Noncompliance with American College of Surgeons Committee on Trauma recommended criteria for full trauma team activation is associated with undertriage deaths

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BACKGROUND: The appropriate triage of acutely injured patients within a trauma system is associated with improved rates of mortality and optimal resource utilization. The American College of Surgeons Committee on Trauma (ACS-COT) put forward six minimum criteria (ACS-6) for full trauma team activation (TTA). We hypothesized that ACS-COT–verified trauma center compliance with these criteria is associated with low undertriage rates and improved overall mortality.

METHODS: Data from a state-wide collaborative quality initiative was used. We used data collected from 2014 through 2016 at 29 ACS verified Level I and II trauma centers. Inclusion criteria are: adult patients (≥16 years) and Injury Severity Score of 5 or less. Quantitative data existed to analyze four of the ACS-6 criteria (emergency department systolic blood pressure ≤ 90 mm Hg, respiratory compromise/intubation, central gunshot wound, and Glasgow Coma Scale score < 9). Patients were considered to be undertriaged if they had major trauma (Injury Severity Score > 15) and did not receive a full TTA.

RESULTS: 51,792 patients were included in the study. Compliance with ACS-6 minimum criteria for full TTA varied from 51% to 82%. The presence of any ACS-6 criteria was associated with a high intervention rate and significant risk of mortality (odds ratio, 16.7; 95% confidence interval, 15.2–18.3; $p < 0.001$). Of the 1,004 deaths that were not a full activation, 433 (43%) were classified as undertriaged, and 301 (30%) had at least one ACS-6 criterion present. Undertriaged patients with any ACS-6 criteria were more likely to die than those who were not undertriaged (30% vs. 21%, $p = 0.001$). Glasgow Coma Scale score less than 9 and need for emergent intubation were the ACS-6 criteria most frequently associated with undertriage mortality.

CONCLUSION: Compliance with ACS-COT minimum criteria for full TTA remains suboptimal and undertriage is associated with increased mortality. These data suggest that the most efficient quality improvement measure around triage should be ensuring compliance with the ACS-6 criteria. This study suggests that practice pattern modification to more strictly adhere to the minimum ACS-COT criteria for full TTA will save lives. (*J Trauma Acute Care Surg.* 2018;84: 287–294. Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Care management, level III.

KEY WORDS: TQIP; activation criteria; undertriage; intervention rate; guideline concordant care.

The appropriate triage of acutely injured patients within a trauma system is associated with improved rates of mortality and optimal resource utilization.[1,2] Given this finding, there is intense interest in identifying the ideal patient populations for each tier of trauma team activation (TTA) to optimize trauma center triage rates while maintaining efficiency. However, there is minimal data on actual compliance with published TTA criteria and potential barriers to compliance. This represents a potential quality gap.

The American College of Surgeons Committee on Trauma (ACS-COT) has put forward six minimum criteria (ACS-6) for full TTA in the *Resources for Optimal Care of the Injured Patient (6th Edition)*.[3]

1. Confirmed blood pressure less than 90 mm Hg at any time in adults.
2. Gunshot wounds to the neck, chest, abdomen, or extremities proximal to the elbow/knee.
3. Glasgow Coma Scale (GCS) score less than 9 with mechanism attributed to trauma.
4. Transfer patients from other hospitals receiving blood to maintain vital signs.
5. Intubated patients transferred from scene or patients who have respiratory compromise or are in need of an emergency airway.
6. Emergency physician's discretion.

These criteria form the foundation for institutional TTA criteria at many ACS-COT–verified Level I and II trauma centers. Highest level TTA has been shown to be associated with increased mortality risk and need for emergent intervention.[2,4,5] However, beyond these guidelines, there is a lack of any formal written requirements for institutional TTA policy.

Trauma centers are requested to structure their activation criteria with the goal of reducing undertriage rates to less than 5%. However, the corresponding rate of overtriage to tolerate and necessary to accomplish this goal is not known. Significant rates of overtriage can result in poor trauma center efficiency and high resource consumption beyond what is required to treat a lesser-injured patient.[2] A formal definition of undertriage does not exist. However, many trauma centers use the trauma triage matrix put forth by Cribari, which defines undertriage as a non-highest level TTA in a patient with an Injury Severity Score (ISS) greater than 15.[3]

In this study, we examined the compliance rate of ACS-COT–verified Level I and II trauma centers in Michigan with the ACS-6 triage criteria. We evaluated the association of these criteria with trauma patient mortality and rates of emergent intervention. Our hypothesis was that ACS-COT–verified trauma center compliance with these criteria is high, and is associated with low undertriage rates and improved overall mortality.

METHODS

Data Collection

The Michigan Trauma Quality Improvement Program (MTQIP) is comprised of all 29 ACS-COT verified Level I and II trauma centers in Michigan.[6] The MTQIP uses a data definitions manual, based upon the National Trauma Data Standard, which is published online and updated annually.[7] Trauma

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This study was presented at the 76th annual meeting of American Association for the Surgery of Trauma Meeting, September 14–17, 2017, in Baltimore, Maryland.

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registrars and data abstractors from participating MTQIP centers undergo training in MTQIP and National Trauma Data Standard data definitions.[8] Data are transmitted from the trauma registry at participating hospitals to the coordinating center at 4-month intervals. The inclusion criteria applied to form the MTQIP patient cohort are as follows:

– Age ≥ 16 years
– At least one valid trauma International Classification of Diseases, 9th Revision, Clinical Modification code in the range of 800 to 959.9. Excluding late effects (905–909.9), superficial injuries (910–924.9), and foreign bodies (930–930.9).
– Primary mechanism of injury classified as either blunt or penetrating:
• Blunt is defined as an injury where the primary E-code is mapped to the following categories: fall, machinery, motor vehicle traffic, pedestrian, cyclist, and struck by against.
• Penetrating is defined as an injury where the primary E-code is mapped to the following categories: cut/pierce and firearm.

– Calculated ISS ≥ 5.
– Emergency department (ED) discharge disposition and hospital discharge disposition must be known.

All ISSs were derived from registrar abstracted and recorded Abbreviated Injury Scale (AIS) 2005 codes with 2008 updates.

This study was submitted to the University of Michigan Medical School Institutional Review Board and given a determination of "not regulated" status as a quality assurance and quality improvement clinical activity.

Analysis

Data were abstracted from the MTQIP database, and the study cohort consists of patients admitted at participating trauma centers between January 1, 2014, and December 31, 2016. Excluded patients for the study are those directly admitted, missing data, or with no signs of life at initial evaluation (ED systolic blood pressure [SBP], 0; pulse, 0; GCS score, 3).[9] The TTA status was divided into four categories: full, partial, trauma consult, and no activation. Data collected reflect the highest tier of activation status and account for activation upgrades. Quantitative data existed to analyze four of the six ACS-6 criteria (ED SBP, ≤ 90 mm Hg, respiratory compromise or emergent intubation, central gunshot wound (cGSW); and GCS score, < 9). Intervention was defined as receiving one or more of the following: transfusion of greater than four units of blood within 4 hours of arrival, emergent central line insertion, emergent operation, emergent angiography, emergent intubation, emergent chest tube placement, or placement of a cerebral monitor. Patients were considered to be undertriaged if they had major trauma (ISS > 15) and did not receive a full TTA. The primary outcome measure was compliance with ACS-6 criteria. Secondary outcome measures were: undertriage rate, emergent intervention rate, and criteria-specific trauma mortality stratified by TTA status.

Statistical Methods

Statistical analysis was performed using Stata MP, version 14 (StataCorp, College Station, TX). Statistical significance was defined as a p value less than 0.05. Data are expressed as the mean ± standard deviation for continuous variables and proportions for categorical variables. We used χ^2 test to identify differences in outcomes for categorical variables. To evaluate activation criteria, intervention, and undertriage effects, a logistic regression model was created for the primary outcome (mortality) as the dependent variable. Comparison of high-compliance trauma centers versus low-compliance trauma centers was performed using a multivariable logistic regression model adjusted for patient factors (sex, age, race), and injury severity factors (ISS, GCS, and blood products received) with mortality as the dependent variable.

RESULTS

51,792 patients were identified, which satisfied our inclusion and exclusion criteria. Patient characteristics are shown for four of the six measurable categories of ACS-6 activation criteria present in the data (Table 1). Demographics were similar for patients with hypotension, respiratory distress, or GCS score less than 9; however, patients who received a cGSW were more likely to be younger, male, black, and less likely to have private insurance. Comparing injury severity between activation criteria, patients with a low GCS score and those who were in respiratory distress were noted to have a significantly higher ISS than patients with a cGSW or SBP less than 90 mm Hg. Surprisingly, over 50% of hypotensive and cGSW patients had an ISS less than 15.

Rates of compliance with ACS-6 activation criteria are listed in Table 2. Twelve percent of the patients had one or more ACS-6 criteria present. Only 66% of patients with at least one ACS-6 criterion received a full TTA. Compliance was poorest for hypotensive patients (51%) compared with intubation (75%), cGSW (75%), and initial GCS score < 9 (82%). Full TTA was rare in patients without the presence of at least one ACS-6 criterion (5%, 2,424 patients).

The presence of an ACS-6 criterion was a good predictor of the need for emergent intervention, with 79% of patients receiving an intervention, and 35% requiring an emergent operation. Undertriaged patients with any ACS-6 criteria were more likely to die than those who were not undertriaged (30% vs. 21%, $p = 0.001$). This result was most pronounced in patients with a GCS score less than 9, where undertriage was associated with a 47% mortality compared with 40% for those not undertriaged ($p = 0.02$).

We analyzed criteria-specific trauma mortality for each level of TTA (Table 3). Patients with any ACS-6 criteria or any intervention had significantly higher mortality for each level of trauma activation than patients without. We noted a drop off in trauma patient mortality between a full TTA and a partial TTA. However, instead of a continued decline in mortality for trauma consultations or nonactivations, there was a spike in trauma mortality for the lowest two levels of TTA. This is even though these patients (trauma consults and nonactivations) had a lower mean ISS compared with full and partial TTAs. These results were more exaggerated for patients with major trauma (undertriages), or when combining patients who had at least one ACS-6 criterion and the need for an intervention (Table 4).

To evaluate the potential impact of improved compliance on outcomes, trauma centers were divided into two groups:

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TABLE 1. Patient Characteristics

Characteristics	ACS-6 Criteria				Any ACS-6 Criteria	No ACS-6 Criteria
	SBP ≤ 90 mmHg	Intubation	Central GSW	GCS Score < 9		
N	1,346	3,459	1,931	2,475	6,080	45,712
Age, %						
18–25 years old	14	21	40	22	24	10
26–45 years old	22	29	44	29	31	16
46–65 years old	32	28	13	27	25	25
66–75 years old	12	10	2	9	8	14
>75 years old	20	13	1	13	12	35
Male, %	64	74	88	73	75	53
Race, %						
White	75	74	24	75	62	83
Black	23	22	73	20	35	14
Other	3	4	3	5	4	3
Private insurance, %	46	51	33	51	46	34
Total GCS score, %						
14–15	66	19	77	0	45	88
9–13	9	15	5	0	10	3
3–8	21	61	15	100	41	0
Missing	4	4	4	0	4	8
ISS, %						
5–15	52	27	62	24	45	86
16–24	21	24	18	22	21	11
25–35	17	36	18	38	26	3
>35	11	13	2	16	9	0.3
AIS head/neck > 2, %	27	64	18	71	44	18
AIS chest > 2, %	35	37	23	37	31	15
AIS abdomen > 2, %	19	12	22	10	14	3
AIS extremity > 2, %	33	17	35	15	25	32
ED SBP, %						
≥91 mm Hg	0	84	86	83	75	97
61–90 mm Hg	83	9	8	8	18	0
≤60 mm Hg	17	3	3	3	4	0
ED pulse, %						
≥121 bpm	14	18	13	17	15	3
51–120 bpm	80	76	82	75	80	93
≤50 bpm	5	3	2	4	2	1

high- and low-compliance centers, using the mean overall compliance rate of 63% as the dividing point. Using multivariable regression analysis, high compliance centers demonstrated improved risk-adjusted in-hospital mortality (odds ratio, 0.8; $p = 0.02$) compared with low-compliance trauma centers (Fig. 1). To investigate the effects of improved compliance on undertriage and overtriage rates, we evaluated the influence of actual activation compliance versus a theoretical 100% triage activation compliance rate. We found that with 100% compliance, undertriage would decrease by 12% (or 728 patients), and the overtriage rate would increase by 45% (or 1,311 patients) over the study period (Fig. 2).

TABLE 2. Compliance With ACS-6 Criteria

ACS-6 Activation Criteria	Incidence	Full Activation	Intervention	Undertriage	Undertriage Mortality
	% (N)	% (N)	% (N)	% (N)	% (N)
Any	12 (6,080)	66 (4,041)	79 (4,781)	12 (728)	30 (217)
None	88 (45,712)	5.3 (2,424)	15 (6,746)	12 (5,572)	4 (216)
SBP ≤ 90 mm Hg	2.6 (1,346)	51 (685)	63 (848)	12 (157)	15 (24)
Intubation	7 (3,459)	75 (2,606)	100 (3,459)	15 (514)	35 (179)
Central GSW	3.7 (1,931)	75 (1,453)	67 (1,285)	2.2 (42)	24 (10)
Total GCS score < 9	4.8 (2,475)	82 (2,037)	92 (2,271)	11 (274)	47 (130)

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DISCUSSION

Although work has focused on identifying the appropriate criteria for each tier of TTA, very little is known about compliance rates with these national guidelines. In this study, we identified a fairly low compliance rate of 66% for highest TTA tier for patients with any ACS-6 criteria. Patients with at least one positive ACS-6 criterion were significantly more likely to receive an intervention, with over a third requiring an emergent operation. Furthermore, we identified two high-risk groups: patients with respiratory distress and patients with GCS score less than 9 who are at the greatest risk for mortality (approaching 50%) if not appropriately triaged.

We could not specifically answer the question of whether the problem of undertriage originates within the prehospital setting or is due to failure of ED personnel responsible for TTA to properly recognize and appropriately triage critically injured trauma patients. We were hindered in our ability to identify two of the six ACS-6 criteria in the data. However, identification of positive results for these two ACS-6 criteria would have lowered the compliance rate of highest tier TTA even further. The high rate of trauma consultations and nonactivations for patients with ACS-6 criteria present suggests that a significant ED component of noncompliance exists. Barriers preventing the identification of these patients (resulting in nonactivations) or preventing a trauma activation (when an ACS-6 criterion is present) need to be investigated.

The undertriage of trauma patients is known to be a significant risk factor for increased mortality and worse outcomes.[2,10–12] Despite a recommended undertriage rate of less than 5%, current published undertriage rates approach 35% to 40%.[12,13] In contrast, we identified an absolute undertriage rate of 12% within the 29 MTQIP hospitals. When comparing undertriage rates between patients with and without ACS-6 criteria, surprisingly both were at 12%. Presence of an ACS-6 criterion was a significant predictor of the need for emergent intervention and higher risk for mortality. This finding is in concordance with previously published research.[2,4,5]

Examination of undertriage mortality exposed a potential target for quality improvement efforts. Within the group of patients with at least one ACS-6 criterion who did not undergo full TTA, the mortality rate was 30%. This is in contrast to the mortality rate of rate of 21% in patients with at least one ACS-6 criterion and full TTA and 4% in patients with no ACS-6 criteria who were identified as having "major" trauma (ISS > 15). The majority of patients who were undertriaged did not exhibit any of the ACS-6 criteria (88%).

These findings have significant implications for trauma system triage process improvement. Given the low mortality (4%) associated with undertriage of patients without evidence of any ACS-6 criteria, it could be argued that trauma centers should not focus on reducing their absolute undertriage rate. They should, instead, make a particular effort to increase their rate of highest TTA in patients that have the presence of one or more ACS-6 criteria. Utilization of ISS greater than 15 as a stand-alone definition of major trauma, without the presence of at least one ACS-6 criterion, is not likely to identify the select

TABLE 3. Criteria-Specific Trauma Mortality Per Activation Status

	Full	Partial	Consult	No Activation
	% (N)	% (N)	% (N)	% (N)
All patients	17 (1,130)	2 (243)	2 (379)	3 (382)
ACS-6				
Any	26 (1,057)	10 (110)	21 (119)	19 (72)
None	3 (73)	1 (133)	2 (260)	2 (310)
SBP ≤ 90 mm Hg	30 (208)	6 (15)	11 (24)	10 (18)
Intubation	35 (915)	19 (96)	35 (82)	39 (47)
Central GSW	19 (278)	0 (0)	11 (11)	5 (3)
Total GCS score < 9	42 (852)	25 (54)	49 (67)	41 (36)
Intervention				
Any	23 (1,049)	6 (173)	9 (178)	8 (136)
TBI	31 (231)	15 (38)	14 (42)	16 (27)
Chest tube	25 (333)	5 (30)	4 (17)	9 (9)
Intubation	35 (915)	19 (96)	35 (82)	39 (47)
Central line	31 (423)	14 (86)	22 (97)	25 (62)
Angiography	14 (64)	4 (11)	8 (10)	1 (1)
Operative	24 (171)	6 (6)	4 (1)	0 (0)
Undertriage	N/A	5 (156)	7 (162)	12 (115)
Any ACS-6 + any intervention	28 (1,000)	14 (104)	29 (96)	31 (58)
Any ACS-6 + undertriage	N/A	20 (87)	43 (86)	46 (44)
Any intervention + undertriage	N/A	10 (128)	16 (105)	21 (58)
Any ACS-6 + any intervention + undertriage	N/A	22 (85)	44 (74)	50 (38)

TABLE 4. Mortality Regression analysis

	Odds Ratio	95% CI	*p*
Any ACS-6	16.7	15.2–18.3	p < 0.001
Any intervention	10.2	9.3–11.2	p < 0.001
Undertriage	1.9	1.7–2.1	p < 0.001
Any ACS-6 + any intervention	18.8	17.1–20.6	p < 0.001
Any ACS-6 + undertriage	10.9	9.2–12.8	p < 0.001
Any intervention + undertriage	3.9	3.4–4.4	p < 0.001
Any ACS-6 + any intervention + undertriage	11.7	9.8–14.0	p < 0.001

95% CI, 95% confidence interval.

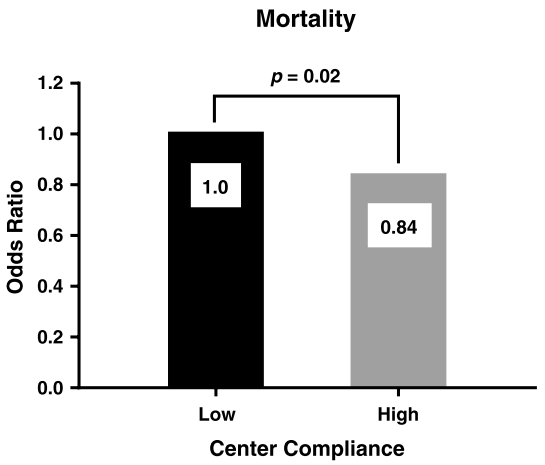

Figure 1. High compliance with trauma triage activation criteria is associated with improved risk-adjusted in-hospital mortality.

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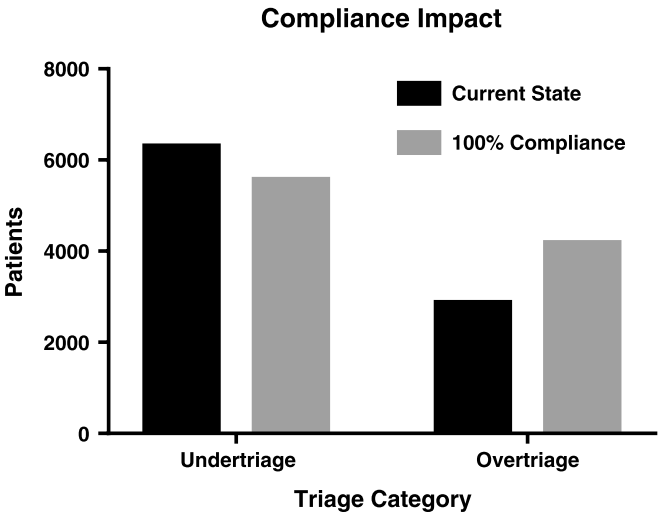

Figure 2. Improved compliance associated with reduced undertriage and increased overtriage rates.

group of injured patients at higher risk of mortality. Instead, our data suggest that compliance with the highest level physiologic criteria for TTA is the most efficient quality improvement metric to assure appropriate triage and TTA.

There are several possible explanations for the low-compliance rate with ACS-6 criteria for TTA. The first is failure to appropriately identify the presence of a criterion. For example, GCS score is prone to miscalculation, especially if the scene or initial trauma survey is being done by trainees. Another potential explanation for the low-compliance rate could be that despite the appropriate recognition of criteria, centers may believe that patients can be adequately cared for within their current level of TTA. For example, if a patient became hypotensive during a partial TTA, the provider may feel that adequate support is already available and elect to not upgrade to a full TTA. Another possible explanation could be reassuring vital signs despite the presence of an ACS-6 criterion, in cases of respiratory distress or a low GCS score.

Similar results were identified in a study specifically evaluating compliance with institutional TTA criteria. This single-center study, performed in China, identified a 72% compliance rate with their institutional TTA criteria.[11] The authors found contributing factors for not receiving a full TTA were: elderly, falls, borderline SBP, GCS score of 9 to 13, and extremes of respiratory rate. Similarly, they identified that patients who did not receive appropriate TTA triage had increased mortality. The authors hypothesized that key process factors related to undertriage included: trauma leader judgment, diagnostic confusion surrounding elderly falls (trauma vs. cerebrovascular accident), and the presence of qualitative trauma triage criteria (e.g., "hemodynamic instability").

An important factor to consider with improved TTA compliance is its effect on overtriage rates, which would likely increase. Initial reports evaluating overtriage effect on mortality were conflicting, with some reports identifying a positive linear relationship with mortality and others identifying no impact on mortality.[14–16] More recent mathematical modeling analyses of casualty events have confirmed that overtriage rates as high as 75% are actually protective for events with a low burden of traumatic injuries (≤5 patients). This is especially important for civilian trauma, where the burden of traumatic injuries is low. We identified that with a 100% MTQIP TTA compliance, overtriage rates during this 3-year study period would increase by 1,311 patients, which equates to approximately 15 additional overtriaged patients per MTQIP trauma center per year. This slight increase in trauma resource utilization may be worthwhile given the likely reduction in undertriage and trauma mortality that would potentially be seen with improved TTA compliance. Finally, while high compliance trauma centers had improved outcomes, we were unable to determine if better compliance rates were the responsible mechanism. It is possible that high compliance with TTA is a surrogate marker for higher performing trauma centers that deliver better overall and timely care.

This study does have several important limitations. First, this study is a retrospective analysis using data which was not specifically recorded to answer the question asked in our study. As with all trauma registry-based studies, there is the possibility of missing or inaccurate data. In addition, two of our activation criteria are based on the lowest recorded value during the prehospital and ED resuscitation, SBP, and GCS. Hypotension can be transient or sustained, and we have no indication which is represented in our database. In addition, GCS can be prone, especially at teaching facilities, to miscalculation.

CONCLUSION

Compliance with the ACS-6 minimum criteria for full TTA remains suboptimal and is associated with increased mortality. Our data suggests that the most efficient quality improvement metric to assure appropriate injured patient triage should be for trauma centers to focus on their compliance with the ACS-6 criteria for TTA. Advocating practice pattern modification to more strictly adhere to the minimum ACS-6 criteria for full TTA should save lives.

AUTHORSHIP

C.J.T. participated in the study design, data collection, data analysis, data interpretation, writing, and critical revision. W.E.V.K. participated in the data collection, writing, critical revision. J.N.M. participated in the study design, data collection, data interpretation, writing, critical revision. M.J.D. participated in the data interpretation, writing, critical revision. M.R.H. participated in the study design, data collection, data analysis, data interpretation, writing, and critical revision.

DISCLOSURE

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REFERENCES

1. Hupert N, Hollingsworth E, Xiong W. Is overtriage associated with increased mortality? Insights from a simulation model of mass casualty trauma care. *Disaster Med Public Health Prep*. 2007;1(Suppl 1):S14–24.

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2. Lehmann RK, Arthurs ZM, Cuadrado DG, Casey LE, Beekley AC, Martin MJ. Trauma team activation: simplified criteria safely reduces overtriage. *Am J Surg*. 2007;193(5):630–4; discussion 4–5.
3. American College of Surgeons Committee on Trauma. Resources for optimal care of the injuried patient. *The Committee, Chicago (IL)*. 2014.
4. Tinkoff GH, O'Connor RE. Validation of new trauma triage rules for trauma attending response to the emergency department. *J Trauma*. 2002;52(6): 1153–8; discussion 8–9.
5. Sava J, Alo K, Velmahos GC, Demetriades D. All patients with truncal gunshot wounds deserve trauma team activation. *J Trauma*. 2002;52(2):276–9.
6. Hemmila MR, Jakubus JL, Cain-Nielsen AH, Kepros JP, Vander Kolk WE, Wahl WL, Mikhail JN. The Michigan Trauma Quality Improvement Program: results from a collaborative quality initiative. *J Trauma Acute Care Surg*. 2017;82(5):867–76.
7. MTQIP Website. www.mtqip.org. Accessed on August 11, 2017.
8. Hemmila MR, Jakubus JL. Trauma quality improvement. *Crit Care Clin*. 2017;33(1):193–212.
9. Calland JF, Nathens AB, Young JS, Neal ML, Goble S, Abelson J, Fildes JJ, Hemmila MR. The effect of dead-on-arrival and emergency department death classification on risk-adjusted performance in the American College of Surgeons Trauma Quality Improvement Program. *J Trauma Acute Care Surg*. 2012;73(5):1086–91; discussion 91–2.
10. Petrie D, Lane P, Stewart TC. An evaluation of patient outcomes comparing trauma team activated versus trauma team not activated using TRISS analysis. Trauma and Injury Severity Score. *J Trauma*. 1996;41(5):870–3; discussion 3–5.
11. Rainer TH, Cheung NK, Yeung JH, Graham CA. Do trauma teams make a difference? A single centre registry study. *Resuscitation*. 2007;73(3):374–81.
12. Staudenmayer K, Lin F, Mackersie R, Spain D, Hsia R. Variability in California triage from 2005 to 2009: a population-based longitudinal study of severely injured patients. *J Trauma Acute Care Surg*. 2014;76(4):1041–7.
13. Xiang H, Wheeler KK, Groner JI, Shi J, Haley KJ. Undertriage of major trauma patients in the US emergency departments. *Am J Emerg Med*. 2014;32(9):997–1004.
14. Frykberg ER. Medical management of disasters and mass casualties from terrorist bombings: how can we cope? *J Trauma*. 2002;53(2):201–12.
15. Severance HW. Mass-casualty victim "surge" management. Preparing for bombings and blast-related injuries with possibility of hazardous materials exposure. *N C Med J*. 2002;63(5):242–6.
16. Aylwin CJ, Konig TC, Brennan NW, Shirley PJ, Davies G, Walsh MS, Brohi K. Reduction in critical mortality in urban mass casualty incidents: analysis of triage, surge, and resource use after the London bombings on July 7, 2005. *Lancet*. 2006;368(9554):2219–25.

DISCUSSION

Dr. Robert J. Winchell (New York City, New York): Good morning, Dr. Cornwell, Dr. Victorino, members and guests. I think this is a really important study.

You might argue not only because it confirms some of our most closely-held beliefs within this group and, largely, in the trauma world: that, actually, trauma team activation works, that all of this stuff we do really matters and that if you activate the full trauma team you save lives. And this is actually evidence that supports that.

I think even more than the primary indication, if you look at the subgroup analysis it shows that the mortality decreases for both levels of trauma team activation and it goes up for the consults and the people that were not activated on, so we make a difference.

I think the second important point from this study is that the physiologic criteria really are the best indicators of what a trauma team is going to do and when you need the trauma team that the criteria that were put together by the CDC that we've largely had or used at the hospital level really do work for finding these important patients and that we really need to link the CDC field triage with the hospital-level activation to make sure that it works, that we are, in fact, getting the team there for the people that matter.

Another one I think it shows very clearly is that post-hoc analysis with ISS is not a really good way to determine whether we should or shouldn't have activated the trauma team, that the physiologic criteria matter.

And another piece of data that was in the manuscript but not shown here is that if you actually look at under-triage/over-triage patients without the physiologic criteria their mortalities are identical.

So, in fact, the post-hoc analysis where many centers focus their time is not really where the money is. And where the money is is getting us to comply with the things that we know work but which the evidence clearly shows we don't comply with at a rate that we really ought to.

And I don't know if that's because people just don't like to think things are as bad as they really are, or what those pieces are but, clearly, there is room for improvement.

So my questions for the authors.

We all know the trauma team matters. Why does the trauma team matter? Is this strictly a time criteria and that the full team activation gets things done faster and that goes incrementally down the line? Do you have data to look into that?

Or does, in fact, the team composition matter? And does having the higher level of cognitive input from more senior people, implied by a full trauma team activation, actually make a difference independent of time? And is there a way to tease that out?

And then, from your perception, why don't we follow these obvious criteria that we all know in our DNA matter? And is that because it happens before the trauma team gets there? Are those factors that can be influenced because that's clearly some place we can make a difference?

And then, finally, how are you guys in Michigan going to use this data to get everybody better and make them toe the line?

My thanks to the authors for the opportunity to review their manuscript and to the association for the privilege of discussing it.

Dr. Robert A. Maxwell (Chattanooga, Tennessee): Great paper. I was wondering within your collaborative you've found out how the high-compliance centers are able to get it done. What are they doing that allows them to be compliant with this?

Dr. James W. Davis (Fresno, California): One, I agree with everything Dr. Winchell said. Two, we've never validated over- and under-triage in the trauma center. It's a system issue.

Three, I think your discussion about being compliant with the physiologic criteria is spot-on and I agree that we should change how we rate trauma centers based on that. So those are my comments.

My question is concerning the mortalities. When did they die? Did they die because of delays in their care from being under-triaged? Or did they die from the underlying injury? How many of these were severe head injuries transferred in on a ventilator that had a poor outcome?

Dr. Forrest Fernandez (Reading, Pennsylvania): I really appreciated your paper. Very appropriate and timely study.

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My question is with regards to the geriatric population. You had mentioned that you had accounted for age. Certainly under-triage is extremely common in this population.

The worry I have about the idea of sort of making all of these patients formal activations is that they have a very low incidence of needing time-dependent intervention and that the price of over-triage, Number 1, is going to do a large amount of over-triage.

But the price really isn't to those patients, it's to all the other sick patients that you're seeing and treating in the unit overnight. So what – could TQIP be used to measure this process with the idea that maybe over-triaging centers might actually have poorer outcomes with their sick patient populations?

Dr. Michael Foreman (Dallas, Texas): I'm curious why the authors chose to exclude patients with an ISS less than five. The last I checked in NTDB the Midwest Region actually has a median ISS of either six or seven which is compared to the rest of the region's median ISS of nine. I am wondering what effect cutting that patient population had and if they performed a sensitivity analysis to examine that effect.

Dr. Michel B. Aboutanos (Richmond, Virginia): I also enjoyed your presentation. I have a similar question with regard to the geriatric, especially if emphasis is on physiological criteria.

When it comes to geriatric, as you know, it's a different physiology. With that did you stratify by that influence how we should be triaging? Thank you.

Dr. Nasim Ahmed (Neptune, New Jersey): Nasim Ahmed from New Jersey. Now, the trauma activation is basically based on the pre-hospital information. ISS score is calculated after the fact when the patient is in-patient.

So I think the problem with under-triage/over-triage is ISS score. You should just eliminate the ISS score and strictly adhere to the physiological parameters. I think that's the problem.

Dr. David J. Dries (Saint Paul, Minnesota): A quick question. The toughest patients for us are the ones that are "dropped off" by a "friend". We have no advanced warning, they are put in a room, and no one knows what is going on with them. What we have is a slow, confusing resuscitation. Can you account for that in your data? Do you have some comments? Thank you.

Dr. Matthew J. Delano (Ann Arbor, Michigan): Thank you for all of those questions. I'll try to go down through these in order and thanks to Dr. Winchell for that nice commentary.

So why does the trauma team matter? As we know, patients aren't just a conglomeration of their ISS scores which, as somebody pointed out, are figured after the fact, not figured out pre-hospital in most cases.

So the trauma team does matter because the trauma team, in most places, has a complex make-up of several providers, at minimum probably an extender, a nurse, or two, and a physician. And those multiple sets of eyes and multiple biases are going to look at patient physiology different than just an ISS.

And we, wholeheartedly, agree that looking at the physiologic parameters are much more indicative than certainly types of injuries or other classifications and, really, looking at what patients need care.

As to why we excluded patients with an ISS of less than five, because in our data base we find that a lot of those patients have injuries which are insignificant and have hospital stays which are just short, you know, hour or two and never really have any statistical impact on needing interventions and things. That's why those patients are excluded.

It's not to create so-to-speak underlying noise in the rest of the data set. Although data on those patients is collected, it was excluded for those reasons.

So how do we improve trauma activation compliance to physiologic parameters? Well, one of the reasons is, as someone on the left indicated, that a lot of these patients, especially in our tertiary care center and others across the state, are transferred in.

They come from rural areas. They come by, you know, plane, train, and automobile. And they arrive in your hospital and somebody maybe has some information on them and they get put in a corner and they sit there for an hour.

They decompensate and then, all of a sudden, they may or may not get activated. Or they have therapies which are already underway and people assume that they've already been treated in triage when, in reality, they haven't. They're there to get triaged to a trauma center.

And so we think that, a couple of things, education of the ED staff and the first responders, people that immediately capture these patients, is going to be Goal Number 1.

We think that improving our dataset to include ED discretion for activation will give us an insight into where we are going awry early and not complying.

And I think including prior blood transfusions in the pre-hospital setting or in the transfer setting will help give us a more powerful tool to determine some of the other physiologic criteria that we're missing.

I think that in order to use this to really improve mortality without exhausting our resources and over-triaging everybody, I think that initially you're going to have to find a balance between over-triage and under-triage.

And certainly, we've found with other things such as resuscitation that sometimes that takes a while. It may take an over-triage while – months to years, even – to figure out where we can ratchet back and where we can't.

But I think if it saves lives, then we have to have a goal-directed way to try to improve appropriate triage to not exhaust our resources but yet save the lives that matter.

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