROMMTT) study was designed primarily to examine issues related to blood product transfusion in trauma patients.[11] The extensive data collected by the PROMMTT investigators made it possible to study other aspects of trauma care as well. The purpose of this study was to determine the impact of T-OR on mortality in trauma patients requiring emergent laparotomy who present with a positive focused assessment with sonography for trauma (FAST). Our hypothesis was that increasing T-OR would lead to decreased survival. The primary end points were 24-hour and 30-day mortality.

PATIENTS AND METHODS

Data were obtained from a database created by the PROMMTT Data Coordinating Center at the University of Texas Health Science Center at Houston for the PROMMTT study. 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 prehospital or in the first 30 minutes after admission, and death within 30 minutes of hospital admission.[11] 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.

Our study examined the subset of patients that had a FAST performed and underwent laparotomy within the first 90 minutes after hospital admission. This time point was selected because we sought to exclude patients who underwent operation in a delayed fashion for missed injury or failure of planned nonoperative management. Examination of the distribution of T-OR for the entire database suggested that 90 minutes from initial presentation was a natural cutoff point for this. The time intervals from hospital admission to the FAST and to the operating room were recorded. Cox proportional hazards models were created including Injury Severity Score (ISS), age, base deficit, hospital site, and T-OR. We also generated the same models using the time interval between performance of the FAST and the operating room (T_{FAST}-OR). In-hospital mortality at 24 hours and 30 days was studied. Hazard ratios (HRs) were expressed in terms of 10-minute intervals in T-OR or T_{FAST}-OR. For each model, the proportional hazards assumption was tested with Schoenfeld residuals. Statistical analyses were carried out with Stata 12.1 (StataCorp, College Station, TX). Values of $p < 0.05$ were considered significant.

RESULTS

The overall PROMMTT study enrolled 1,245 patients. FAST studies were obtained in 838 patients, of which 255 were positive (30.4%). Among these, 72% (n = 184) underwent laparotomy within the first 24 hours (mean T-OR, 64 ± 92 minutes). T-OR was 90 minutes or less in 147 patients (79.8%); 115 patients had complete data and comprised the study group. Baseline demographic and injury severity scoring data are shown in Table 1. Physiologic and biochemical data obtained on hospital arrival are shown in Table 2. The mean time to performance of the FAST was 8.2 ± 9.7 minutes.

The operative procedures conducted are listed in Table 3. Damage control operations were done in 76 cases (66%). Forty-seven patients (40.8%) had a bowel resection or repair, 42 patients (36.5%) underwent splenectomy or splenorrhaphy, and 41 patients (35.6%) had some form of operative hemostasis of the liver. A concomitant thoracic operation was performed in 23 cases (20%), and a craniotomy was performed in one patient (0.8%). Three patients had nontherapeutic laparotomies (2.6%). All laparotomies in patients with initial systolic blood pressure less than 90 mm Hg (n = 43) were therapeutic.

TABLE 2. Initial Physiologic and Biochemical Data Among 115 PROMMTT Patients With Positive FAST Who Underwent Emergent Laparotomy

SBP, mm Hg	100 ± 30
DBP, mm Hg	64 ± 23
HR	106 ± 27
Hemoglobin, g/dL	11.2 ± 2.5
pH	7.23 ± 0.13
Base deficit	7.8 ± 5.7
INR	1.5 ± 1.0
PTT	32.7 ± 20.0

Values are mean ± SD.
DBP, diastolic blood pressure; HR, heart rate; INR, international normalized ratio; PTT, partial thromboplastin time; SBP, systolic blood pressure.

TABLE 3. Operative Procedures Performed on Patients With a Positive FAST Undergoing Laparotomy in 90 Minutes or Less (N = 115)

Operation	n (%)
Splenectomy	39 (34)
Small-bowel resection	29 (25)
Hemostasis of liver	25 (22)
Repair small bowel	23 (20)
Perihepatic packing	21 (18)
Repair of artery	16 (14)
Colon resection	15 (13)
Repair colon	13 (11)
Repair of vein	11 (10)
Genitourinary procedure	9 (8)
Nephrectomy or other kidney procedure	6 (5)
Colostomy or ileostomy	6 (5)
Pancreatic procedure	5 (4)
Partial hepatectomy	4 (3)
Cholecystectomy	4 (3)
Splenorrhaphy	3 (3)

Percentages add to greater than 100 because of multiple procedures in some patients.

Blood product requirements for the cohort are listed in Table 4. Massive transfusions (defined as ≥10 units RBC given in the first 24 hours) were required in 51 cases (44.3%). In 39 of these cases (76.4%), the threshold for massive transfusion was reached within the first 6 hours.

Unadjusted in-hospital mortality at different time points is shown in Table 5. Overall in- hospital mortality for the cohort was 20%, with slightly more than half of the deaths occurring within the first 24 hours (Table 5). Fifty-seven percent of deaths were caused by hemorrhage. Head injury was listed as one of the causes of death in four patients (3.6%).

The mean T-OR was 36 ± 21 minutes. The multivariable Cox proportional hazards model showed that increased T-OR was associated with increased in-hospital mortality at 24 hours (HR for each 10-minute increase, 1.50; confidence interval [CI], 1.14–1.97; $p = 0.003$) and 30 days (HR, 1.58; CI, 1.18–2.10; $p = 0.002$). Increased T_{FAST}-OR was also associated with increased mortality at 24 hours (HR, 1.34; CI, 1.03–1.72; $p = 0.03$) and 30 days (HR, 1.40; CI, 1.06–1.84; $p = 0.02$). For each model, the proportional hazards assumption was verified by analysis of Schoenfeld residuals (data not shown). Figure 1 shows the theoretical survival curve for the T-OR model in which each variable in the model is fixed at its mean value.

TABLE 4. Blood Product Requirements Among Patients With a Positive FAST Undergoing Laparotomy in 90 Minutes or Less (N = 115)

Blood Product, units	6 h	24 h
RBC	10.5 ± 11.0	13.1 ± 11.0
Plasma	7.9 ± 8.6	10.7 ± 10.7
Platelets	5.8 ± 9.8	7.2 ± 11.3

Values are mean ± SD.

TABLE 5. Mortality at Different Time Points Among Patients With a Positive FAST Undergoing Laparotomy in 90 Minutes or Less (N = 115)

Time	Percent Mortality
2 h	3.5
6 h	5.2
12 h	10.4
24 h	11.3
72 h	12.1
30 d	20.0

Separate curves for T-OR = 36 minutes (the mean value for the cohort) and T-OR = 56 minutes (meant to represent the mean value plus 20 minutes) are shown.

DISCUSSION

Common sense dictates that patients who require an emergent laparotomy for trauma should do better if the operation is done in an expedient fashion. This concept is deeply ingrained in the trauma community. Trauma systems and clinical protocols are designed to minimize the time required to obtain definitive surgical control of hemorrhage. The time from hospital arrival to emergent surgical intervention has been used as an audit filter for assessment of trauma systems in several different countries.[4,12]

Despite this, a direct correlation between T-OR and mortality has been difficult to demonstrate. One study by Clarke et al.[10] showed a correlation between increased time in the ED and mortality in hypotensive trauma patients. In contrast, another study reported that patients examined using an audit filter of 2 hours to laparotomy showed decreased mortality in the more-than-2-hour group.[13] A similar phenomenon has been seen in studies showing a lower overall mortality in patients with longer times to evacuation of acute subdural hematoma.[14,15]

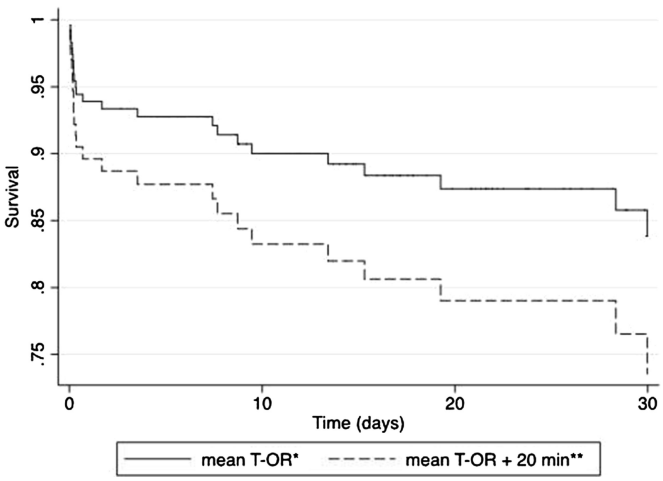

Figure 1. Survival curve for FAST(+) patients undergoing laparotomy in 90 minutes or less. *Mean T-OR for the cohort was 36 minutes. **Theoretical curve for patients with T-OR = 56 minutes.

Indication bias was present in each study, in that patients with more severe injuries tended to undergo operation sooner.

We attempted to minimize this bias by creating a Cox proportional hazards model and by using a highly selected group of patients. The cohort represents the subset of trauma patients with severe injuries in whom the need for laparotomy is identified on initial evaluation in the emergency department. Because this study was limited to patients who required an operation in the first 90 minutes after arrival, it is unlikely that patients with delayed recognition of bowel injury or failure of planned nonoperative management of solid organ injuries were included. We controlled for other factors that are known to affect mortality, such as ISS and age. Base deficit was included as a surrogate for shock. Hospital site was also included in the model.

One important caveat for this study is that findings on FAST did not correlate well with the need for an emergent operation. Only 72% of patients with a positive FAST received a laparotomy within the first 24 hours. Although a few patients may have had significant injuries that were initially not detected, we presume that these instances were rare, and that most patients who did not undergo operation were found on subsequent workup to have injuries that were amenable to nonoperative management. Therefore, it would be premature to proceed directly to the operating room in all patients with positive FAST studies. This would lead to a significant number of nontherapeutic laparotomies, which are thought to be associated with significant morbidity,[16–18] although this has been questioned.[1] In this study, only three patients underwent nontherapeutic laparotomy.

When an injured patient is noted to have a positive FAST, a choice must be made between obtaining additional diagnostic studies or proceeding to the operating room. Because delays in operation in this group are associated with higher mortality, efforts to minimize the T-OR are justified.[19] In many hospitals, much of the delay is accounted for by the length of time needed to obtain computed tomographic (CT) scans. This typically requires a number of ancillary tasks, including transporting the patient to the CT scanner, transfer to the gantry, manipulation of lines and devices, injection of contrast, programming the scanner, and so forth. This is rarely accomplished in less than 20 minutes and may take an hour or more in many centers. Selection of patients with positive FAST scans who should go directly to the operating room without obtaining a CT scan is therefore important. It is generally accepted that hypotensive patients with a positive FAST should undergo immediate laparotomy.[20] No other specific indications for deferring the CT scan have been described. Scoring systems have been developed,[21–23] but none have been widely adopted.

There are other ways to minimize the T-OR in patients with a positive FAST examination. Trauma center protocols could be modified so that all FAST-positive patients would be upgraded to the highest level of trauma team activation. This would result in earlier mobilization of the attending surgeon, the anesthesiologist, and OR staff. In nontrauma hospitals, a positive FAST should prompt immediate surgical consultation. Clinicians in hospitals without surgical capabilities should consider arranging for transfer of all patients with a positive FAST to a trauma center before obtaining a confirmatory CT scan.

This study has a variety of limitations. The database contained only patients who received at least one unit of RBCs, so our findings may not apply to the entire population of trauma patients. In addition, many of the factors that may contribute to variations in T-OR are not captured in the original PROMMTT database. We were not able to quantify the time required to obtain diagnostic studies and mobilize the anesthesia and OR staff and thus could not determine the relative impact of these factors. There may also be a degree of imprecision in recording exactly when a patient arrived in the OR. The time from initial OR arrival to the actual start of the surgical procedure and the time to definitive hemorrhage control were also not recorded.

In conclusion, this is the only study to date that uses survival analysis to demonstrate that increasing T-OR is associated with increased mortality in patients with a positive FAST who undergo emergent laparotomy. The established standard that hypotensive patients should proceed directly to operation should be maintained. Additional criteria that would mandate immediate laparotomy in the presence of a positive FAST should be sought in future studies. Efforts to allocate resources so as to minimize the T-OR in patients with a positive FAST are justified.

AUTHORSHIP

R.R.B., S.E.R., E.E.F., J.B.H., D.J.d.J., and M.H.R. contributed to the study concept and design. L.H.A., K.J.B., E.M.B., M.J.C., B.A.C., J.B.H., P.C.M., J.G.M., H.A.P., and M.A.S. acquired data. R.R.B., S.E.R., E.E.F., and M.A.S. analyzed and interpreted data. R.R.B. and S.E.R. drafted the manuscript. R.R.B., S.E.R., E.E.F., E.M.B., K.J.B., M.A.S., J.B.H., C.E.W., L.H.A., M.J.C., B.A.C., P.C.M., J.G.M., and H.A.P. contributed to critical revision of the manuscript for important intellectual content. M.H.R. obtained funding. M.H.R., J.B.H., E.E.F., D.J.d.J., L.H.A., K.J.B., E.M.B., M.J.C., B.A.C., P.C.M., J.G.M., H.A.P., M.A.S., and C.E.W. contributed to administrative, technical, or material support. M.H.R. and J.B.H. supervised the study.

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PRospective Observational Multicenter Major Trauma Transfusion (PROMMTT) Study Group:

University of Texas Health Science Center at Houston, Houston, TX:

Data Coordinating Center: Mohammad H. Rahbar, PhD (principal investigator); John B. Holcomb, MD (co-investigator); Erin E. Fox, PhD (co-investigator and project coordinator); Deborah J. del Junco, PhD (co-investigator); Bryan A. Cotton, MD, MPH (co-investigator); Charles E. Wade, PhD (co-investigator); Jiajie Zhang, PhD (co-investigator); Nena Matijevic, PhD (co-investigator); Yu Bai, MD, PhD (co-investigator); Weiwei Wang, PhD (co-investigator); Jeanette Podbielski, RN (study coordinator); Sarah J. Duran, MSCIS (data manager); Ruby Benjamin-Garner, PhD (data manager); Robert J. Reynolds, MPH (data manager); Xuan Zhang, MS (data analyst); Aisha Dickerson, MSPH (graduate assistant); Elizabeth S. Camp, MSPH (data analyst). Clinical Site: John B. Holcomb, MD (co-principal investigator); Bryan A. Cotton, MD, MPH (co-principal investigator); Marily Elopre, RN (study coordinator); Quinton M. Hatch, MD (research associate); Michelle Scerbo (research associate); Zerremi Caga-Anan, MD (research associate).

Other Clinical Sites:

Brooke Army Medical Center, San Antonio, TX: Christopher E. White, MD (principal investigator); Kimberly L. Franzen, MD (co-investigator); Elsa C. Coates, MS, RN (study coordinator).

Medical College of Wisconsin, Milwaukee, WI: Karen J. Brasel, MD, MPH (principal investigator); Pamela Walsh (study coordinator).

Oregon Health and Sciences University, Portland, OR: Martin A. Schreiber, MD (principal investigator); Samantha J. Underwood, MS (study coordinator); Jodie Curren (study coordinator).

University of California, San Francisco, San Francisco, CA: Mitchell J. Cohen, MD (principal investigator); M. Margaret Knudson, MD (co-investigator); Mary Nelson, RN, MPA (study coordinator); Mariah S. Call, BS (study coordinator).

University of Cincinnati, Cincinnati, OH: Peter Muskat, MD (principal investigator); Jay A. Johannigman, MD (co-investigator); Bryce RH Robinson, MD (co-investigator); Richard Branson (co-investigator); Dina Gomaa, BS, RRT (study coordinator); Cendi Dahl (study coordinator).

University of Pittsburgh Medical Center, Pittsburgh, PA: Louis H. Alarcon, MD (principal investigator); Andrew B. Peitzman, MD (co-investigator); Stacy D. Stull, MS, CCRC (study coordinator); Mitch Kampmeyer MPAS, CCRC, PA-C, (study coordinator); Barbara J. Early, RN, BSN, CCRC (study coordinator); Helen L. Shnol, BS, CRC (study coordinator); Samuel J. Zolin, BS (research associate); Sarah B. Sears, BS (research associate).

University of Texas Health Science Center at San Antonio, San Antonio, TX: John G. Myers, MD (co-principal investigator); Ronald M. Stewart, MD (co-principal investigator); Rick L. Sambucini, RN, BS (study coordinator); Marianne Gildea, RN, BSN, MS (study coordinator); Mark DeRosa CRT (study coordinator); Rachelle Jonas, RN, BSN (study coordinator); Janet McCarthy, RN (study coordinator).

University of Texas Southwestern Medical Center, Dallas, TX: Herbert A. Phelan, MD, MSCS (principal investigator); Joseph P. Minei, MD (co-investigator); Elizabeth Carroll, MD (study coordinator).

University of Washington, Seattle, WA: Eileen M. Bulger, MD (principal investigator); Patricia Klotz, RN (study coordinator); Keir J. Warner, BS (research coordinator).

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