PEDIATRIC EMERGENCY MEDICINE CRITICAL ARTICLE REVIEW (PEMCAR)	
QUESTION	In trauma patients, 16-60 years of age, presenting to a level one trauma center, is a prehospital narrow pulse pressure (< 30 mmHg) with a systolic blood pressure of > 90 mmHg, associated with in-hospital mortality, need for a resuscitative thoracotomy, need for an emergent intervention (NFEI), need for a trauma intervention (NFTI) and mortality?
TYPE	Harm
TOPIC	Trauma: Hemorrhagic Shock
DATE	January 2022
REVIEWER	Michael Mojica, MD
CITATION	Schellenberg M, Owattanapanich N, Getrajdman J, Matsushima K, Inaba K. Prehospital Narrow Pulse Pressure Predicts Need for Resuscitative Thoracotomy and Emergent Intervention After Trauma J Surg Res. 2021 Dec; 268:284-290 (Epub 2021 Aug 12), PubMed ID: 34392182

STUDY DEFINITIONS	
POPULATION	Inclusion: Age 16-60 years Exclusion: Age < 16 (lower BP range) or < 60 years (higher BP range) Unrecorded prehospital vital signs Transferred from an outside hospital On-scene cardiac arrest Missing discharge disposition Setting: Single Level I Trauma Center (Trauma registry data), (1/2008-5/2020)
EXPOSURE	Narrow Pulse Pressure (PP): PP < 30 mmHg AND systolic BP ≥ 90 mmHg (Pulse pressure = Systolic BP – Diastolic BP) Hypotensive: Systolic BP < 90 mmHg (regardless of pulse pressure)
NO EXPOSURE	Normotensive: Systolic BP ≥ 90 mmHg AND Pulse Pressure ≥ 30 mmHg
OUTCOME	• Resuscitative thoracotomy* • Need For Emergent Intervention (NFEI): See definition below* • Need For Trauma Intervention (NFTI): See definition below* • Mortality* • Arrival in cardiac arrest • Central line insertion • Chest tube placement • Hospital and intensive care unit length of stay • Ventilator days *Primary outcomes for multivariable logistic regression analysis
	Need For Emergent Intervention (NFEI): Transfer directly from the ED to the: • Operating room • Interventional radiology Need For Trauma Intervention (NFTI): ≥ 1 of the following: • Packed red cell transfusion < 4 hours after arrival • Need for operative intervention or angioembolization < 90 minutes of arrival • Admission to the ICU from the ED with LOS ≥ 3 days • Mechanical ventilation initiated within 72 hours of arrival

	• Mortality within the first 60 hours.
DESIGN	Observational: Retrospective Cohort

HOW SERIOUS WAS THE RISK OF BIAS? (COHORT STUDY)	
DID THE EXPOSED AND CONTROL GROUPS START AND FINISH WITH THE SAME RISK FOR THE OUTCOME?	
Were patients similar for prognostic factors that are known to be associated with the outcome (or were adjustments made using statistical methods)	No (Table 1, 2). Patients with a narrow pulse pressure or hypotensive were more likely to have penetrating trauma than normotensive patients. Injury severity scores for narrow pulse pressure patients were intermediate between normotensive patients and hypotensive patients. Multiple logistic regression analysis was used to account for differences in potential confounders.
Were the circumstances and methods for detecting the outcome similar?	Yes. Data was collected prospectively as part of an institutional trauma registry rather from abstraction from the medical record.
Was follow-up sufficiently complete?	Yes. All of the assessed outcomes occurred during the initial hospital stay. There was no long term follow up to assess for mortality after discharge.

WHAT ARE THE RESULTS

HOW STRONG IS THE ASSOCIATION BETWEEN EXPOSURE AND OUTCOME?

N=39,144

STUDY GROUPS

		Prehospital	1st ED
	Prevalence	Median BP (PP)	Median BP (PP)
Normotensive	92% (36,248/39,144	136/83 (50)	134/85 (49)
Narrow PP	5% (1,834/39,144)	112/90 (25)	127/83 (41)
Hypotensive	3% (1,062/39,144)	80/48 (30)	117/76 (36)

In the univariable analysis, patients with a narrow pulse pressure were intermediate in risk of resuscitative thoracotomy, need for trauma intervention, need for any operative intervention, central line insertion, chest tube insertion, and mortality compared to the normotensive and hypotensive groups. In addition, there were no statistically significant differences between the Narrow PP and Hypotensive groups.

UNIVARIABLE ANALYSIS: OUTCOMES (TABLE 3)

	Normotensive	Narrow PP	Hypotensive
Arrive in Cardiac Arrest	<1% (38/36,248)	1% (23/1,834)	4% (40/1,062)
Resuscitative Thoracotomy	1% (312/36,248)	4% (80/1,834)	11% (112/1,062)
Need for Trauma Intervention	19% (6,722/36,248)	33% (612/1,834)	57% (507/1,062)
NFEI: Embolization[1]	< 1% (96/36,248)	<1% (8/1,834)	2% (16/1,062)
NFEI: Any Operative[1]	6% (2,157/36,248)	15% (273/1,834)	27% (287/1,062)
Central Line Insertion	4% (1,277/36,248)	10% (175/1,834)	23% (238/1,062)
Chest Tube	3% (1,179/36,248)	10% (172/1,834)	21% (216/1,062)
Mortality	1% (502/36,248)	5% (92/1,834)	12% (130/1,062)
Hospital Length of Stay (days)	2 (1-4)	3 (2-7)	4 (2-12)
ICU Length of Stay (days)	4 (2-7)	4 (3-9)	4 (3-9)
Ventilator Days	3 (2-8)	4 (2-8)	3 (2-7)

GREEN = Statistically Significant compared to the Normotensive group
RED = Not Statistically Significant compared to the Normotensive group
No statistically significant differences between the Narrow PP and Hypotensive groups
WEBLINK: Centre for EBM Prospective Study Calculator
1. NFEI: Need for Emergent Intervention, NETI: Need for Trauma Intervention

In the multivariable analysis, a narrow pulse was an independent predictor of the need for a trauma intervention (aOR 1.45, 95% CI (1.20, 1.75)), the need for resuscitative thoracotomy (aOR 2.04 95% CI (1.46, 2.84)) and the need for an emergent intervention (aOR 1.38, 95% CI (1.15, 1.66)). A narrow pulse pressure was not an independent predictor of mortality (p value 0.15, aOR 1.31 with 95% CI not presented). A penetrating mechanism, trauma team activation and injury severity score were also independent predictors of all three outcomes.

MULTIVARIABLE ANALYSIS: INDEPENDENT PREDICTORS (TABLE 4,5,6)

	Need For Trauma Intervention	Need For Emergent Intervention	Resuscitative Thoracotomy
Age	1.02 (1.01, 1.02)	1.00 (0.99, 1.00)	1.003 (0.99, 1.01)
Male Gender	1.30 (1.18, 1.42)	1.42 (1.23, 1.63)	1.27 (0.88, 1.82)
Penetrating Mechanism	1.11 (1.01, 1.22)	3.79 (3.39, 4.24)	6.0 (4.56, 7.88)
Helicopter Transport	1.08 (0.91, 1.28)	1.07 (0.86, 1.35)	1.51 (0.92, 2.46)
Normal BP	Reference	Reference	Reference
Narrow pulse pressure	1.28 (1.01, 1.49)	1.43 (1.20, 1.70)	1.75 (1.23, 2.47)
Hypotensive	1.45 (1.20, 1.75)	1.38 (1.15, 1.66)	2.04 (1.46, 2.84)
Transport Time	0.99 (0.96, 0.99)	1.00 (0.99, 1.01)	0.99 (0.97, 1.01)
Trauma Team Activation	6.05 (5.54, 6.61)	4.04 (3.61, 4.51)	3.52 (2.51, 4.95)
Injury Severity Score	1.21 (1.21, 1.22)	1.08 (1.07, 1.09)	1.07 (1.06, 1.08)
Intubation in the ED	Not presented	1.94 (1.70, 2.21)	6.20 (4.70, 8.19)
Arrival in Cardiac Arrest	Not presented	0.48 (0.30, 0.74)	199.8 (90.3, 442.1)

GREEN = Statistically Significant, RED = Not Statistically Significant

HOW PRECISE IS THE ESTIMATE OF RISK?

The large sample size resulted in narrow confidence intervals for the adjusted odds ratios associated with narrow pulse pressure.

HOW CAN I APPLY THE RESULTS TO PATIENT CARE?

Were the study patients similar to the patients in my practice?	Given the large sample size and limited exclusions, the study's results are likely generalizable to most trauma patients at level I trauma center. However, the single center nature of the study may limit generalizability to other non-level one trauma centers and level one trauma center with different patient mixes. 15% of patient were categorized as penetrating trauma. Penetrating trauma occurred 2 times as frequently in the narrow pulse pressure group and 3.3 times as frequently in the hypotensive group compared to the normotensive group. Study results may not be generalizable to level 1 trauma center with a lower rate of penetrating trauma. A subgroup analysis comparing penetrating to blunt trauma would have been helpful. In addition, the results may not

	be applicable to pediatric and geriatric trauma patients.
Was follow-up sufficiently long?	Yes. The study outcomes included in-hospital interventions and length of stay. Mortality after hospital discharge was not reported.
Is the exposure similar to what might occur in my patient?	A narrow prehospital blood pressure occurred in 5% (1 in 20) of study patients. Pulse pressure would need to be age-adjusted in the pediatric population.
What is the magnitude of the risk?	The adjusted odds ratios for a narrow pulse pressure were small. The increase in risk for the need for a trauma intervention was 45% (aOR 1.45, 95% CI (1.20, 1.75), the need for resuscitative thoracotomy was 104% (aOR 2.04 95% CI (1.46, 2.84)) and the need for an emergent intervention was 38% (aOR 1.38, 95% CI (1.15, 1.66)).
Are there any benefits that offset the risks associated with exposure?	A pre-hospital narrow pulse pressure could serve as a marker of intermediate risk when compared to normotensive and hypotensive patients and prompt mobilization or personnel (e.g. trauma team activation) and resources (e.g. initiation of a massive transfusion protocol).

CLINICAL BOTTOM LINE

BACKGROUND: Prehospital trauma team activation criteria allow for prompt mobilization of personnel and resources. Prehospital hypotension is one of those criteria. Pulse pressure is the difference between systolic and diastolic blood pressure. This is variously defined as a difference of 30-40 mmHg. A narrow pulse pressure occurs due to compensatory increased systemic vascular resistance in the setting of decreased cardiac output. A narrow pulse pressure has been shown to predict the need for hemorrhage control in the ED setting but has not been assessed as a predictor in the prehospital setting. This study was undertaken to "to examine patients with prehospital narrow pulse pressure to determine the impact of narrow pulse pressure on outcomes after trauma" with the hypothesis that "narrow pulse pressure in the field would portend poor outcomes among trauma patients and may therefore be clinically useful as an early warning sign of patients at risk for circulatory collapse."

CLINICAL QUESTION: In trauma patients, 16-60 years of age, presenting to a level one trauma center, is a prehospital narrow pulse pressure (< 30 mmHg) with a systolic blood pressure of > 90 mmHg, associated with in-hospital mortality, need for a resuscitative thoracotomy, need for an emergent intervention (NFEI), need for a trauma intervention (NFTI) and mortality?

DESIGN/RISK OF BIAS: The was a single center, retrospective analysis of trauma registry data including patients were 16-60 years of age. Patients were excluded for unrecorded prehospital vital signs, transferred from another institution, had an on-scene cardiac arrest or were missing discharge disposition data. The primary exposure of interest were normotensive patients with a narrow prehospital blood pressure defined as a difference between systolic and diastolic blood pressure of less than 30 mg/kg. This group was compared to hypotensive patients (systolic < 90 mmHg patients regardless of pulse pressure) and normotensive patients (systolic ≥ 90 mmHg).

Primary outcomes for multivariable logistic regression were: the need for resuscitative thoracotomy, the need for emergent Intervention (NFEI), the need for trauma intervention (NFTI) and mortality. NFEI was defined as transfer directly from the ED to the operating room or to interventional radiology. NFTI was defined as 1 or more of the following: packed red cell transfusion less than 4 hours after arrival, the need for operative intervention or angioembolization within 90 minutes of arrival, admission to the ICU from the ED with a length of stay of at least 3 days and mechanical ventilation initiated within 72 hours of arrival. NFEI and NFTI are composite outcome measures and results for the individual outcomes that make up the composite are not reported.

There were statistically significant differences between the blood pressure groups. Narrow pulse pressure and hypotensive patients were more likely to have penetrating trauma than normotensive patients. Injury severity scores were intermediate between normotensive patients and hypotensive patients for narrow pulse pressure patients. Multiple logistic regression analysis was used to account for differences in potential confounders.

PRIMARY RESULTS: 39,144 patients were included in the analysis. 28% of patients were excluded due to absent pre-hospital BP indicating the possibility of selection bias. 92% (36,248/39,144) were normotensive, 5% (1,834/39,144) had a narrow pulse pressure and 3% (1,062/39,144) were hypotensive.

In the univariable analysis, patients with a narrow pulse pressure were intermediate in risk of resuscitative thoracotomy, need for trauma intervention, need for any operative intervention, central line insertion, chest tube insertion, and mortality compared to the normotensive and hypotensive groups. In addition, there were no statistically significant differences between the Narrow PP and Hypotensive groups.

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A penetrating mechanism, trauma team activation and injury severity score were also independent predictors of all three outcomes.

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APPLICABILITY: Given the large sample size and limited exclusions, the study's results are likely generalizable to most trauma patients at level I trauma center. However, the single center nature of the study may limit generalizability to non-level one trauma centers and level one trauma center with different patient mixes. 15% of patient were categorized as penetrating trauma. Penetrating trauma occurred 2 times as frequently in the narrow pulse pressure group and 3.3 times as frequently in the hypotensive group compared to the normotensive group. Study results may not be generalizable to level 1 trauma center with a lower rate of penetrating trauma. A subgroup analysis comparing penetrating to blunt trauma would have been helpful. In addition, the results may not be applicable to pediatric and geriatric trauma patients.

AUTHOR'S CONCLUSION: "As we continuously seek methods to improve our care of the injured patient, prompt control of hemorrhage to reduce morbidity and mortality remains one of the central tenets of trauma surgery. For this reason, appreciation of early indicators of blood loss are invaluable. In the current study, narrow pulse pressure in the field was independently associated with the need for resuscitative thoracotomy, emergent intervention for hemorrhage control, and the presence of major traumatic injuries. We propose that narrow pulse pressure be further studied in the future as a possible addition to existing American College of Surgeons Committee on Trauma prehospital trauma team activation criteria."

POTENTIAL IMPACT: A pre-hospital narrow pulse pressure could serve as a marker of intermediate risk when compared to normotensive and hypotensive patients and prompt

mobilization of personnel (e.g. trauma team activation) and resources (e.g. initiation of a massive transfusion protocol). A prospective, multicenter study to examine the impact of a narrow pre-hospital pulse pressure on trauma interventions and outcomes would validate its importance and improve the study's generalizability.