Faster Refill in an Urban EMS System Saves Lives: A Prospective Preliminary Evaluation of a Prehospital Advanced Resuscitative Care Bundle

Kristen D Nordham MD MS, Jacob M Broome MD, Sydney Caputo BS, Cameron Belding MD, Mark Piehl MD MPH, Valerie J De Maio MD MSc, Danielle Tatum PhD, Sharven Taghavi MD MPH MS, Olan Jackson-Weaver PhD, Charles Harris MD, Alison A Smith MD PhD, Emily Nichols MD, Tom Dransfield, David Rayburn MD, Meg Marino MD, Jennifer Avegno MD, Juan C Duchesne MD

Disclosures

Mark Piehl MD MPH: Founder and CMO, 410 Medical

DoD grants:

USSOCOM W81XWH-22-C-0002

USAF SBIR AF212-CSO1 Phase II, F2-15653

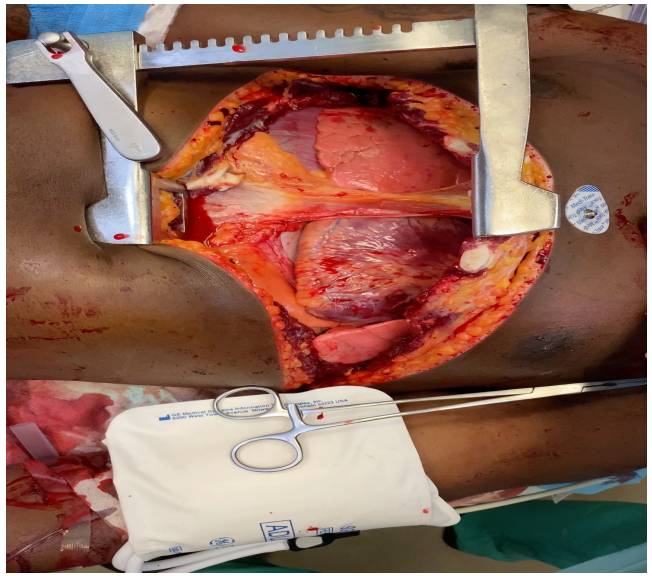
USAF SBIR AF211-CSO1 Phase II, F2-15254

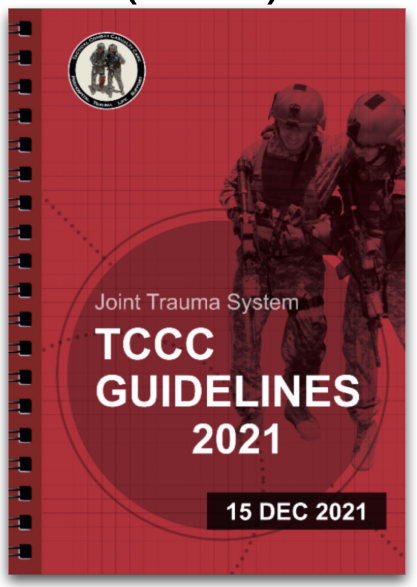
Valerie J De Maio MD MSc: Director of Clinical Science & Research, 410 Medical

No funding provided for this research

Background

- Uncontrolled hemorrhage: #1 cause of preventable deaths after traumatic injury
- Military experience: ↓ mortality with pre-hospital blood
- Tactical Combat Casualty Care: 2u whole blood, 2g tranexamic acid (TXA)





Civilian Literature

Plasma-first resuscitation to treat haemorrhagic shock during emergency ground transportation in an urban area: a randomised trial

Prehospital Plasma du

Hunter B Moore, Ernest E Moore, Michael P Chapman, Kevin McVaney, Gary Bryskiewicz, Robert Blechar, Theresa Chin, Clay Cothren Burlew, Fredric Pieracci, F Bernadette West, Courtney D Fleming, Arsen Ghasabyan, James Chandler, Christopher C Silliman, Anirban Banerjee, Angela Sauaia

Prehospital whole blood reduces early mortality in patients with hemorrhagic shock

Maxwell A. Braverman[1] | Alison Smith[1] | Douglas
Benjamin Axtman[1] | Charles Patrick Shahan[1] | Laur
Hannah Corral[1] | Rachelle Babbitt Jonas[1] | Michael
Randall Schaefer[3] | Eric Epley[3] | Christopher Winck
Elizabeth Waltman[5] | Brian J. Eastridge[1] | Susannah
Ronald M. Stewart[1] | Donald H. Jenkins[1]

M.D., Darrell J. Triulzi, M.D., Barbara J. Early-Young, B.S.N., Peter W.
, M.D., Herb A. Phelan, M.D., M.S.C.S., et al., for the PAMPer Study

Resuscitation with blood products in patients with trauma-related haemorrhagic shock receiving prehospital care (RePHILL): a multicentre, open-label, randomised, controlled, phase 3 trial

Nicholas Crombie, Heidi A Doughty, Jonathan R B Bishop, Amisha Desai, Emily F Dixon, James M Hancox, Mike J Herbert, Caroline Leech, Simon J Lewis, Mark R Nash, David N Naumann, Gemma Slinn, Hazel Smith, Iain M Smith, Rebekah K Wale, Alastair Wilson, Natalie Ives, Gavin D Perkins, on behalf of the RePHILL collaborative group*

Objective

Evaluate effects of prehospital acute resuscitative care (ARC) bundle in an urban ground EMS system with short transport times on outcomes in penetrating trauma patients with hemorrhagic shock.

Pre-hospital ARC bundle

- 2u pRBCs via rapid infuser (non-warmed), 2g CaCl, 2g TXA
- Bundle triggers:
  - SBP ≤ 70 mmHg

  or
  - SBP ≤ 90 mmHg & HR > 110 at EMS arrival on-scene
- Implemented 10/2021

Hypothesis

A ***prehospital ARC bundle*** for ***penetrating trauma*** patients with ***hemorrhagic shock*** decreases ***in-hospital mortality*** in an urban setting with short EMS transport times.

Methods

- ARC bundle patients (10/2021-1/2023)

  vs.
- Control hypotensive penetrating trauma patients (1/2016-1/2019)
- Inclusion criteria: all patients with penetrating injuries and pre-hospital SBP ≤ 90 mmHg at EMS arrival
- Exclusion criteria: head injuries, pre-hospital cardiac arrest

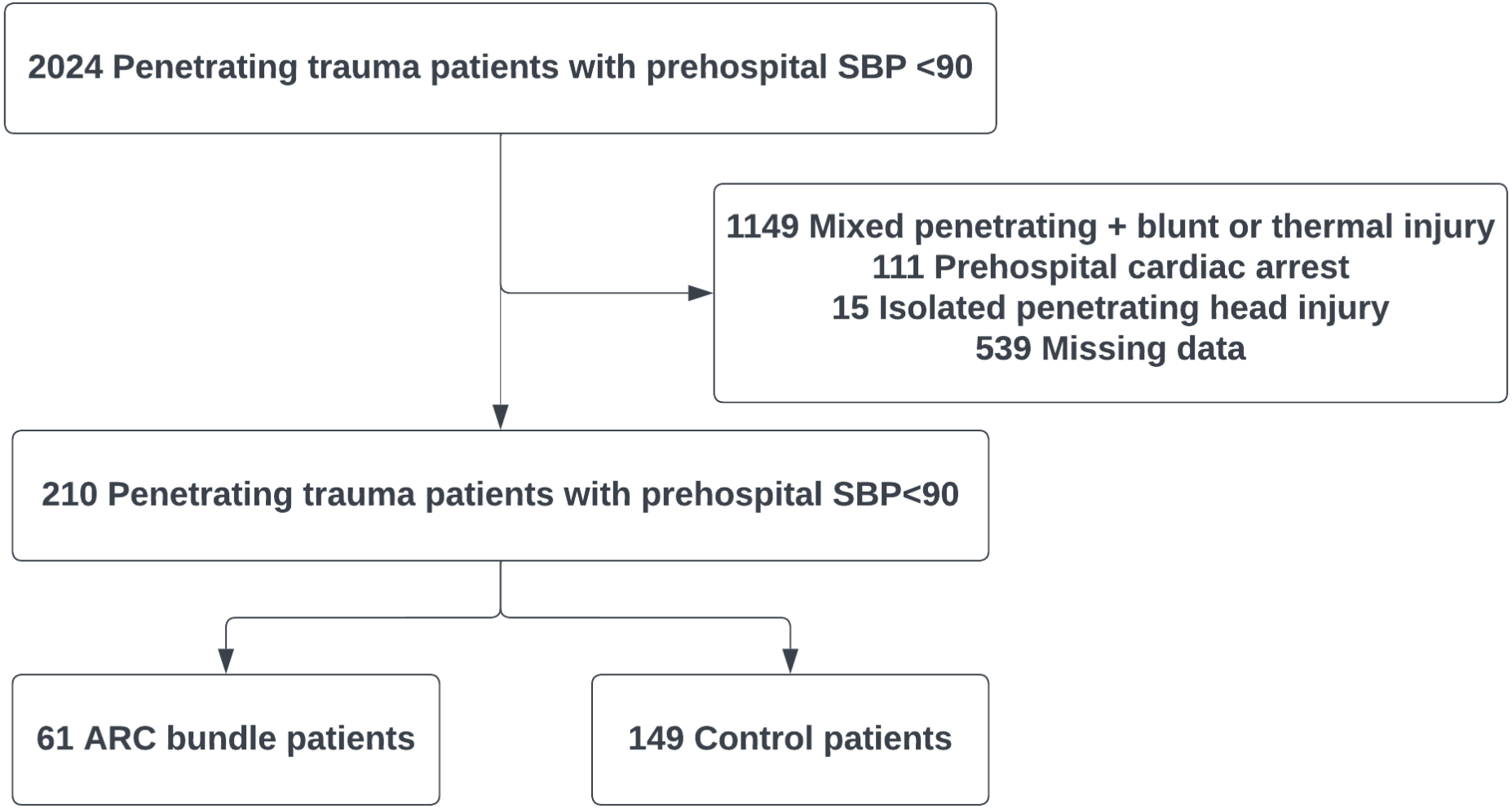
Statistics

- Categorical variables: Chi-Square.
- Continuous variables: Independent sample Mann-Whitney U analysis.
- Univariate logistic regression & stepwise Akaike information criterion identified independent predictors of mortality.
- Multivariable logistic regression assess influence of independent predictors on in-hospital mortality.
- Receiver operating characteristic analysis evaluated performance of the prognostic model

Outcomes

- Primary
  - 24-hour and in-hospital mortality
- Secondary
  - EMS transport times
  - Vital sign changes
  - Prehospital advanced airway use
  - ED interventions
  - Length of stay

Cohort


2024 Penetrating trauma patients with prehospital SBP <90
1149 Mixed penetrating + blunt or thermal injury
111 Prehospital cardiac arrest
15 Isolated penetrating head injury
539 Missing data
210 Penetrating trauma patients with prehospital SBP<90
61 ARC bundle patients
149 Control patients

Demographics

	All (n=210)	ARC Bundle (n=61)	Control (n=149)	p-value
Age (years), median (IQR)	32 (24-41)	35 (25-47)	30 (23-39)	**0.05**
Male, n (%)	191 (91%)	55 (90%)	136 (91%)	0.8
African American, n (%)	175 (83%)	51 (84%)	124 (83%)	0.95

Injuries

	All (n=210)	ARC Bundle (n=61)	Control (n=149)	p-value
NISS	17 (6-29)	18 (10-31)	17 (5-29)	0.13
AIS-Head	0 (0-1)	0 (0-1)	0 (0-1)	0.99
AIS-Chest	3 (3-5)	3 (3-5)	3 (3-4)	0.29
AIS-Abdomen	3 (3-4)	3 (3-4)	3 (3-4)	0.51
AIS-Extremity	2 (1-3)	2 (2-3)	2 (1-3)	0.18

Prehospital Vital Signs

	All (n=210)	ARC Bundle (n=61)	Control (n=149)	p-value
SBP, mmHg	80 (62-88)	70 (62-87)	80 (62-88)	0.6
Heart Rate, bpm	107 (130-73)	110 (87-136)	103 (72-126)	0.08
Shock Index	1.29 (0.90-1.66)	1.44 (1.01-1.91)	1.21 (0.89-1.60)	**0.05**
Glasgow Coma Scale	15 (11-15)	14 (10-15)	15 (12-15)	**0.01**

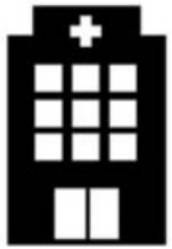
Prehospital Timing Intervals

911 call

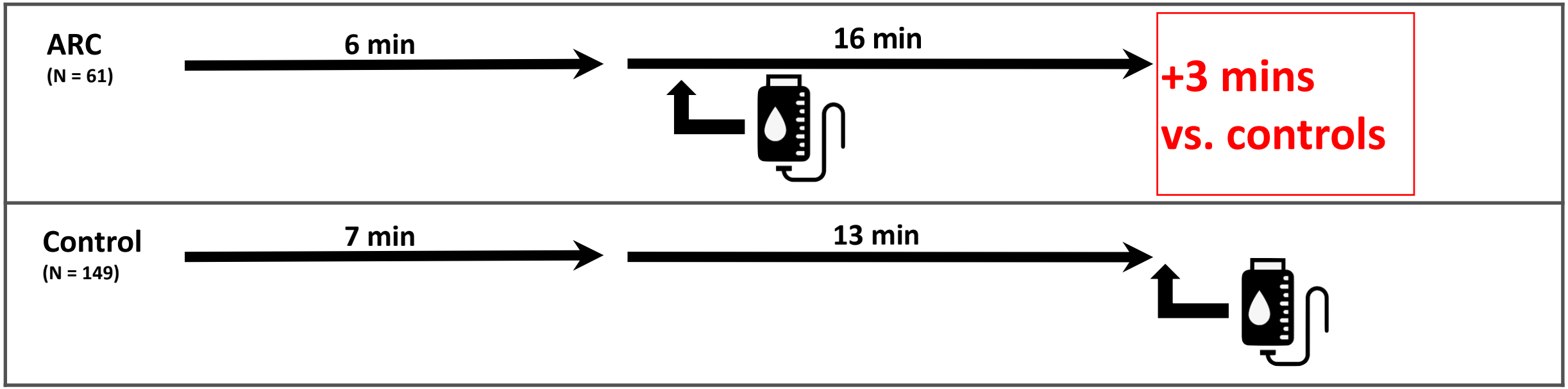
Response

Scene

Transport



Trauma Bay



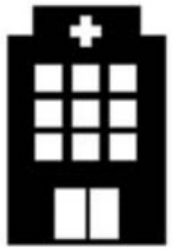
Prehospital Timing Intervals

911 call

Response

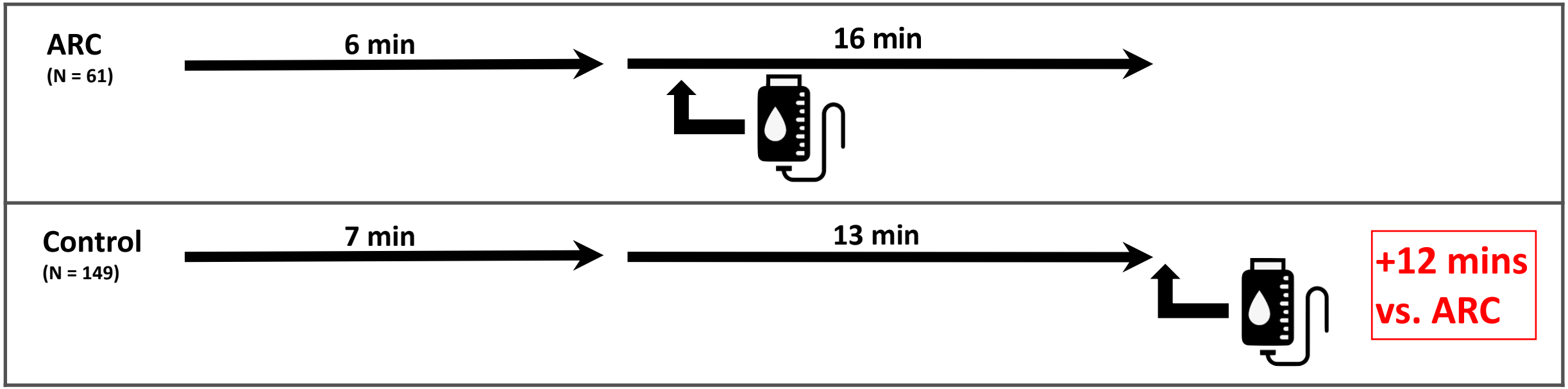
Scene

Transport



Trauma Bay

Time to 1st unit of Blood



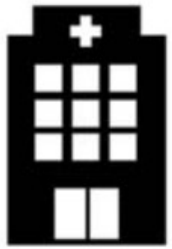
Prehospital Timing Intervals


911 call

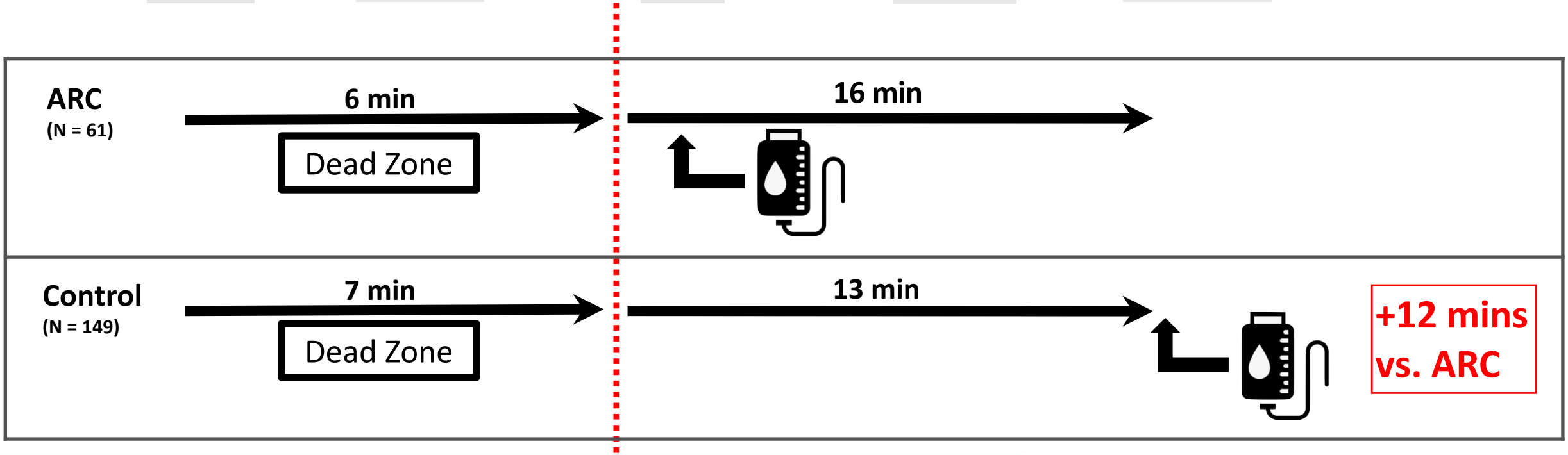

Response


Scene


Transport


Trauma Bay


Time to 1st unit of Blood



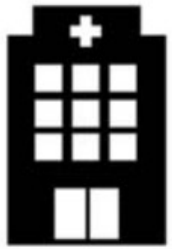
Prehospital Timing Intervals


911 call


Response


Scene


Transport


Trauma Bay

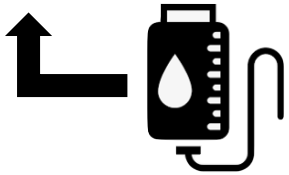

Time to 1st unit of Blood

ARC
(N = 61)

6 min

Dead Zone

16 min



ARC Bundle

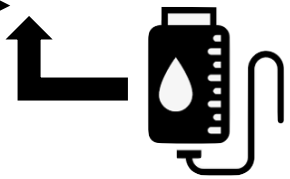
Control
(N = 149)

7 min

Dead Zone

13 min

Dead Zone



+12 mins vs. ARC

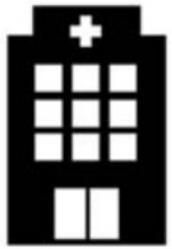
Prehospital Timing Intervals


911 call


Response


Scene


Transport


Trauma Bay

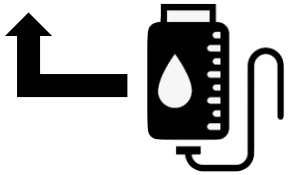

Time to 1st unit of Blood

ARC
(N = 61)

6 min

Dead Zone

16 min



ARC Bundle

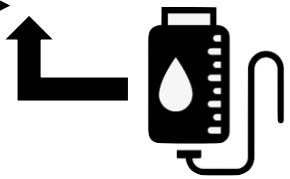
Control
(N = 149)

7 min

Dead Zone

13 min

Dead Zone

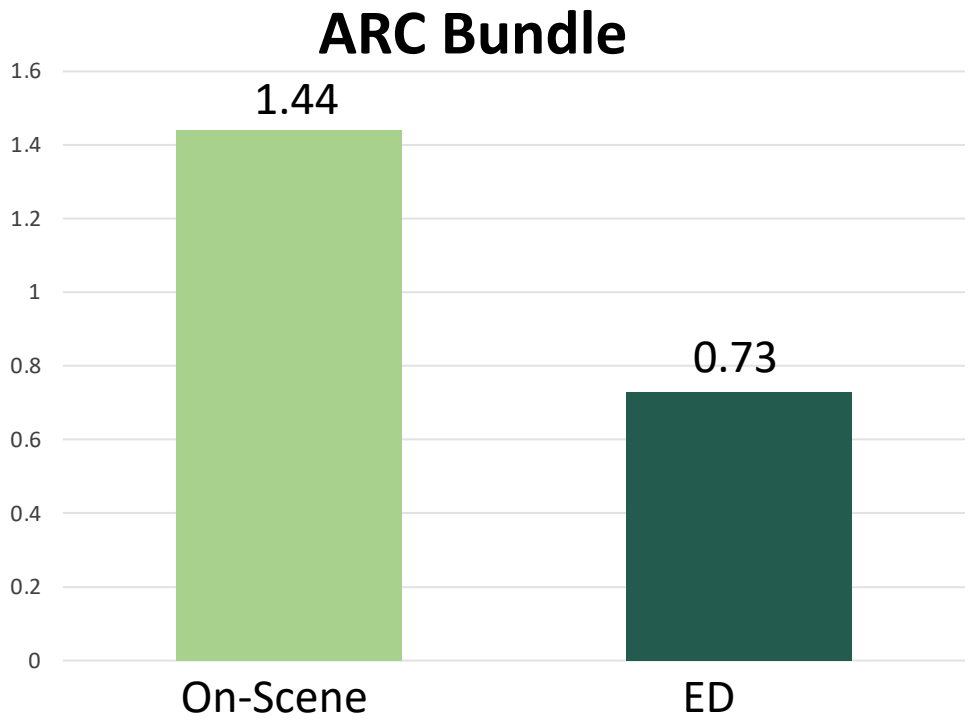


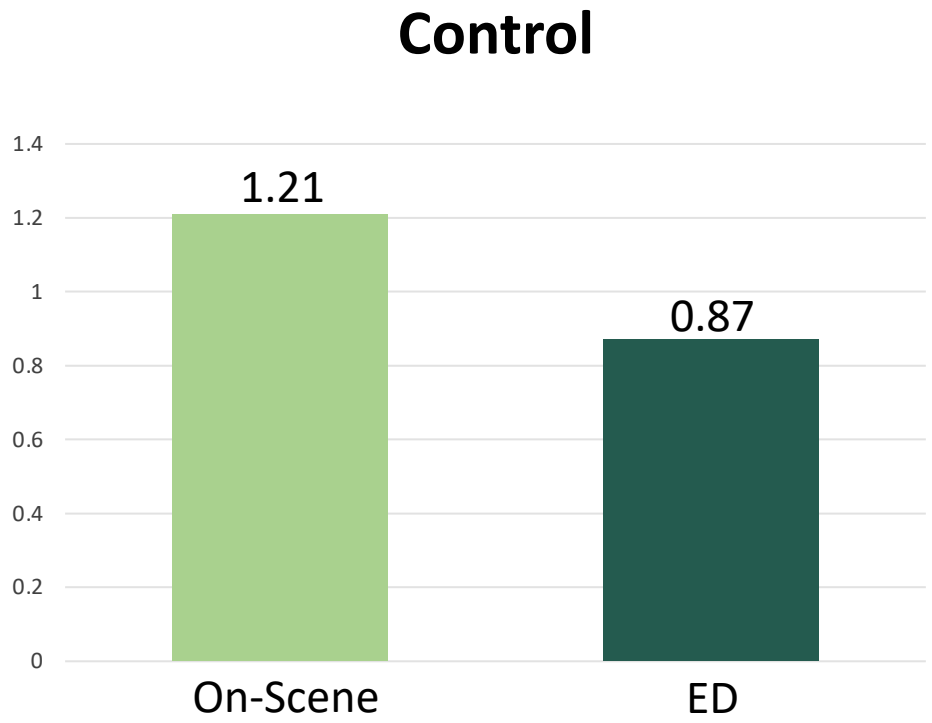
+12 mins vs. ARC

At Hospital Arrival

	All (n=210)	ARC Bundle (n=61)	Control (n=149)	p-value
Initial ED Characteristics				
ED SBP, mmHg	107 (82-133)	117 (88-140)	106 (72-132)	0.1
ED Heart Rate, bpm	93 (68-118)	79 (62-102)	95 (74-120)	**0.03**
ED Shock Index	0.84 (0.65-1.15)	0.73 (0.50-1.03)	0.87 (0.70-1.25)	**<0.01**
ED Glasgow Coma Scale	15 (13-15)	15 (13-15)	15 (12-15)	0.97
Arrived at ED intubated, n (%)	14 (6.8)	1 (1.6)	18 (12.1)	**0.04**
Intubated in ED, n (%)	47 (22.0%)	14 (23.0%)	33 (22.1%)	0.9

ARC Impact on Shock Index

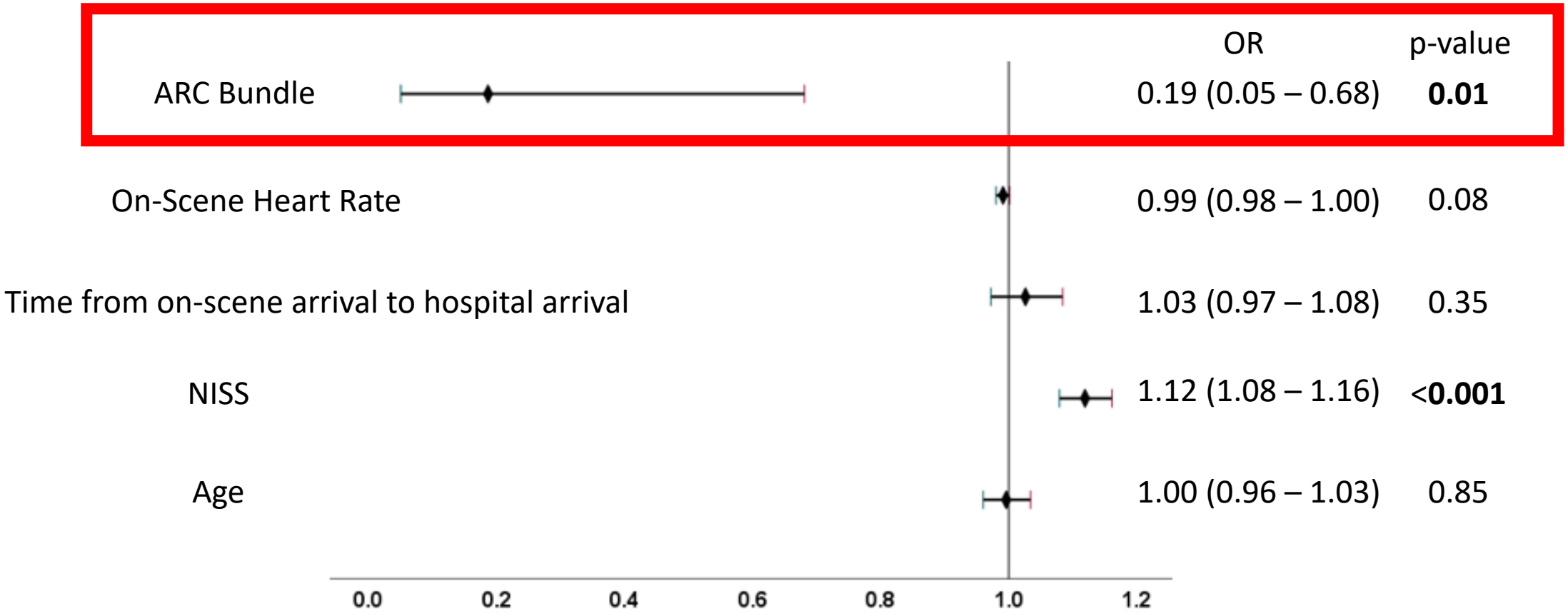




Mortality Outcomes

	All (n=210)	ARC Bundle (n=61)	Control (n=149)	p-value
24-Hour Mortality, n (%)	36 (17.1%)	4 (6.6%)	32 (21.5%)	**0.04**
In-hospital Mortality n (%)	45 (21.4%)	7 (11.5%)	38 (25.5%)	**0.03**

Factors Associated with Mortality



Discussion

- First study investigating ARC bundle in US urban ground EMS for penetrating trauma with hemorrhagic shock
- First study of prehospital blood in this setting to show mortality improvement to hospital discharge
- Prehospital ARC bundle utility with short pre-hospital times
  - Despite +3 mins transport time, ARC bundle patients received blood 12 mins sooner than controls
- Non-warmed blood
  - No temperature difference between groups in the ED

Limitations

- Missing data
- Single EMS system
- Historical controls

Conclusions

In an urban EMS system with short transport times, a pre-hospital ARC bundle decreased mortality in penetrating trauma patients with shock compared to previous standard of care.

Conclusions

Pre-hospital ARC bundle can be effectively integrated into an urban EMS system with short prehospital times.

Acknowledgements

Jacob Broome, MD, MS

Special thanks to:

- Chief of EMS Bill Salmeron - New Orleans EMS
- Deputy Chief of Logistics Cedric Palmisano - New Orleans EMS
- Deputy Chief of Operations Christopher Keller - New Orleans EMS
- Deputy Chief of Education and Training Lynn Ramagos - New Orleans EMS
- Captain Matteo Avocato - New Orleans EMS
- Major Gerry Figueroa - New Orleans EMS
- The Blood Center of New Orleans
- EMS World Magazine
- Prodigy EMS
- Hilary Gates - Prodigy EMS
- Lt William Bullock - San Antonio TX FD
- Chief Eric Bank - Harris County TX ESD 48
- Wren Nealy - Cypress Creek TX EMS
- Loudin County Virginia EMS

- NOEMS Blood Medics: David Perez-Luna, Heather Currie, Joe Frazier, Leslie Bean, Lindsay Fealko, Nicole Dupepe, Saber Holland, Shaq Harris Thomas Mauro, Titus Carriere, Alexia Archaga, Andrew Bouck, Arkady Acosta, Brooke Christy, Caleb Parker, Charles Brown, Christine Guidry, Christopher Martinez, Eugene McMillen, Holly Sherman, Janick Lewis, Jerome S. Winston, John Macaluso, Laura Russell, Lori Flick, Matthew Happel, Nathan Chomsky, Nick Sokolik, Noah Feldman, Omowale Abdul-Aziz, Perry Lew, Sam Rehage, Scott Schlumbrecht, Spencer Mitchell, Tiffany Mendoza, Valerie Bergeron, Vanessa Sheffield, William F. Niemeck

New Orleans Pre-Hospital Blood Registry

Juan Duchesne
jduchesn@tulane.edu

Faster Refill in an Urban EMS System Saves Lives: A Prospective Preliminary Evaluation of a Prehospital Advanced Resuscitative Care Bundle

Kristen D Nordham MD MS, Jacob M Broome MD, Sydney Caputo BS, Cameron Belding MD, Mark Piehl MD MPH, Valerie J De Maio MD MSc, Danielle Tatum PhD, Sharven Taghavi MD MPH MS, Olan Jackson-Weaver PhD, Charles Harris MD, Alison A Smith MD PhD, Emily Nichols MD, Tom Dransfield, David Rayburn MD, Meg Marino MD, Jennifer Avegno MD, Juan C Duchesne MD