The evolution of TQIP Best Practices for Massive Transfusion

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Background

- Hemorrhage: most common cause of death within the first hour of arrival.
- >80% of deaths in the OR and nearly 50% of deaths in 1st 24 hours due to hemorrhage.
- While only 3% of civilian traumas will receive a massive transfusion (MT), these patients consume 70% of all trauma blood transfused.

Kauvar DS et al, J Trauma 2006
Sauaia A et al, J Trauma 1995
Como JJ et al, Transfusion 2004

Background

- MT scenarios are unplanned, require processing/delivery of large amounts of products rapidly in a sustained fashion .
- Significant pre-planning and coordination between blood bank, ER, OR and Trauma.
- TQIP set out to identify necessary parts and processes of an MTP and address key issues involved in their development.

Cotton BA et al, J Trauma 2008
O'Keeffee T et al, J Trauma 2008

Why develop a MTP?

- Protocolization of the process is associated with decreased mortality, reduction in overall transfusions and less MOF/ARDS.

- MTP are associated with reduced times to first products available and decrease in blood product wastage.

- These findings are independent of the ratio fo plasma: RBC chosen.

Cotton BA et al, J Trauma 2009
Riskin DJ et al, JACS 2009
Gunter O et al, J Trauma 2009

Damage Control Hematology: The Impact of a Trauma Exsanguination Protocol on Survival and Blood Product Utilization

Bryan A. Cotton, MD, Oliver L. Gunter, MD, James Isbell, MD, Brigham K. Au, BS, Amy M. Robertson, MD, John A. Morris, Jr., MD, Paul St. Jacques, MD, and Pampee P. Young, MD, PhD

Background: The importance of early and aggressive management of trauma-related coagulopathy remains poorly understood. We hypothesized that a trauma exsanguination protocol (TEP) that systematically provides specified numbers and types of blood components immediately upon initiation of resuscitation would improve survival and reduce overall blood product consumption among the most severely injured patients.

Methods: We recently implemented a TEP, which involves the immediate and continued release of blood products from the blood bank in a predefined ratio of 10 units of packed red blood cells (PRBC) to 4 units of fresh frozen plasma to 2 units of platelets. All TEP activations from February 1, 2006 to July 31, 2007 were retrospectively evaluated. A comparison cohort (pre-TEP) was selected from all trauma admissions between August 1, 2004 and January 31, 2006 that (1) underwent immediate surgery by the trauma team and (2) received greater than 10 units of PRBC in the first 24 hours. Multivariable analysis was performed to compare mortality and overall blood product consumption between the two groups.

Results: Two hundred eleven patients met inclusion criteria (117 pre-TEP, 94 TEP). Age, sex, and Injury Severity Score were similar between the groups, whereas physiologic severity (by weighted Revised Trauma Score) and predicted survival (by trauma-related Injury Severity Score, TRISS) were worse in the TEP group (p values of 0.037 and 0.028, respectively). After controlling for age, sex, mechanism of injury, TRISS and 24-hour blood product usage, there was a 74% reduction in the odds of mortality among patients in the TEP group ($p = 0.001$). Overall blood product consumption adjusted for age, sex, mechanism of injury, and TRISS was also significantly reduced in the TEP group ($p = 0.015$).

Conclusions: We have demonstrated that an exsanguination protocol, delivered in an aggressive and predefined manner, significantly reduces the odds of mortality as well as overall blood product consumption.

Key Words: Hemorrhage, Exsanguination, Trauma, Massive transfusion.

J Trauma. 2008;64:1177–1183.

Table 2 Univariate Analyses of Primary and Secondary Outcome Measures

Variable	Pre-TEP (n = 117)	TEP (n = 94)	*p*
30-d mortality (%)	65.8	51.1	0.030*
24-h blood product use (units)	39 ± 28	31.8 ± 19	0.017*
24-h RBC use (units)	19.8 ± 12.8	18.8 ± 11.2	0.695
24-h FFP use (units)	12.4 ± 12.5	9.9 ± 7	0.595
24-h PLT use (units)	6.8 ± 7.2	3.1 ± 3.7	<0.001*
Intraoperative RBC use (units)	11.1 ± 8.5	16 ± 11.4	0.001*
Intraoperative FFP use (units)	4.3 ± 4	8.2 ± 6.8	<0.001*
Intraoperative PLT use (units)	1.1 ± 2.6	2.2 ± 2.3	<0.001*
Intraoperative crystalloid (L)	6.7 ± 4.2	4.9 ± 3.0	0.002*
Unexpected survivors (%)	5.1	22.3	<0.001*
Unexpected deaths (%)	22.2	8.5	0.007*

A Massive Transfusion Protocol to Decrease Blood Component Use and Costs

Terence O'Keeffe, MB, ChB, MSPH; Majed Refaai, MD; Kathryn Tchorz, MD; John E. Forestner, MD; Ravi Sarode, MD

Hypothesis: A massive transfusion protocol (MTP) decreases the use of blood components, as well as turnaround times, costs, and mortality.

Design: Retrospective before-and-after cohort study.

Setting: Academic level I urban trauma center.

Patients and Methods: Blood component use was compared in 132 patients during a 2-year period following the implementation of an MTP; 46 patients who were treated the previous year served as historical control subjects.

Intervention: Introduction of an MTP that included recombinant factor VIIa for patients with exsanguinating hemorrhage.

Main Outcome Measures: The amount of each blood component transfused, turnaround times, blood bank and hospital charges, and mortality rates.

Results: After introduction of the MTP, there was a significant decrease in packed red blood cells, plasma, and platelet use. The turnaround time for the first shipment was less than 10 minutes, and the time between the first and second shipments was reduced from 42 to 18 minutes, compared with historical controls. The decreased use of blood products represented a savings of $2270 per patient or an annual savings of $200 000, despite increased costs for recombinant factor VIIa. There was no difference in mortality in either group; it remained around 50%. Thromboembolic complications did not increase, despite a significant increase in the use of recombinant factor VIIa.

Conclusions: The MTP resulted in a reduction in the use of blood components with improved turnaround times and significant savings. Mortality was unaffected. The use of recombinant factor VIIa did not increase thromboembolic complications in these patients.

Arch Surg. 2008;143(7):686-691

Table 3. Differences in Units of Blood Component Transfused Between Groups

Component	Pre-MTP[a]	MTP[a]	*P* Value
PRBCs	15.5 (15.5)	11.8 (11.8)	<.001
Thawed plasma	8.7 (6.9)	5.7 (5.4)	<.02
Platelets	3.8 (5.2)	1.1 (1.3)	<.001
Cryoprecipitate	0.7 (0.9)	0.6 (0.8)	.32
rFVIIa, mg	0.63 (1.8)	1.91 (2.5)	<.002

Abbreviations: MTP, massive transfusion protocol; PRBCs, packed red blood cells; rFVIIa, recombinant factor VIIa.

[a] Data are given as mean (SD).

Massive Transfusion Protocols: The Role of Aggressive Resuscitation Versus Product Ratio in Mortality Reduction

Daniel J Riskin, MD, MBA, Thomas C Tsai, BS, Loren Riskin, MD, Tina Hernandez-Boussard, PhD, MPH, Maryanne Purtill, MD, Paul M Maggio, MD, MBA, FACS, David A Spain, MD, FACS, Susan I Brundage, MD, MPH, FACS

J Am Coll Surg 2009

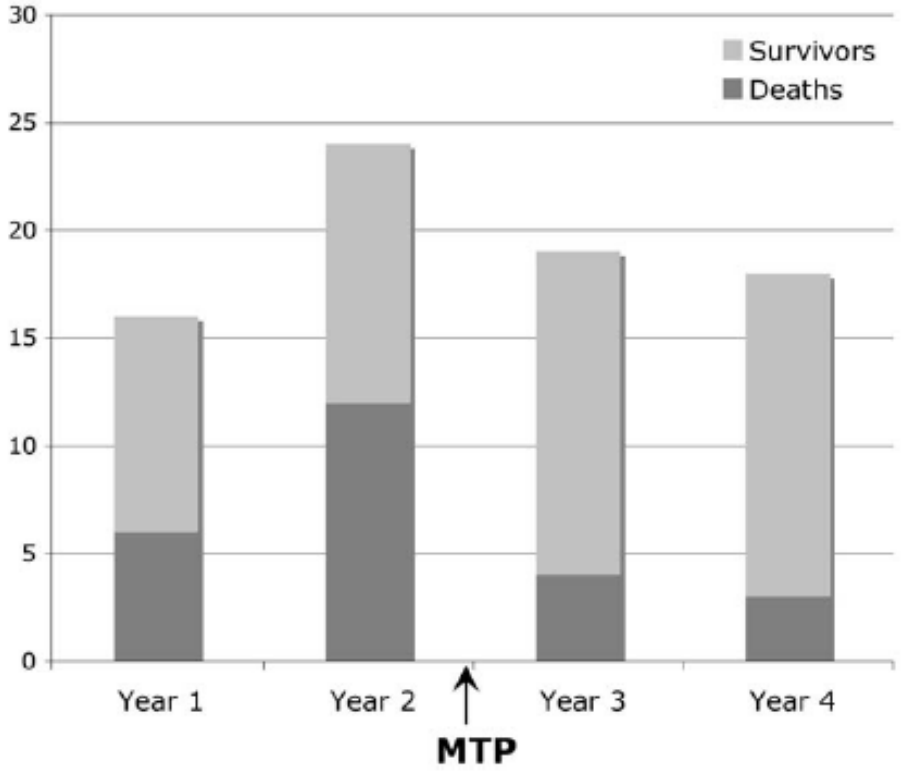


Figure 2. Patient survival by year. MTP, massive transfusion protocol.

Table 4. Mortality Rates Between Cohorts

Variable	Pre-MTP	Post-MTP	p Value
Patients, n	40	37	
Deaths, n	18	7	
Mortality, %	45	19	0.02*

Predefined Massive Transfusion Protocols are Associated With a Reduction in Organ Failure and Postinjury Complications

Bryan A. Cotton, MD, Brigham K. Au, BS, Timothy C. Nunez, MD, Oliver L. Gunter, MD, Amy M. Robertson, MD, and Pampee P. Young, MD, PhD

Introduction: Massive transfusion (MT) protocols have been shown to improve survival in severely injured patients. However, others have noted that these higher fresh frozen plasma (FFP): red blood cell (RBC) ratios are associated with increased risk of organ failure. The purpose of this study was to determine whether MT protocols are associated with increased organ failure and complications.

Methods: Our institution's exsanguination protocol (TEP) involves the immediate delivery of products in a 3:2 ratio of RBC:FFP and 5:1 for RBC:platelets. All patients receiving TEP between February 2006 and January 2008 were compared with a cohort (pre-TEP) of all patients from February 2004 to January 2006 that (1) went immediately to the operating room and (2) received MT (≥10 units of RBC in first 24 hours).

Results: Two hundred sixty-four patients met inclusion (125 in the TEP group, 141 in the pre-TEP). Demographics and Injury Severity Score were similar. TEP received more intraoperative FFP and platelets but less in first 24 hours ($p < 0.01$). There was no difference in renal failure or systemic inflammatory response syndrome, but pneumonia, pulmonary failure, open abdomens, and abdominal compartment syndrome were lower in TEP. In addition, severe sepsis or septic shock and multiorgan failure were both lower in the TEP patients (9% vs. 20%, $p = 0.011$ and 16% vs. 37%, $p < 0.001$, respectively).

Conclusions: Although MT has been associated with higher organ failure and complication rates, this risk appears to be reduced when blood products are delivered early in the resuscitation through a predefined protocol. Our institution's TEP was associated with a reduction in multiorgan failure and infectious complications, as well as an increase in ventilator-free days. In addition, implementation of this protocol was followed by a dramatic reduction in development of abdominal compartment syndrome and the incidence of open abdomens.

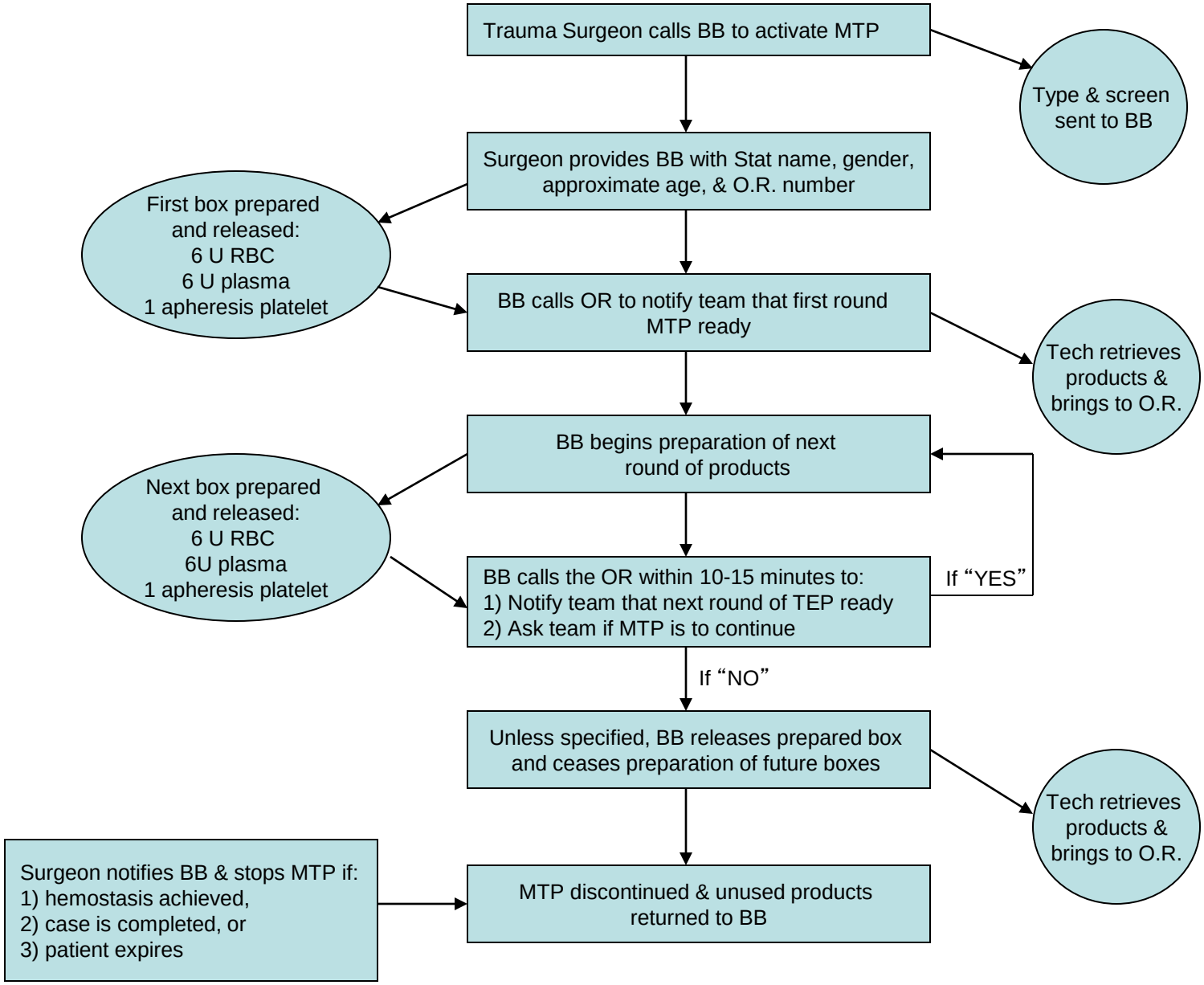
Key Words: Hemorrhage, Exsanguination, Trauma, Massive transfusion.

J Trauma. 2009;66:000–000.

Reduce transfusions…reduce exposure… reduce complications

The protocol

- Should be a written document, accessible to all, and adopted by the center.
- Anyone who “touches” the MTP should be involved with development and oversight.
- Provide for ratio based blood products, empirically delivered.
- Standardization of coagulation assessment, plans to treat acidosis, hypothermia, hypoCa+.

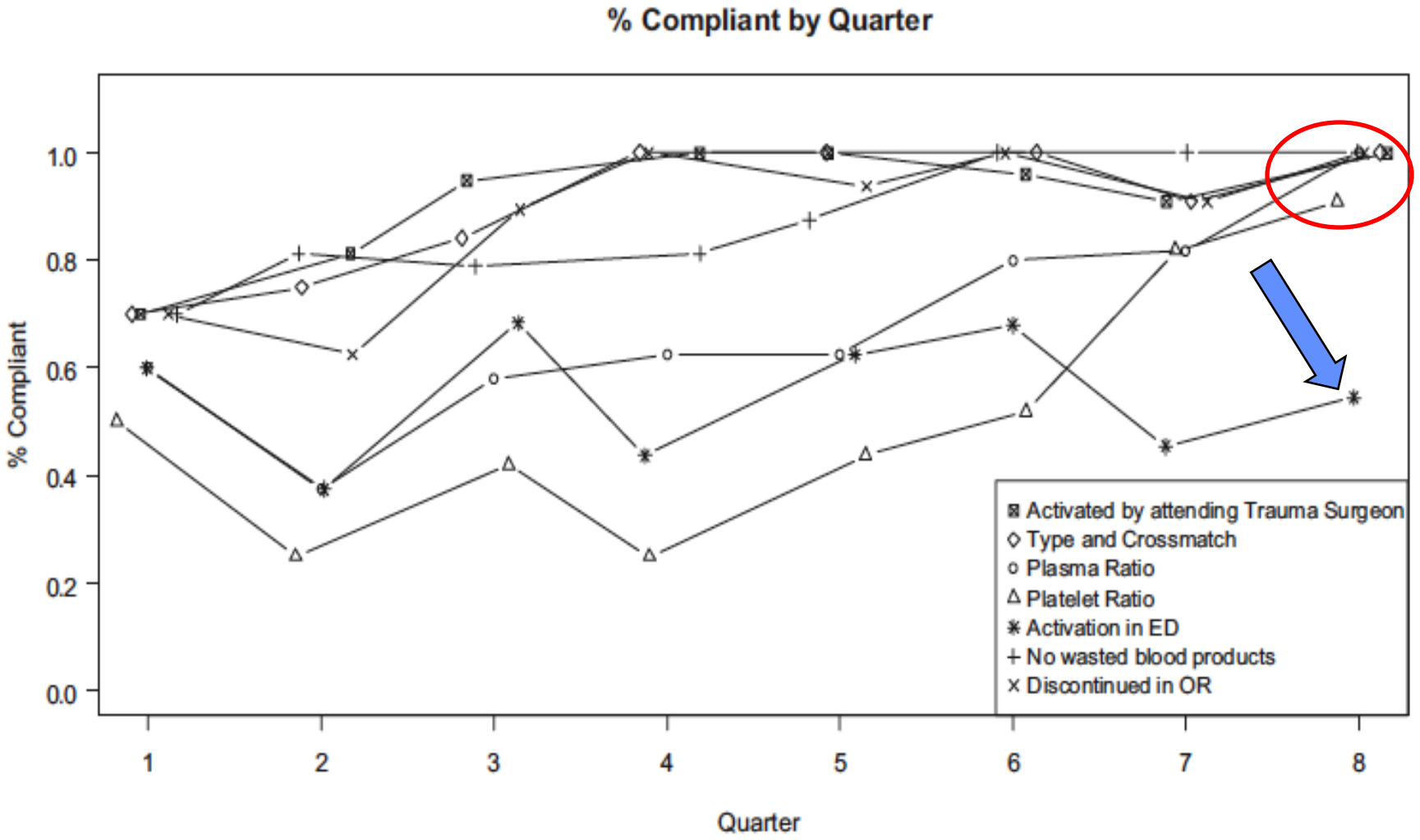

Trauma Surgeon calls BB to activate MTP
Type & screen sent to BB
Surgeon provides BB with Stat name, gender, approximate age, & O.R. number
First box prepared and released: 6 U RBC 6 U plasma 1 apheresis platelet
BB calls OR to notify team that first round MTP ready
Tech retrieves products & brings to O.R.
BB begins preparation of next round of products
Next box prepared and released: 6 U RBC 6U plasma 1 apheresis platelet
BB calls the OR within 10-15 minutes to: 1) Notify team that next round of TEP ready 2) Ask team if MTP is to continue
If "YES"
If "NO"
Unless specified, BB releases prepared box and ceases preparation of future boxes
Tech retrieves products & brings to O.R.
Surgeon notifies BB & stops MTP if: 1) hemostasis achieved, 2) case is completed, or 3) patient expires
MTP discontinued & unused products returned to BB

Predicting need for MTP

- Predicting the need for MT is difficult.
- Mortality is improved with rapid implementation of appropriate MT guidelines but complications are increased if patients have unnecessary exposure to blood products.
- Prediction tools have been developed for both military and civilian trauma patients, with specificities that range between 80% and 90%.

TABLE 7. Unadjusted and Adjusted ORs for 30-d Survival by Individual PI Measure Compliance

Variable	Crude OR	95% CI	Adjusted OR	95% CI
ED protocol activation	3.44	1.927–6.157	2.79	1.039–7.497
Plasma:RBC ratio of 2:3	6.91	3.797–12.556	12.28	3.860–39.069
Platelet:RBC ratio of 1:5	7.78	3.814–15.871	3.72	1.392–9.975
Trauma attending activation	2.30	1.402–3.778	0.895	0.960–8.337
ED type and screen sent	2.15	1.315–3.539	0.195	0.023–1.621
Age (yr)	0.98	0.968–0.997	0.98	0.957–1.015
Male	1.12	0.841–1.500	0.75	0.264–2.157
ISS	0.98	0.963–0.0997	0.96	0.941–1.357


% Compliant by Quarter
% Compliant
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
4
5
6
7
8
Quarter
Activated by attending Trauma Surgeon
Type and Crossmatch
Plasma Ratio
Platelet Ratio
Activation in ED
No wasted blood products
Discontinued in OR

Available scoring systems

	ABC[7]	TASH[14]	Schreiber[22]	McLaughlin[11]	ETS[21]	PWH[27]
Age					X	
Penetrating mechanism	X		X			
Tachycardia	X	X				X
Hypotension	X	X			X	X
(+) FAST	X	X				X
pH value				X		
Base deficit		X				X
PT/INR			X			
Hemoglobin/hematocrit		X	X	X		X
Pelvic fracture		X			X	X
GCS						X

ABC Score

- Four (4) dichotomous components available during the “A-B-C’ s”

- The presence of any one component contributes one point to the total score (range 0-4)
- Parameters: Penetrating MOI (0=no, 1=yes), ED SBP ≤ 90mmHg (0=no, 1=yes), ED HR ≥120 bpm (0=no, 1=yes), (+) FAST (0=no, 1=yes)

Early Prediction of Massive Transfusion in Trauma: Simple as ABC?

Timothy C. Nunez, MD, Igor V. Voskresensky, MD, Lesly A. Dossett, MD, MPH, Ricky Shinall, BS, William D. Dutton, MD, and Bryan A. Cotton, MD

Background: Massive transfusion (MT) occurs in about 3% of civilian and 8% of military trauma patients. Although many centers have implemented MT protocols, most do not have a standardized initiation policy. The purpose of this study was to validate previously described MT scoring systems and compare these to a simplified nonlaboratory dependent scoring system (Assessment of Blood Consumption [ABC] score).

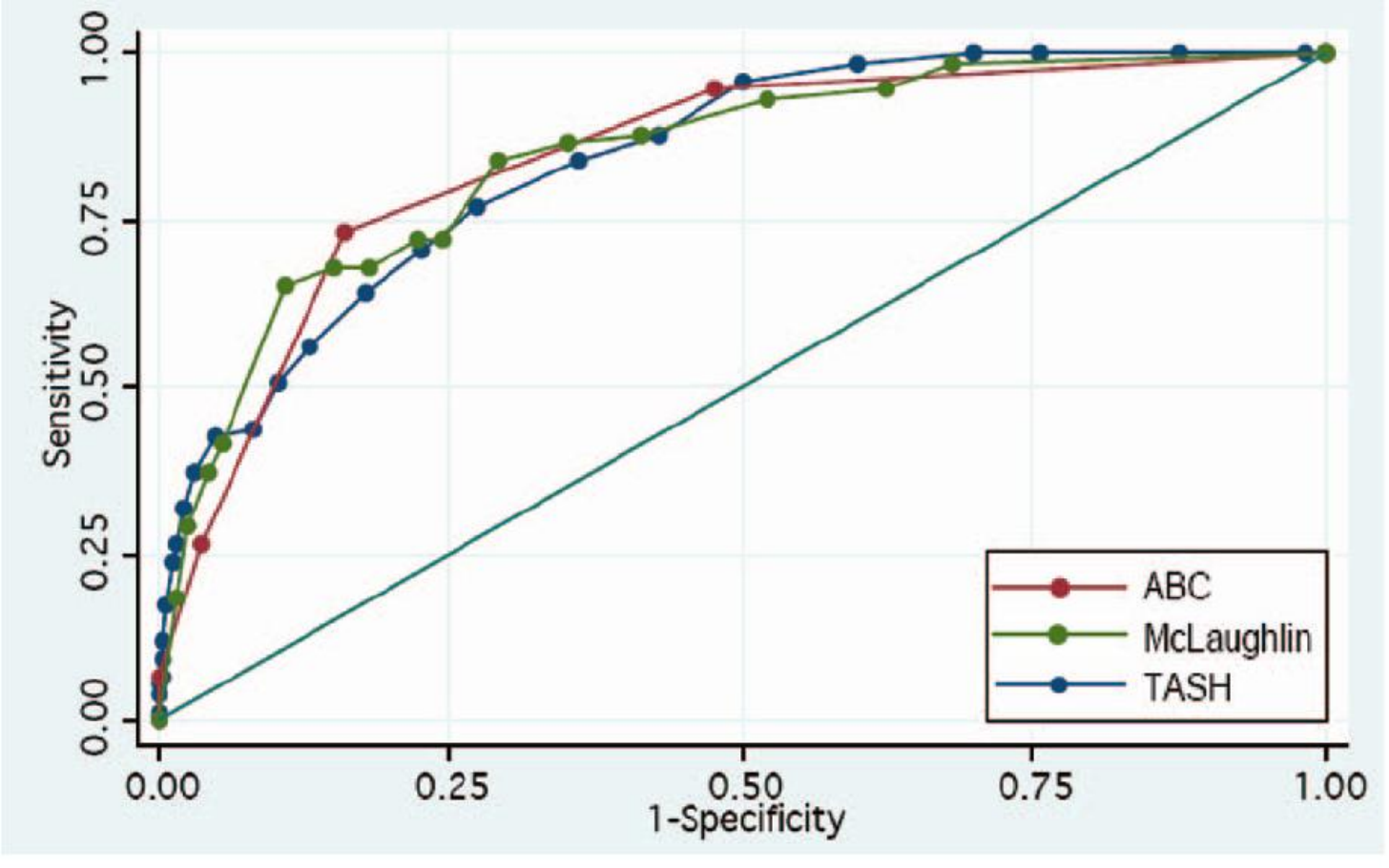
Methods: Retrospective cohort of all level I adult trauma patients transported directly from the scene (July 2005 to June 2006). Trauma-Associated Severe Hemorrhage (TASH) and McLaughlin scores calculated according to published methods. ABC score was assigned based on four nonweighted parameters: penetrating mechanism, positive focused assessment sonography for trauma, arrival systolic blood pressure of 90 mm Hg or less, and arrival heart rate ≥120 bpm. Area under the receiver operating characteristic curve (AUROC) used to compare scoring systems.

Results: Five hundred ninety-six patients were available for analysis; and the overall MT rate of 12.4%. Patients receiving MT had higher TASH (median, 6 vs. 13; $p < 0.001$), McLaughlin (median, 2.4 vs. 3.4; $p < 0.001$) and ABC (median, 1 vs. 2; $p < 0.001$) scores. TASH (AUROC = 0.842), McLaughlin (AUROC = 0.846), and ABC (AUROC = 0.842) scores were all good predictors of MT, and the difference between the scores was not statistically significant. ABC score of 2 or greater was 75% sensitive and 86% specific for predicting MT (correctly classified 85%).

Conclusions: The ABC score, which uses nonlaboratory, nonweighted parameters, is a simple and accurate in identifying patients who will require MT as compared with those previously published scores.

Key Words: Hemorrhage, Trauma, Massive transfusion, Prediction, Scoring systems.

ABC vs. McLaughlin vs. TASH

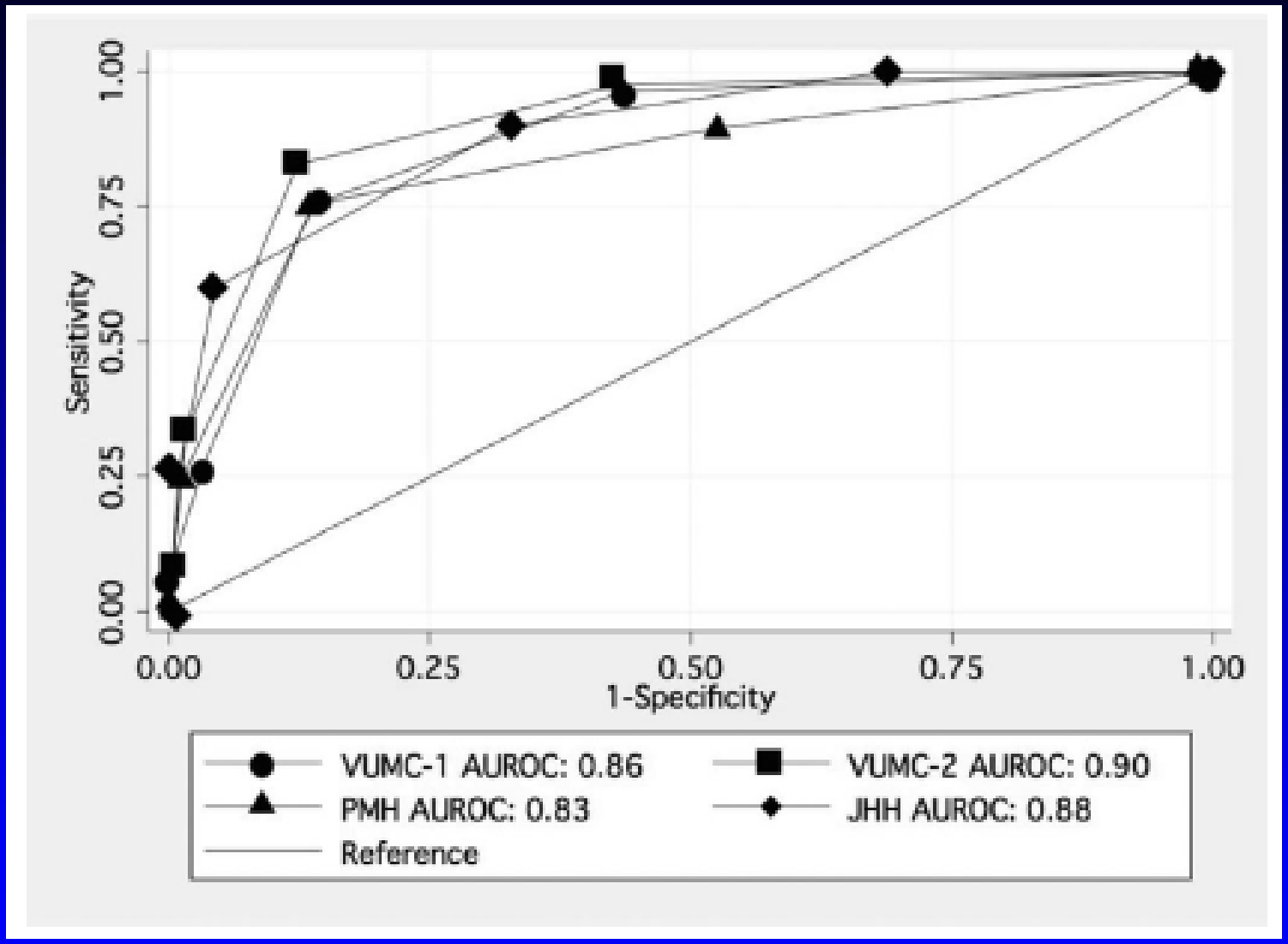


ORIGINAL ARTICLE

Multicenter Validation of a Simplified Score to Predict Massive Transfusion in Trauma

Bryan A. Cotton, MD, MPH, Lesly A. Dossett, MD, MPH, Elliott R. Haut, MD, Shahid Shafi, MD, MPH, Timothy C. Nunez, MD, Brigham K. Au, MD, Victor Zaydfudim, MD, MPH, Marla Johnston, RN, MSN, Patrick Arbogast, PhD, and Pampee P. Young, MD, PhD

J Trauma 2010


Sensitivity
0.00
0.25
0.50
0.75
1.00
1-Specificity
0.00
0.25
0.50
0.75
1.00
VUMC-1 AUROC: 0.86
VUMC-2 AUROC: 0.90
PMH AUROC: 0.83
JHH AUROC: 0.88
Reference

Comparison of massive blood transfusion predictive models in the rural setting

Nicole J. Krumrei, MD, Myung S. Park, MD, Bryan A. Cotton, MD, MPH, *and* **Martin D. Zielinski, MD,**
Rochester, Minnesota

BACKGROUND: Hemorrhage is the leading cause of preventable death in trauma patients, of which 3% require massive transfusion (MT). MT predictive models such as the Assessment of Blood Consumption (ABC), Trauma-Associated Severe Hemorrhage (TASH), and McLaughlin scores have been developed, but only included patients requiring blood transfusion during their hospital stay, excluding a large percentage of trauma patients. Our purpose was to validate these MT predictive models in our rural Level I trauma center patient population, using all major trauma victims, regardless of blood product requirements.

METHODS: Review of all Level I trauma patients admitted in 2008 to 2009 was performed. ABC, TASH, and McLaughlin scores were calculated using 80% probability for the need for MT.

RESULTS: Three hundred seventy-three patients were admitted; 13% had a penetrating mechanism and 52% were scene transports. MT patients had higher Injury Severity Score (median, 43 vs. 13; $p < 0.001$) and lower Trauma-Injury Severity Score (0.310 vs. 0.983; $p < 0.001$). Mortality was higher in MT patients (18.4% vs. 5.4%; $p < 0.009$). Thirty-eight (10%) required MT; 34 were predicted by ABC, one by TASH, and six by McLaughlin. ABC (area under the receiver operating characteristic [AUROC] = 0.86) was predictive of MT, whereas TASH (AUROC = 0.51) and McLaughlin (AUROC = 0.56) were not.

CONCLUSIONS: The ABC score correctly identified 89% of MT patients and was predictive of MT in major trauma patients at our rural Level I trauma center; the TASH and McLaughlin scores were not. The ABC score is simpler, faster, and more accurate. Based on this work, we strongly recommend adoption of the ABC score for MT prediction. (*J Trauma.* 2012;72: 211–215. Copyright © 2012 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: III.

KEY WORDS: Massive blood transfusion; trauma; rural trauma; trauma systems; prediction model.

J Trauma
Volume 72, Number 1

Activation of the MTP

- ABC over triage rate is high (PPV 50-55%)
- Under-triage rate <5% (NPV 95-97%).
- You can always send the cooler back, but you can't make it quicker when you're wrong.
- Other scores have been developed and all include the presence of severe tissue injury and hemorrhagic shock as important risk factors

A Randomized Controlled Pilot Trial of Modified Whole Blood Versus Component Therapy in Severely Injured Patients Requiring Large Volume Transfusions

Bryan A. Cotton, MD, MPH,† Jeanette Podbielski, BSN,† Elizabeth Camp, MSPH,† Timothy Welch, NREMT-P,† Deborah del Junco, PhD,† Yu Bai, MD, PhD,‡ Rhonda Hobbs, MT (ASCP),‡ Jamie Scroggins, MT (ASCP),§ Beth Hartwell, MD,§ Rosemary A. Kozar, MD, PhD,* Charles E. Wade, PhD,*† and John B. Holcomb, MD*† on behalf of The Early Whole Blood Investigators*

PROPPR

Pragmatic, **R**andomized **O**ptimal **P**latelet and **P**lasma **R**atios

CeTR

Trauma bay, OR, and IR

- Universal RBC (O-/+) and thawed AB plasma immediately available, ideally stored in ED.
- Centers using thawed plasma early in resus have seen reductions in blood product use.
- If unable to provide adequate stores of AB plasma, low (anti-B) titer A plasma may be utilized (or liquid plasma).

ORIGINAL ARTICLE

An Emergency Department Thawed Plasma Protocol for Severely Injured Patients

Zayde A. Radwan, BS; Yu Bai, MD, PhD; Nena Matijevic, PhD, PharmD; Deborah J. del Junco, PhD; James J. McCarthy, MD; Charles E. Wade, PhD; John B. Holcomb, MD; Bryan A. Cotton, MD, MPH

Importance: In an effort to expedite delivery of plasma for patients requiring massive transfusions, US medical centers began keeping thawed plasma (TP) in their blood banks (BBs), markedly reducing time to release of plasma; however, the time to transfusion was still excessively long.

Objective: To expedite delivery and transfusion of TP through implementation of an emergency department (ED) protocol.

Design and Setting: Retrospective cohort study in an American College of Surgeons–verified level I trauma center.

Participants: Using the Trauma Registry of the American College of Surgeons database, we evaluated all adult trauma patients admitted from June 1, 2009, through August 31, 2010, who arrived directly from the scene, were the institution's highest level trauma activation, and received at least 1 U of red blood cells and 1 U of plasma in the first 6 hours after admission. The protocol was initiated in February 2010 by giving 4 U of AB plasma to patients in the ED. Patients were then divided into 2 groups: those admitted 8 months before (TP-BB) and 8 months after implementing TP location change (TP-ED).

Main Outcome Measures: Primary outcome was time to first unit of plasma. Secondary outcomes included 24-hour blood use and 24-hour and 30-day mortality.

Results: A total of 294 patients met the study criteria (130 in the TP-BB group and 164 in the TP-ED). Although the patient demographics were similar, TP-ED patients had greater anatomical injury (median Injury Severity Score, 18 vs 25; $P=.02$) and more physiologic disturbances (median weighted Revised Trauma Score, 6.81 vs 3.83; $P=.008$). The TP-ED patients had a shorter time to first plasma transfusion (89 vs 43 minutes, $P<.001$). The TP-ED protocol was associated with a reduction in 24-hour transfusion of RBCs ($P=.04$), plasma ($P=.04$), and platelets ($P<.001$). Logistic regression identified TP-ED as an independent predictor of decreased 30-day mortality (odds ratio, 0.43; 95% CI, 0.194-0.956; $P=.04$).

Conclusions: We demonstrated that implementation of an ED-TP protocol expedites transfusion of plasma to severely injured patients. This approach is associated with a reduction in overall blood product use and a 60% decreased odds in 30-day mortality.

JAMA Surg. 2013;148(2):170-175

Trauma bay, OR, and IR

- To avoid “popping the clot,” DCR principles suggest RBC/plasma be delivered by rapid infuser/warmer.
- Initial rate of transfusion should restore perfusion but allow for permissive hypotension until operation to stop the bleeding has begun.
- Platelets and cryoprecipitate should not be administered through a blood warmer.

ORIGINAL ARTICLE

Hypotensive Resuscitation Strategy Reduces Transfusion Requirements and Severe Postoperative Coagulopathy in Trauma Patients With Hemorrhagic Shock: Preliminary Results of a Randomized Controlled Trial

C. Anne Morrison, MD, MPH, Matthew M. Carrick, MD, Michael A. Norman, MD, Bradford G. Scott, MD, Francis J. Welsh, MD, Peter Tsai, MD, Kathleen R. Liscum, MD, Matthew J. Wall, Jr., MD, and Kenneth L. Mattox, MD

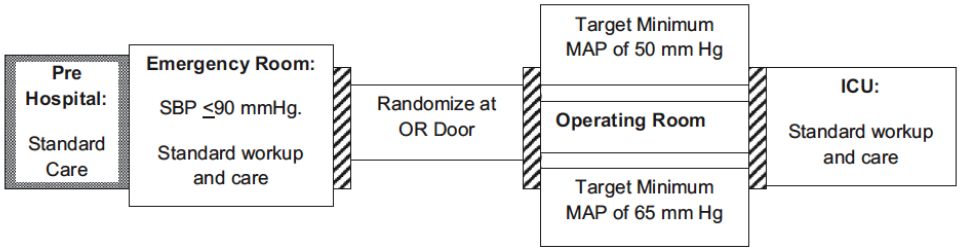
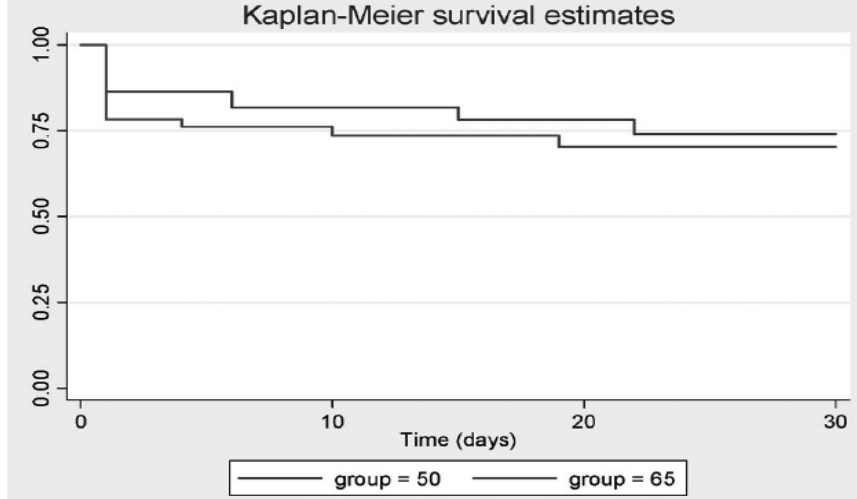


Figure 1. Diagram of the patient flow from left to right.

TABLE 6. Intraoperative Fluids

	MAP = 50 mm Hg				MAP = 65 mm Hg				
	n	Mean	SD	CI	n	Mean	SD	CI	*p*
IVF									
Crystalloid (mL)	44	2,883	1,921	2,299–3,467	46	3,282	2,010	2,667–3,866	0.34
Colloid (mL)	44	512	469	367–656	46	609	470	469–748	0.33
Blood products									
PRBC (mL)	44	1,335	1,812	784–1,886	46	2,244	2,466	1,512–2,977	0.05
FFP (mL)	44	198	471	54–341	46	528	860	272–783	0.02
Platelets (mL)	44	61	214	3–137	46	114	242	42–186	0.27
Total inputs									
Non-blood products (mL)	44	3,438	2,103	2,791–4,086	46	3,875	2,098	3,252–4,498	0.33
Blood products (mL)	44	1,594	2,292	897–2,291	46	2,898	3,299	1,918–3,877	0.03
Total fluids	44	3,070	3,631	3,952–6,187	46	6,762	4,559	5,408–8,116	0.06
Total outputs									
Estimated blood loss (mL)	44	1,964	2,215	1,290–2,637	46	3,008	2,948	2,132–3,883	0.06
Urine output (mL)	40	272	284	181–363	40	347	353	234–460	0.29
Total fluid balance	40	3,026	2,470	2,225–3,826	40	3,089	2,383	2,327–3,851	0.90



Goals of early resuscitation in Trauma bay, OR, and IR

- Transfuse universal products in a ratio between 1:1 and 1:2 (plasma to RBC) at 100 mL/min.
- Transfuse one bag of platelets/ 6 units RBC.
- Products should be automatically sent by BB within 15 minutes of MTP activation.
- Subsequent coolers should be delivered at 15 minute intervals until MTP terminated.

Goals of early resuscitation in Trauma bay, OR, and IR

- In OR/IR, rapid delivery and transfusion should continue (at set ratios) and at a rate to keep the patient euvolemic while actively bleeding.

- Once major bleeding controlled and transfusion rate slowed, appropriate to switch to lab or point of care (POC)-based transfusion.

Radwan ZA et al. JAMA Surg
Zielinski MD et al. J Trauma Acute Care Surg
Armand R and Hess JR. Transfus Med Rev. 2003

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ICU resuscitation

- MT=ICU admission
- ICU team should anticipate arrival of these patients with the necessary equipment and personnel to care for these patients.
- However, ongoing bleeding and RAPID transfusion should return to OR
- Priorities: correct coagulopathy and associated issues (hypothermia, acidosis, hypocalcemia)

ICU resuscitation

- ICU driven algorithm should be optimized to use blood components for goal directed therapy.
- Hgb 8-10 g/dL (rheologic, facilitate clotting)
- Upon arrival, baseline labs, repeat frequently until defects corrected (coags, TEG, iCa, abg)
- Once results available, goal directed resus

Royston D et al. Br J Anaesth. 2001
Holcomb JB et al. Ann Surg 2012
Ak K et al. J Card Surg, 2009

Transfusion Services

- Designated trauma centers should have on-site Transfusion Service, operating 24/7, with SOP for immediate, continuous delivery of products.
- Timely, precise communication between trauma team, ED, OR, anesthesia and BB is critical.
- Most efficient way to immediately provide products is with refrigerator in resuscitation bay.
- Rapid delivery of coolers from BB is best accomplished through a dedicated runner.

Dutton RP et al. J Trauma 2005
Armand R and Hess JR. Transfus Med Rev 2003
Quillen K et al Transfusion 2011

CeTR

Transfusion Services

- Liquid or thawed plasma immediately available.
- AB ideal universal plasma, but only 4% donors.
- However, 40% donors A, many are low anti-B titers; can be safely given to almost everyone.
- Switch to group specific plasma ASAP (10 min).
- Upon termination of MTP, PROMPT return of all remaining blood products and coolers to BB.


UNCROSSMATCHED
Removed from refrigerator:
Date
Time
UNCROSSMATCHED
Removed from refrigerator:
Date
Time
UNCROSSMATCHED
Removed from refrigerator:
Date
Time
UNCROSSMATCHED
Removed from refrigerator:
Date
Time
UNCROSSMATCHED
RED BLOOD CELLS
ADENINE – SALINE (AS – 1) ADDED
LEUKOCYTES REDUCED

Emergency use of prethawed Group A plasma in trauma patients

Martin D. Zielinski, MD, Pamela M. Johnson, MD, Donald Jenkins, MD, Naeem Goussous, MD, *and* James R. Stubbs, MD, *Rochester, Minnesota*

BACKGROUND: Massive transfusion protocols lead to increased use of the rare universal plasma donor, Type AB, potentially limiting supply. Owing to safety data, with a goal of avoiding shortages, our blood bank exploited Group A rather than AB for all emergency release plasma transfusions. We hypothesized that ABO-incompatible plasma transfusions had mortality similar to ABO-compatible transfusions.

METHODS: Review of all trauma patients receiving emergency release plasma (Group A) from 2008 to 2011 was performed. ABO compatibility was determined post hoc. Deaths before blood typing were eliminated. $p < 0.05$ was considered statistically significant.

RESULTS: Of the 254 patients, 35 (14%) received ABO-incompatible and 219 (86%) received ABO-compatible transfusions. There was no difference in age (56 years vs. 59 years), sex (63% vs. 63% male), Injury Severity Score (ISS) (25 vs. 22), or time spent in the trauma bay (24 vs. 26.5 minutes). Median blood product units transfused were similar: emergency release plasma (2 vs. 2), total plasma at 24 hours (6 vs. 4), total red blood cells at 24 hours (5 vs. 4), plasma–red blood cells at 24 hours (1.3:1 vs. 1.1:1), and plasma deficits at 24 hours (2 vs. 1). Overall complications were similar (43% vs. 35%) as were rates of possible transfusion-related acute lung injury (2.9% vs. 1.8%), acute lung injury (3.7% vs. 2.5%), adult respiratory distress syndrome (2.9% vs. 1.8%), deep venous thrombosis (2.9% vs. 4.1%), pulmonary embolism (5.8% vs. 7.3%), and death (20% vs. 22%). Ventilator (6 vs. 3), intensive care unit (4 vs. 3), and hospital days (9 vs. 7) were similar. There were no hemolytic reactions. Mortality was significantly greater for the patients who received incompatible plasma if concurrent with a massive transfusion (8% vs. 40%, $p = 0.044$). Group AB plasma use was decreased by 96.6%.

CONCLUSION: Use of Group A for emergency release plasma resulted in ABO-incompatible transfusions; however, this had little effect on clinical outcomes. Blood banks reticent to adopt massive transfusion protocols owing to supply concerns may safely use plasma Group A, expanding the pool of emergency release plasma donors. (*J Trauma Acute Care Surg*. 2013;74: 69–75.

LEVEL OF EVIDENCE: Therapeutic study, level IV; prognostic study, level III.

KEY WORDS: Hemostatic resuscitation; plasma; transfusion; blood products; ABO compatibility.

End-points of transfusion

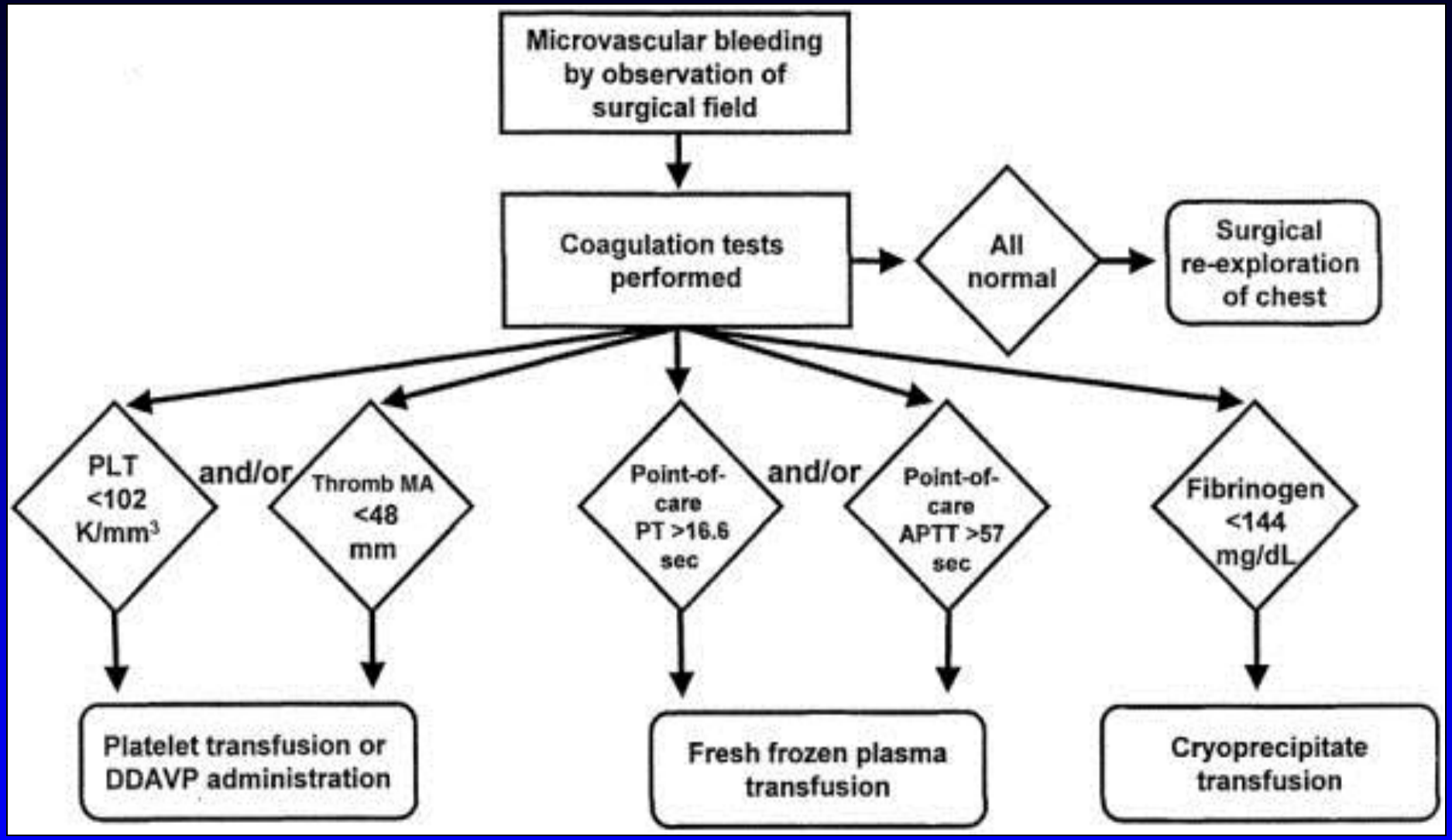
- Criteria for stopping MTP should include both anatomic (control of bleeding) and physiologic criteria (normalizing hemodynamic status).

- Decision to stop should be made by surgeon and anesthesiologist, if still in OR, or the intensivist/ trauma surgeon if in the ICU.

- Specific lab endpoints used to guide further resus should be based on data and clinical experience of those caring for the patient.

TABLE 7. Current Memorial Hermann Hospital Transfusion Recommendations Based on Abnormal r-TEG Values in Bleeding Patients

Laboratory Values	Blood Product Transfusion
ACT > 128	Plasma and RBCs
r-value > 1.1	Plasma and RBCs
k-time > 2.5	Cryoprecipitate / fibrinogen / plasma
α-angle < 56	Cryoprecipitate / fibrinogen / platelets
MA < 55	Platelets / cryoprecipitate / fibrinogen
LY30 > 3%	Tranexamic acid
PT > 18.0	Plasma
aPTT > 35	Plasma
INR >1.5	Plasma
Platelet count < 150×10^9/L	Platelets
Fibrinogen < 180 g/L	Cryoprecipitate / fibrinogen


Microvascular bleeding by observation of surgical field
Coagulation tests performed
All normal
Surgical re-exploration of chest
PLT <102 K/mm3
and/or
Thromb MA <48 mm
Point-of-care PT >16.6 sec
and/or
Point-of-care APTT >57 sec
Fibrinogen <144 mg/dL
Platelet transfusion or DDAVP administration
Fresh frozen plasma transfusion
Cryoprecipitate transfusion

PAPERS OF THE 132ND ASA ANNUAL MEETING

Admission Rapid Thrombelastography Can Replace Conventional Coagulation Tests in the Emergency Department

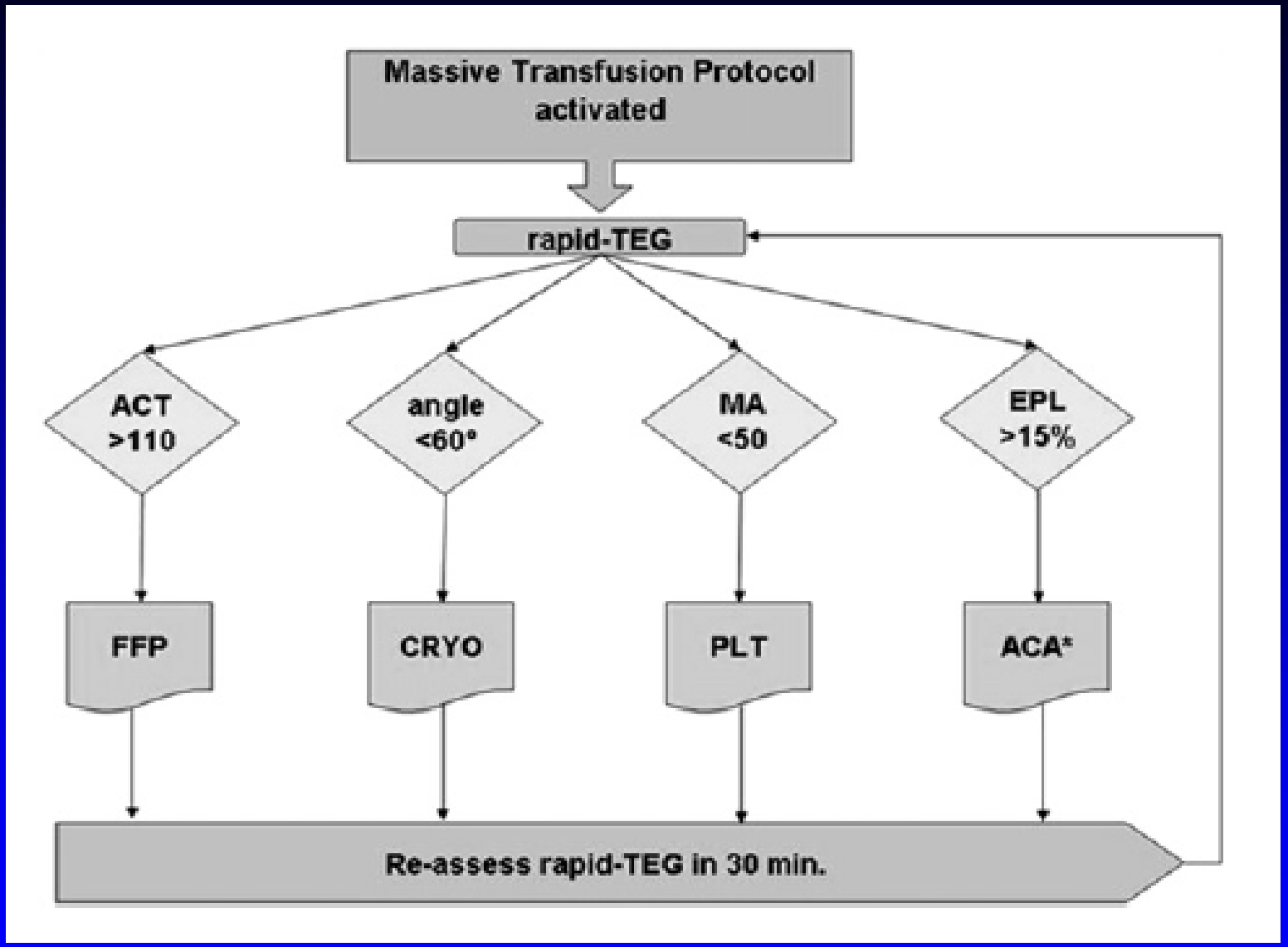
Experience With 1974 Consecutive Trauma Patients

John B. Holcomb, MD, Kristin M. Minei, BS, Michelle L. Scerbo, BS, Zayde A. Radwan, BS, Charles E. Wade, PhD, Rosemary A. Kozar, MD, PhD, Brijesh S. Gill, MD, Rondel Albarado, MD, Michelle K. McNutt, MD, Saleem Khan, MD, Phillip R. Adams, MD, James J. McCarthy, MD, and Bryan A. Cotton, MD, MPH

***Ann Surg* 2012**

Admission Rapid Thrombelastography Can Replace Conventional Coagulation Tests in the Emergency Department

ACT > 128	**Transfuse plasma and RBC**
r-value > 1.1	**Transfuse plasma and RBC**
k-time > 2.5	**Transfuse plasma** **Add cryoprecipitate/fibrinogen if angle also abnormal**
α-angle < 56	**Transfuse cryoprecipitate (or fibrinogen)** **Add platelets if mA is also abnormal**
MA < 55	**Transfuse platelets** **Add cryoprecipitate/fibrinogen if angle also abnormal**
LY-30 > 3%	**Administer tranexamic acid or amino-caproic acid**



Pezold et al Sugery 2011

Reviewing your MTP

- You have to live to have a complication!
- Review hemorrhage/transfusion complications
- Review availability and management of blood products during MTP.
- Review MTP cases with the following complications: coagulopathy on ICU arrival, thrombotic cx, ARDS, TACO/TRALI, death

Reviewing your MTP

- Performance indicators for the process of massive transfusion should include:
  - * Time from calling MTP to 1st unit RBC
  - * Time from calling MTP to 1st unit plasma
  - * Adherence to pre-determined ratios
  - * Informing BB when MTP terminated
  - * Wastage/mishandling blood products

Room for (Performance) Improvement: Provider-Related Factors Associated With Poor Outcomes in Massive Transfusion

Bryan A. Cotton, MD, MPH, Lesly A. Dossett, MD, MPH, Brigham K. Au, BS, Timothy C. Nunez, MD, Amy M. Robertson, MD, and Pampee P. Young, MD, PhD

Background: Massive transfusion (MT) protocols improve survival in patients with exsanguinating hemorrhage. Both the increased plasma to red blood cells (RBC) and platelets to RBC ratios, and the "protocolization" of product delivery seem to be critical components of the reduction in mortality. The purpose of this study was to identify the incidence and impact of MT protocol noncompliance and to intervene in provider-related events associated with poor compliance and outcomes.

Methods: A MT protocol was initiated in 2006 at a Level I trauma center. All cases of protocol activation were reviewed by a multidisciplinary performance improvement (PI) group for compliance and the need for "real-time" protocol adjustments. Educational conferences, Grand Rounds presentations, and individual provider education were performed on a quarterly basis. Compliance of seven measures were evaluated as follows: type and screen sent from emergency department (ED), activation of protocol in ED, activation by trauma attending, administration of 2:3 plasma to RBC, administration of 1:5 platelets to RBC, protocol discontinuation on leaving operating room, and no products wasted. Univariate, multivariate, and time-series analyses were performed.

Results: All 125 MT protocol activations occurring from February 2006 to January 2008 were reviewed. Full compliance for all PI measures during the entire period was 27%. There were no differences in demographics, injury severity, or physiologic scores between patients for whom activations were compliant and those who were noncompliant. Full compliance was an independent predictor of survival (86.7% vs. 45.0%, $p < 0.001$). Both activation of the protocol in the ED and achievement of prespecified ratios of plasma: RBC (2:3) and platelets: RBC (1:5) were independent predictors of 24-hour and 30-day survivals. All PI measures demonstrated improved compliance during the study period with the exception of ED activation. Failure to send type and screen from the ED is an independent predictor of wasted blood products.

Conclusion: Early activation of a MT protocol and achieving predefined ratios was associated with improved survival. ED activation and direct blood bank notification by the trauma attending were associated with a reduction in blood product wastage. A multidisciplinary PI process helps to identify provider/specialty noncompliance and to assess the impact of these factors,

TABLE 1. TEP PI/QI Audit Filters

Activated by the attending trauma surgeon
A type and screen sample is sent from the ED
PRBC and plasma are administered in a ratio of 3:2
PRBC and platelets are administered in a ratio of 5:1
Blood products are received from the blood bank in a timely fashion
Unused blood products are appropriately stored
The TEP is deactivated when the risk of active exsanguinations has passed

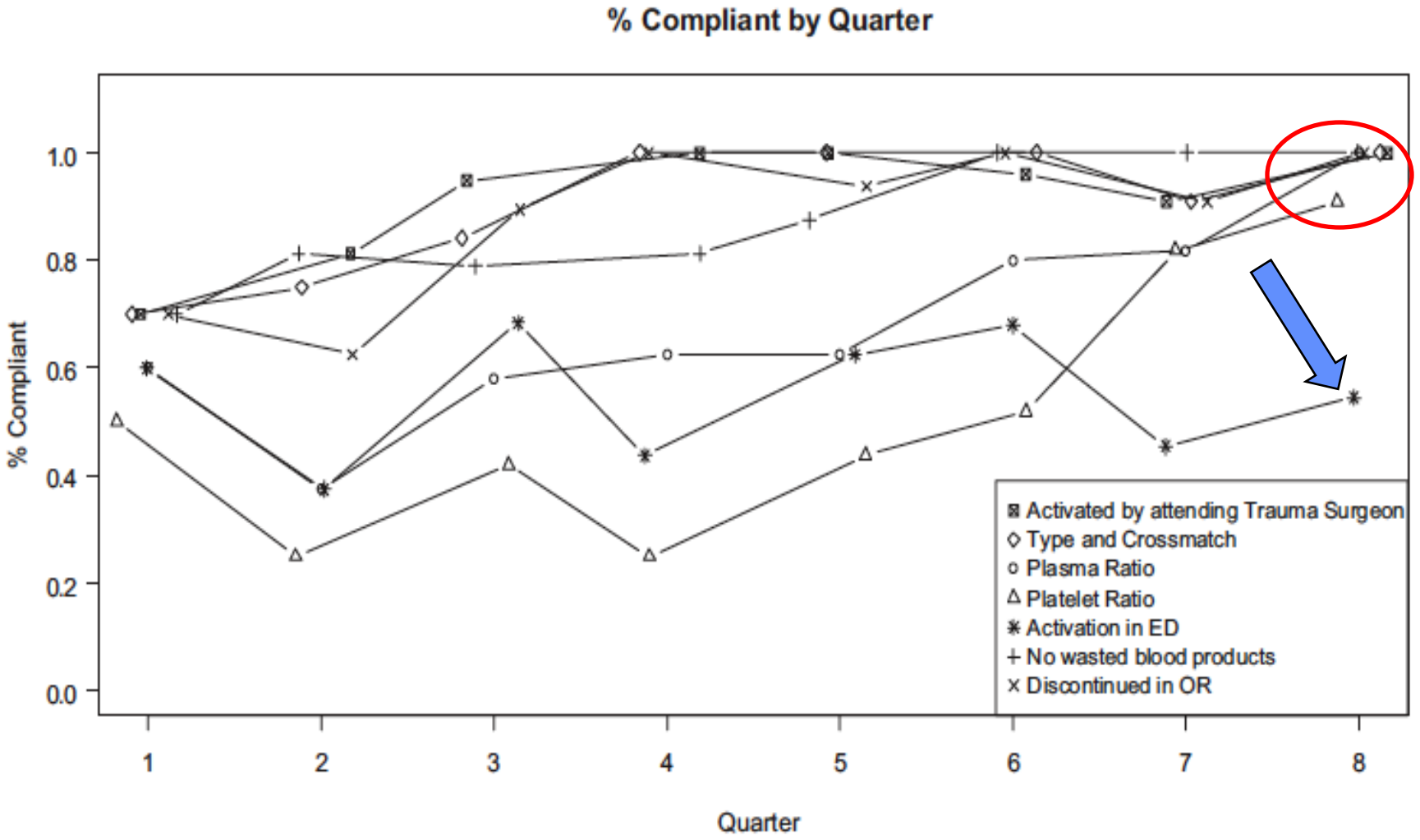
TABLE 4. Outcomes and Blood Utilization by Compliance

	Compliant (n = 34)	Noncompliant (n = 91)	*p*
24-h survival (%)	88.2 ± 5.5	61.5 ± 5.1	0.004
30-d survival (%)	86.7 ± 5.6	45.0 ± 5.2	<0.001
TEP cycles used	2.07 ± 1.0	2.28 ± 1.1	0.605
24-h RBC units	13.7 ± 1.3	19.5 ± 1.2	0.012
24-h plasma units	9.3 ± 0.7	10.7 ± 0.8	0.301
24-h platelets	4.1 ± 0.7	3.6 ± 0.7	0.372

Values are presented as mean ± SD.

TABLE 7. Unadjusted and Adjusted ORs for 30-d Survival by Individual PI Measure Compliance

Variable	Crude OR	95% CI	Adjusted OR	95% CI
ED protocol activation	3.44	1.927–6.157	2.79	1.039–7.497
Plasma:RBC ratio of 2:3	6.91	3.797–12.556	12.28	3.860–39.069
Platelet:RBC ratio of 1:5	7.78	3.814–15.871	3.72	1.392–9.975
Trauma attending activation	2.30	1.402–3.778	0.895	0.960–8.337
ED type and screen sent	2.15	1.315–3.539	0.195	0.023–1.621
Age (yr)	0.98	0.968–0.997	0.98	0.957–1.015
Male	1.12	0.841–1.500	0.75	0.264–2.157
ISS	0.98	0.963–0.0997	0.96	0.941–1.357


% Compliant by Quarter
% Compliant
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
4
5
6
7
8
Quarter
Activated by attending Trauma Surgeon
Type and Crossmatch
Plasma Ratio
Platelet Ratio
Activation in ED
No wasted blood products
Discontinued in OR

Conclusions

- Development and design must be multi-D
- Immediate availability of products
- Ratios of plasma and platelets matter
- Protocolization of the process matters
- Continuous PI/QI process is essential

The evolution of TQIP Best Practices for Massive Transfusion

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