Simple Derivation of the Initial Fluid Rate for the Resuscitation of Severely Burned Adult Combat Casualties: *In Silico* Validation of the Rule of Ten

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The opinions or assertions contained in this herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense

SUMMARY ARTICLE

American Burn Association Practice Guidelines Burn Shock Resuscitation

Tam N. Pham, MD,* Leopoldo C. Cancio, MD,† Nicole S. Gibran, MD*

Journal of Burn Care & Research
Volume 29, Number 1

"Optimal fluid resuscitation aims to support organ perfusion with the least amount of fluid necessary, at the least physiologic cost."

Table 2. Common estimates of volume resuscitation in the first 24 hours

	Formula Name	Solution	Volume in First 24 hr	Rate of Administration
Adult	Parkland	Lactated Ringer's	4 ml/kg/%burn	Over 8 hr, over 16 hr
	Modified Brooke	Lactated Ringer's	2 ml/kg/%burn	over 8 hr, Over 16 hr

Pham, Cancio, and Gibran

Journal of Burn Care & Research
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Four steps required…

Real Case Scenario

- 1992 – Aircraft crash and fire
  - 130 burn casualties to ED at Womack

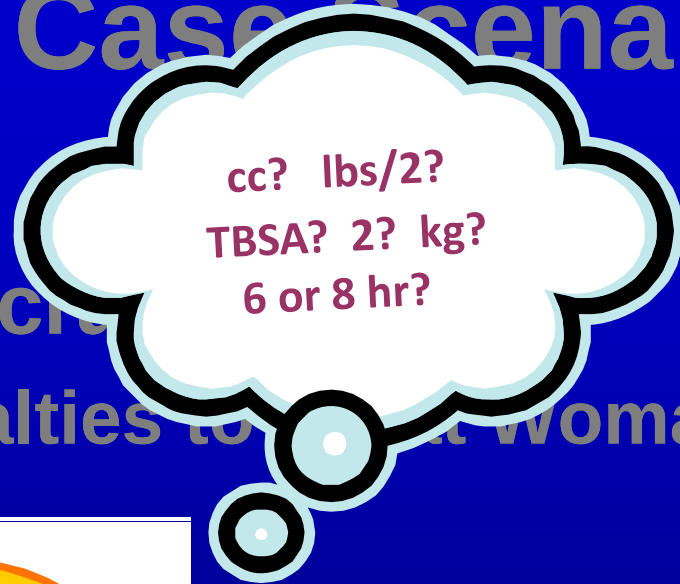
Mozingo DW, Barillo DJ, Holcomb JB. J Burn Care Res 2005.

Real Case Scenario

- 1992 – Aircraft crash and fire
  - 130 burn casualties to ED at Womack
- 2005 – Armored vehicle hit by IED
  - 6 severely burned initially managed at FOB

Mozingo DW, Barillo DJ, Holcomb JB. J Burn Care Res 2005.

Real Case Scenario



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  - 130 burn casualties to ... Womack
- 2005 – ... icle hit by IED
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Traditional formulas too cumbersome…especially when dealing with multiple casualties.

The Problems of Burn Resuscitation Formulae: A Need for a Simplified Guideline

Satyanarayan Bhat, Yvonne M. Humphries, Salil Gulati, Barney Rylah, William E. Olson, John Twomey, Jimmy Parks and David W. Mozingo

Department of Surgery, Southern Illinois University School of Medicine, Springfield, Illinois; HCA/Retreat Hospital, Richmond, Virginia; Burn Center, Hennepin County Medical Center, Minneapolis, Minnesota; Arkansas Children Hospital Burn Center; Department of Surgery, University of Florida.

Correspondence:sbhat@siumed.edu

Bhat S, Humphries YM, Gulati S, Rylah B, Olson WE, Twomey J, Parks J and Mozingo DW. The problems of burn resuscitation formulae; a need for a simplified guideline. Journal of Burns and Wounds [serial online] 2004;3(1)7 Available from: URL:http://www.journalofburnsandwounds.com]

Published October 16, 2004

Adequate flu ... eral formulae
are used to ai ... artment. These
departments ... This study,
prompted by ... Association,
provides new ... ned patients.
In the first pa ... ysicians to
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appropriate f ... roup of 22
final year me ... h only 51
(25.75%) cou ... errors in
calculations ... ae appear to
be an unrelia ... rn
management.

'only 26% could accurately recall a recognized burn resuscitation formula'

Formulas just a starting point…

Saffle JR. J Burn Care Res 2007.
Engrave LH et al. J Burn Care Res 2008.
Blumetti J et al. J Burn Care Res 2008.
Alvarado R et al. Burns 2009.

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"Fluid resuscitation, regardless of solution type or estimated need, should be titrated to maintain a urine output of approximately 0.5-1.0 ml/kg/hr in adults."

The Problems of Burn Resuscitation Formulae: A Need for a Simplified Guideline

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Adequate fluid resuscitation is a critical factor in the initial management of burn victims. Several formulae are used to aid the calculation of fluid requirements, typically, initiated in the emergency department. These departments are often staffed by personnel with modest experience in the treatment of burns. This study, prompted by the Organization and Delivery of Burn Care Committee of the American Burn Association, provides new data to evaluate the utility of standard burn formulae in the resuscitation of burned patients. In the first part of the study, surveys were carried out to ascertain the ability of emergency physicians to accurately recall any burn formula. In the second part of the study, the mathematical ability to prescribe appropriate fluids required for initial and subsequent burn fluid resuscitation was tested in a group of 22 final year medical students. The total numbers of physicians surveyed numbered 198, of which only 51 (25.75%) could accurately recall a recognized burn resuscitation formula. Huge mathematical errors in calculations occurred in adult and pediatric case studies. The use of burn resuscitation formulae appear to be an unreliable tool to guide fluid resuscitation for medical personnel less experienced in burn management.

Is there a way to simplify how the initial fluid rate is derived?

'ISR Rule of Ten'

1. Estimate Burn Size to the nearest 10%

2. Burn Size X 10 = INITIAL HOURLY FLUID RATE
   - Applies to ADULT patients 40-80 kg

3. For every 10 kg above 80 kg, add 100cc to the hourly rate.

Chung et al. ABA 2008 (abstract/poster presentation)

Four severely burned casualties

- 30% TBSA
- 50% TBSA
- 70% TBSA
- 50% TBSA, 90 kg

- 300 cc/hr
- 500 cc/hr
- 700 cc/hr
- 600 cc/hr (500+100)

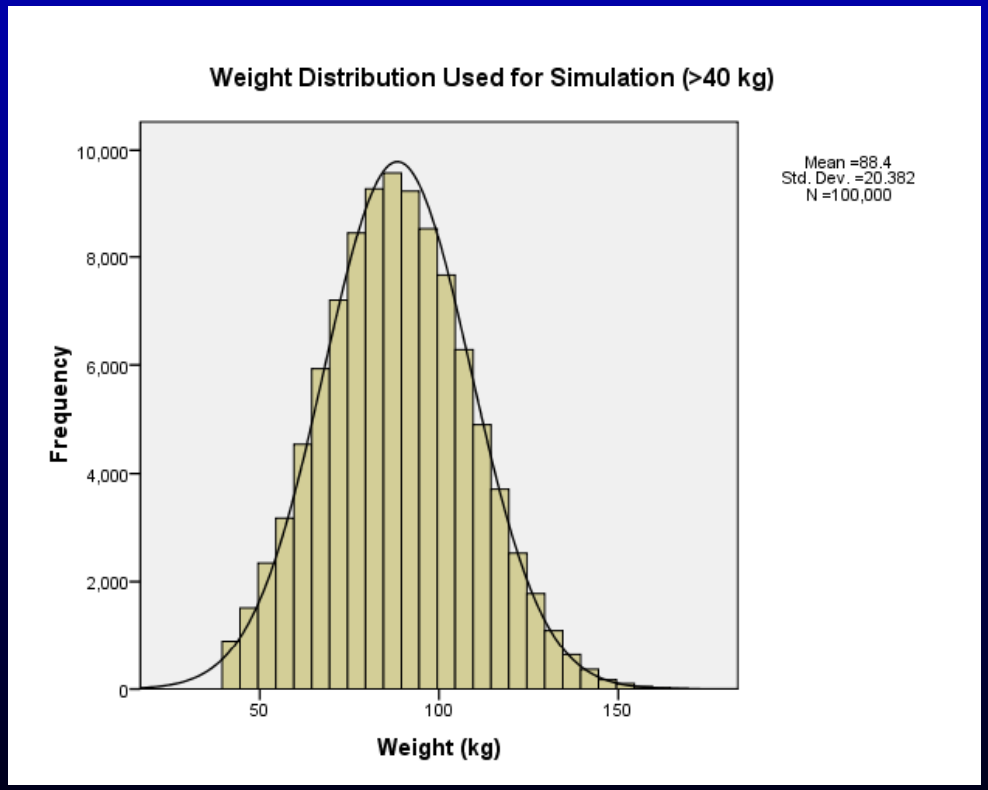
Resuscitate using basic critical care principles…titrate the rate up and down based on urine output

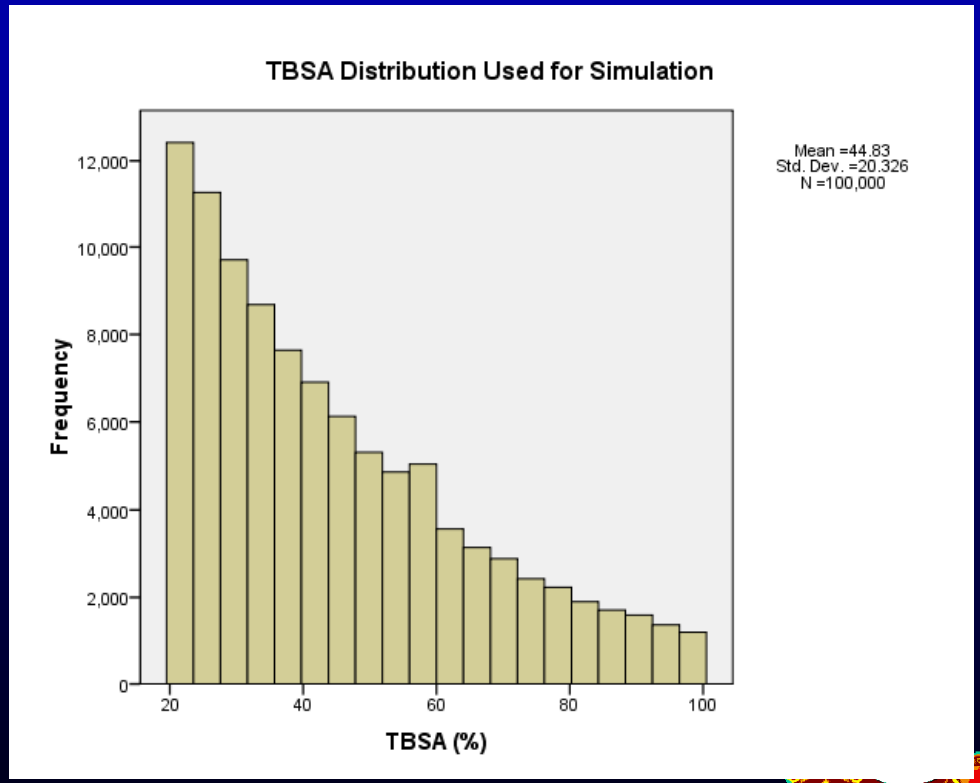
How do we know the ISR Rule of Ten will derive a reasonable initial fluid rate in all adults?

In Silico study

Methods

- Logarithmic model to determine 'highest fit'
  - N = 449 burns >20% TBSA (2003-2008)
- Generated N = 100,000 simulated 'patients'

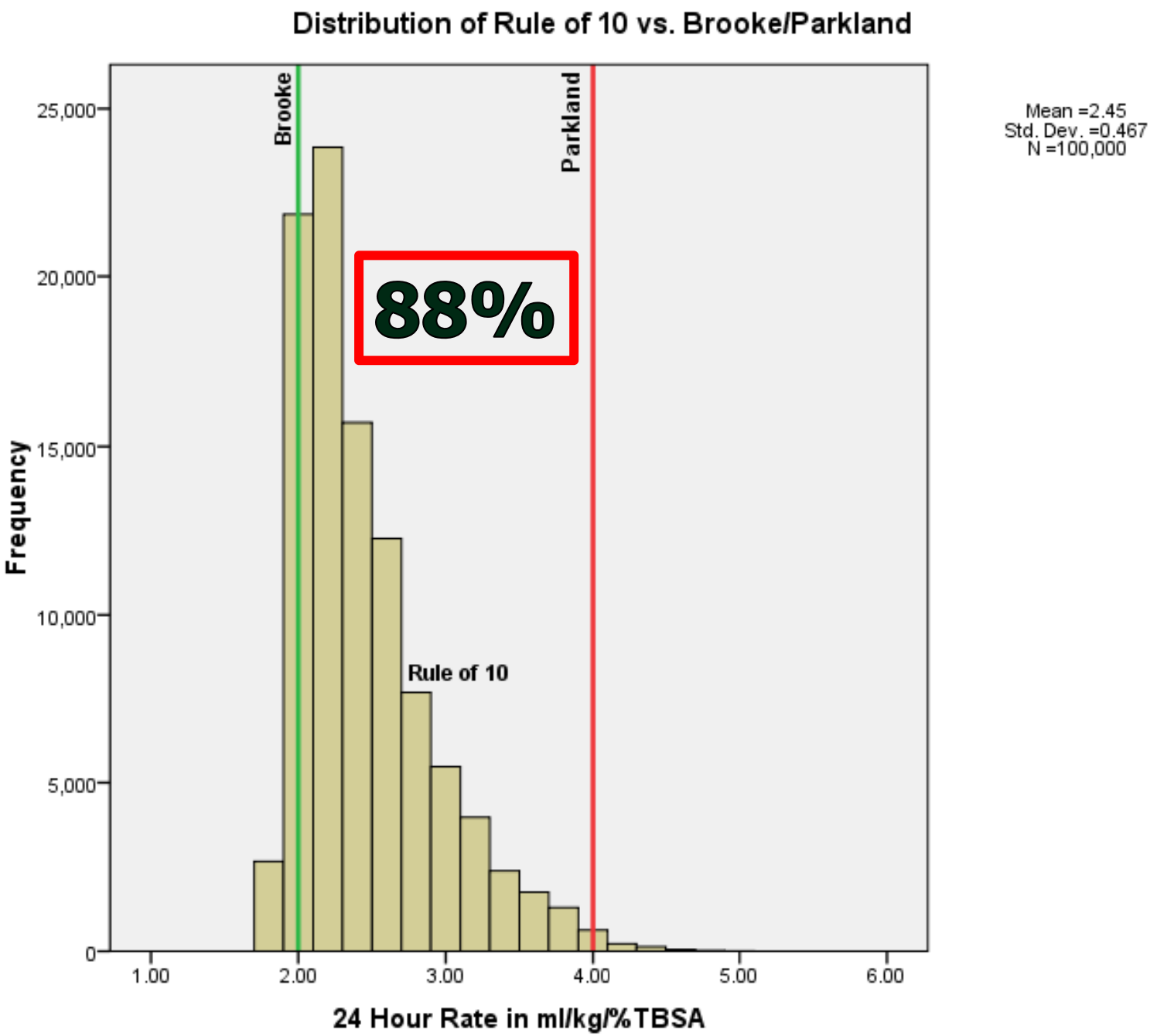


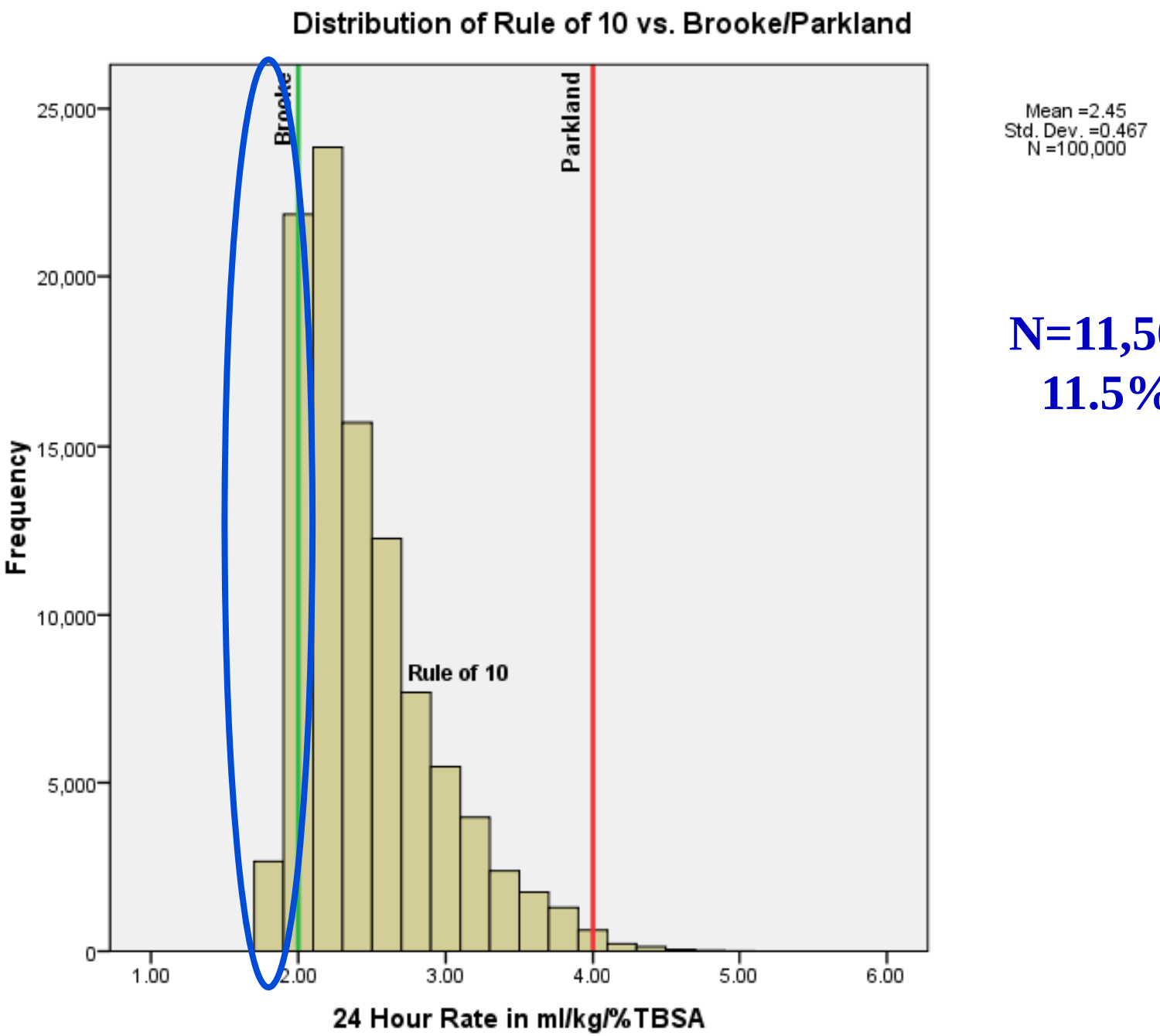


Initial Rates Calculated

- ISR Rule of Ten
- Compared against the boundaries determined by traditional formulas
  - Modified Brooke
  - Parkland

Results


Distribution of Rule of 10 vs. Brooke/Parkland
Brooke
Parkland
88%
Rule of 10
Mean =2.45
Std. Dev. =0.467
N =100,000
Frequency
25,000
20,000
15,000
10,000
5,000
0
1.00
2.00
3.00
4.00
5.00
6.00
24 Hour Rate in ml/kg/%TBSA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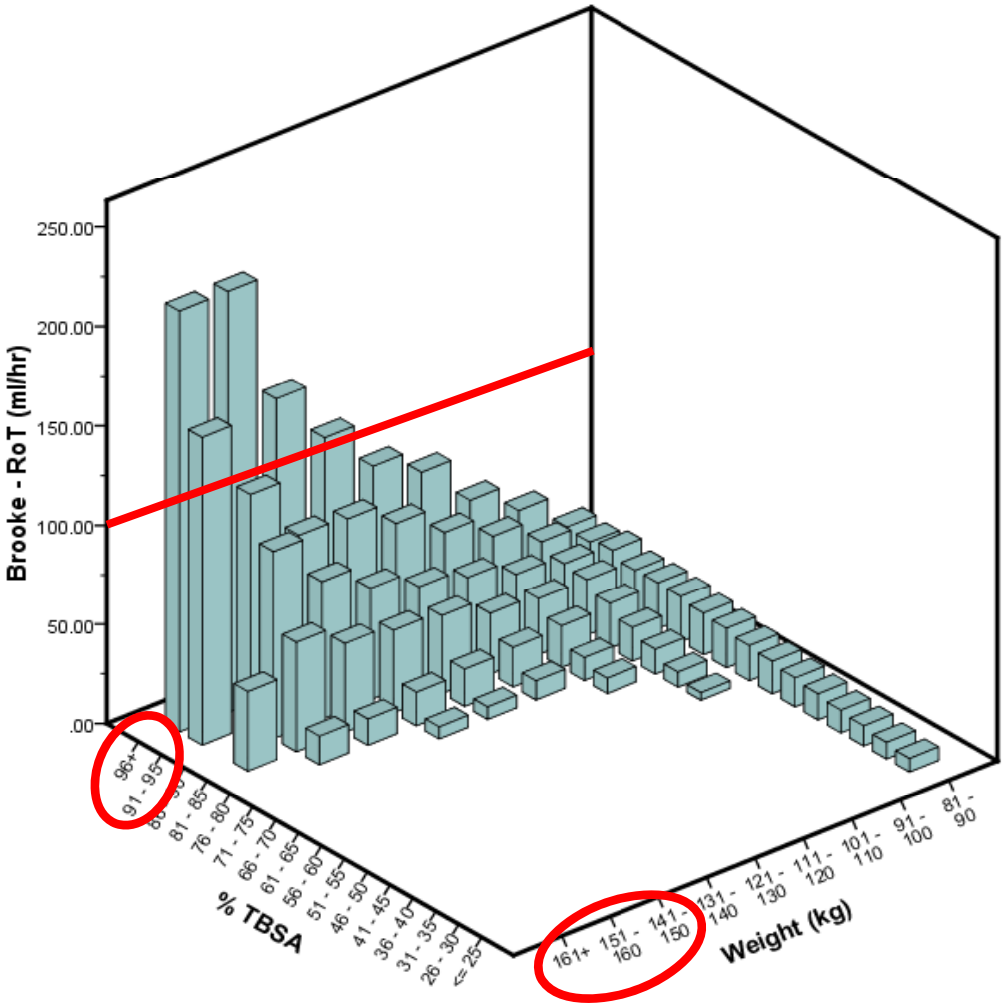
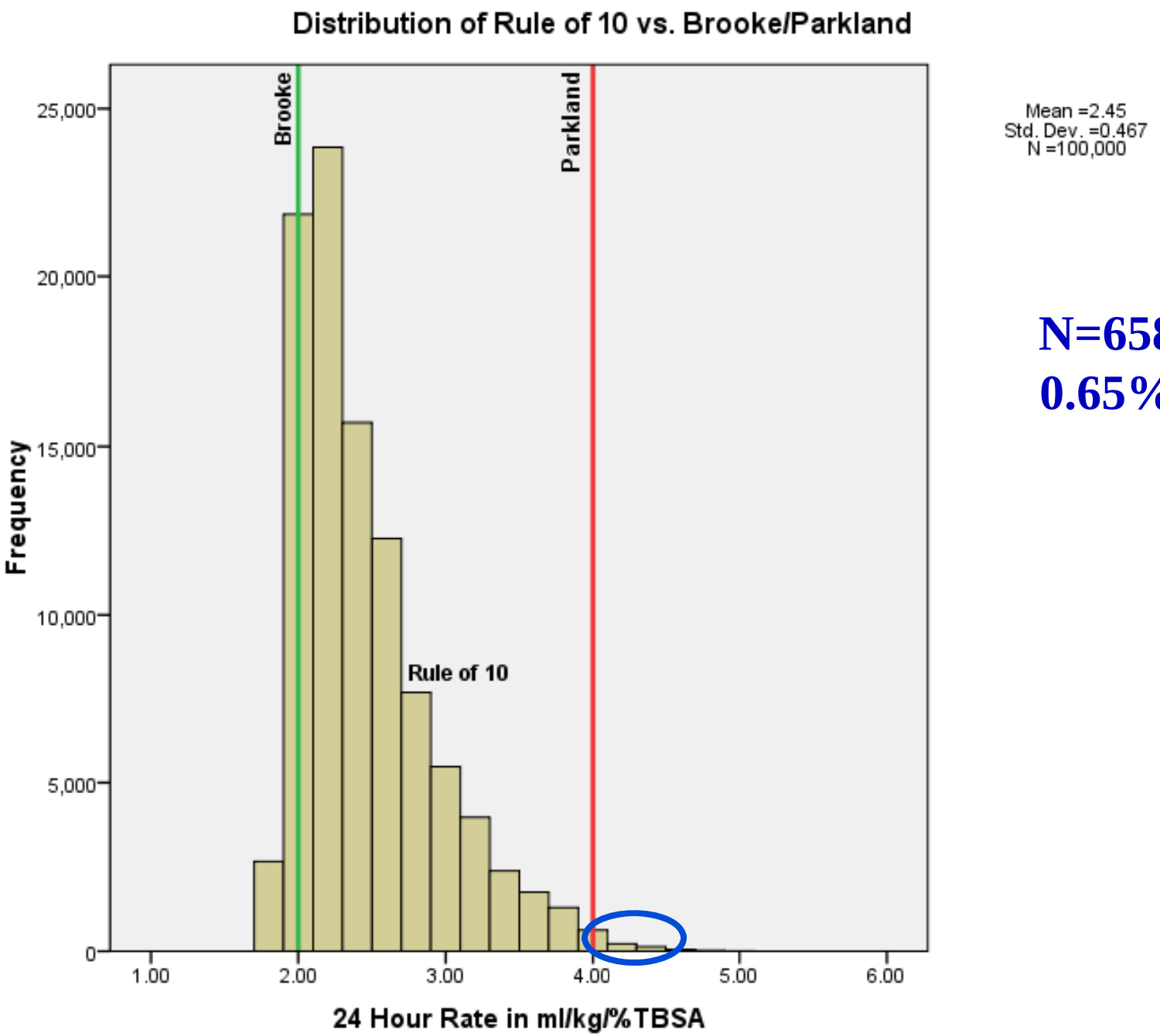
5,000
0
1.00
2.00
3.00
4.00
5.00
6.00
24 Hour Rate in ml/kg/%TBSA

N=11,502
11.5%

Difference in initial fluid rate

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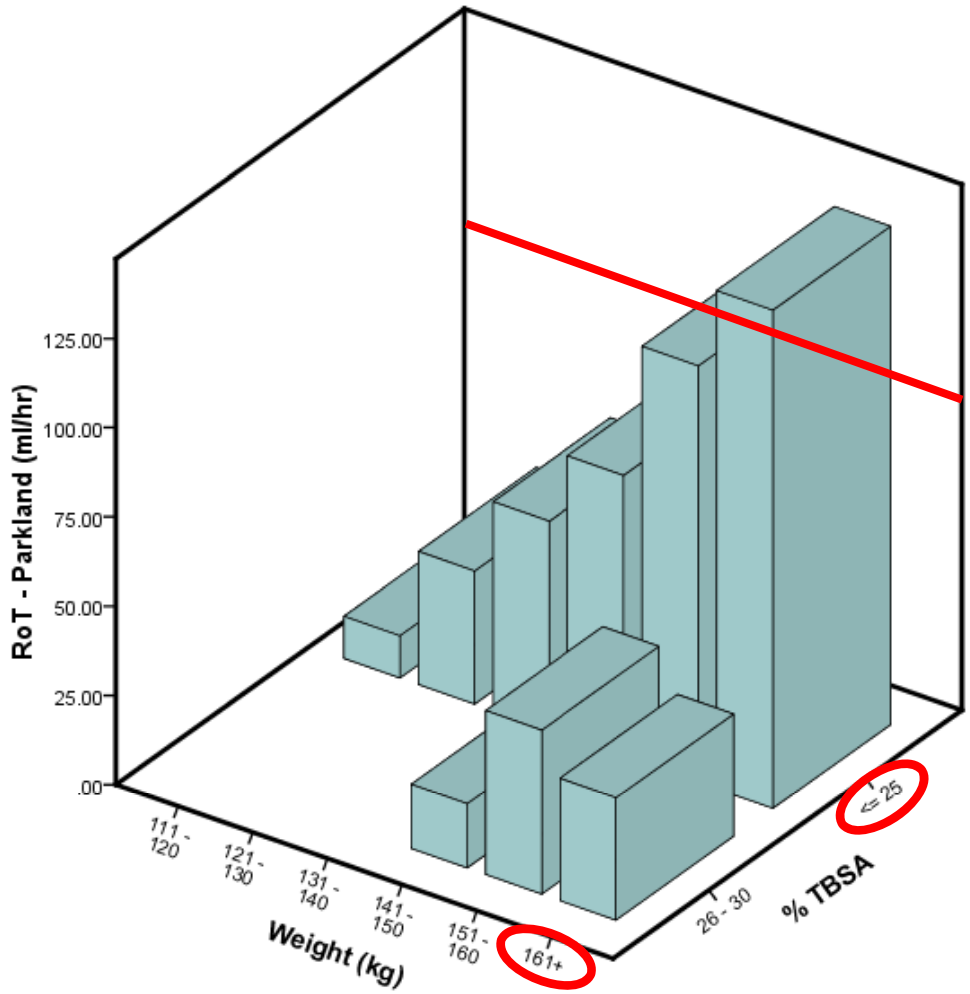
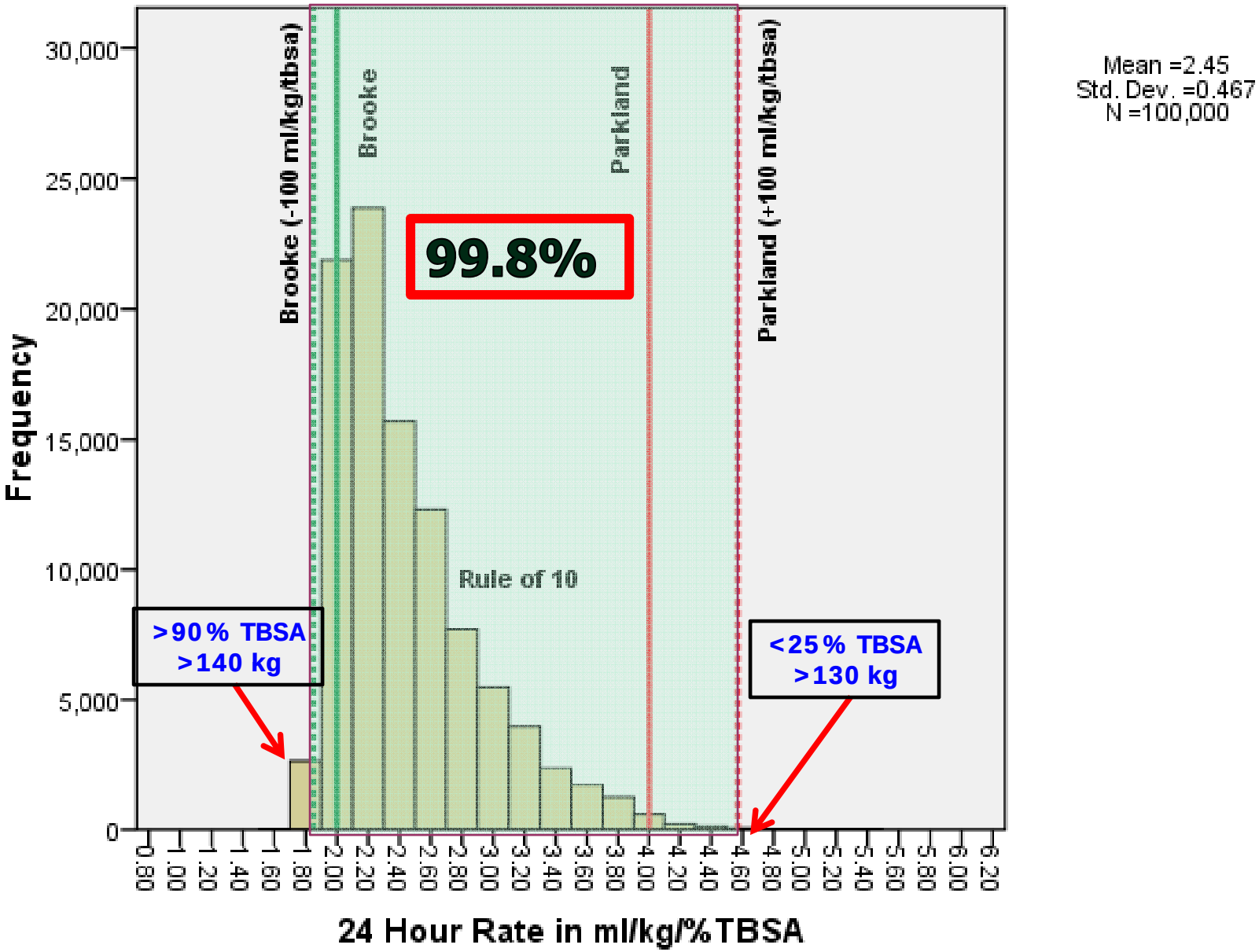
1.00
2.00
3.00
4.00
5.00
6.00
24 Hour Rate in ml/kg/%TBSA

N=658
0.65%

Difference in initial fluid rate



Distribution of Rule of 10 vs. Brooke/Parkland (+/- 100 ml/hr)



Conclusion

- **The Rule of Ten approximates the initial fluid rate within acceptable ranges (for Adults)**

Recommendation

- Immediate use in level II (pre-hospital) and III (ED) setting

- Use traditional formulas as benchmark
  - Real time or *post hoc*

Co-Contributors

- Jose Salinas, PhD[1]
- Evan M Renz[1]
- Ricardo A Alvarado MD[2]
- Booker T. King[1]
- David J Barillo MD[1]
- Leopoldo C Cancio MD[1]
- Steven E Wolf MD[1, 2]
- Lorne H Blackbourne MD[1]

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[2]UT Health Science Center at San Antonio; San Antonio, TX

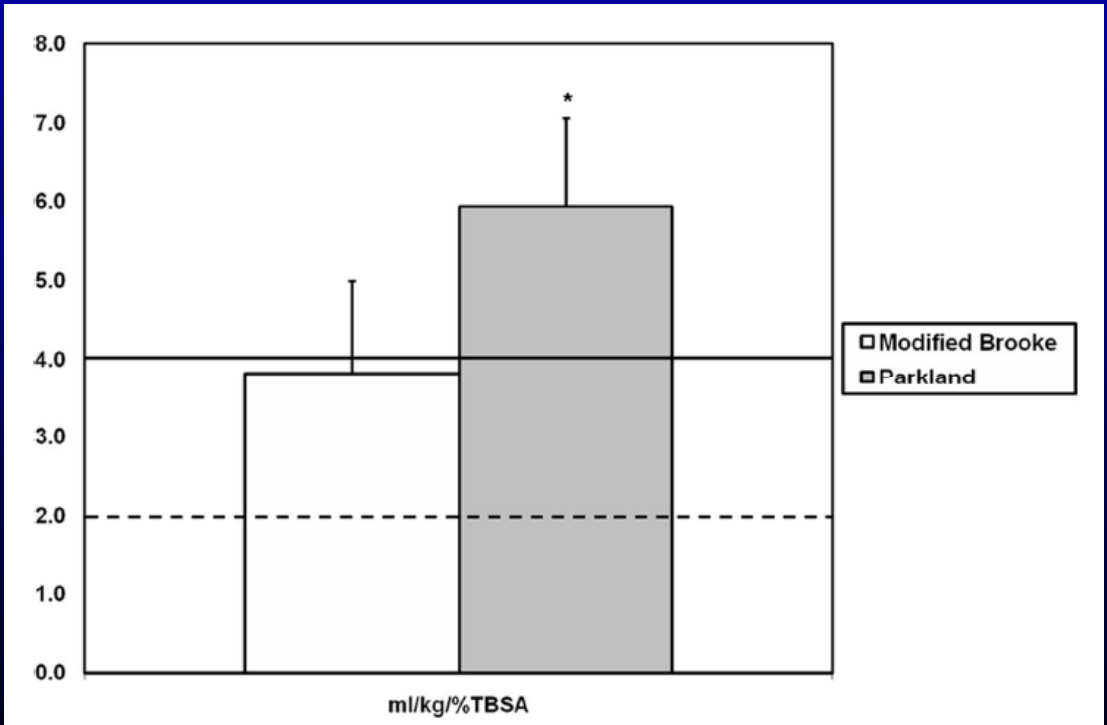
Thank You

ORIGINAL ARTICLE

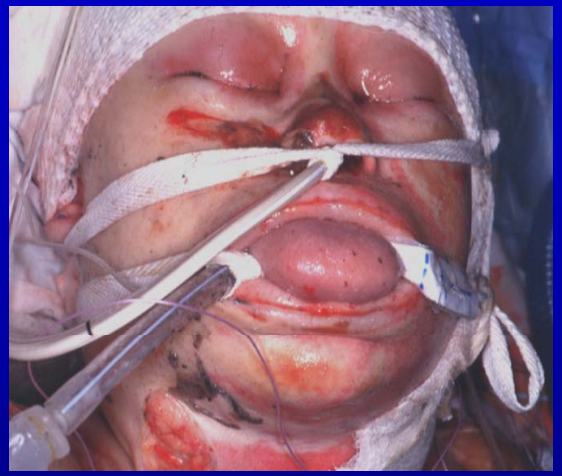
Resuscitation of Severely Burned Military Casualties: Fluid Begets More Fluid

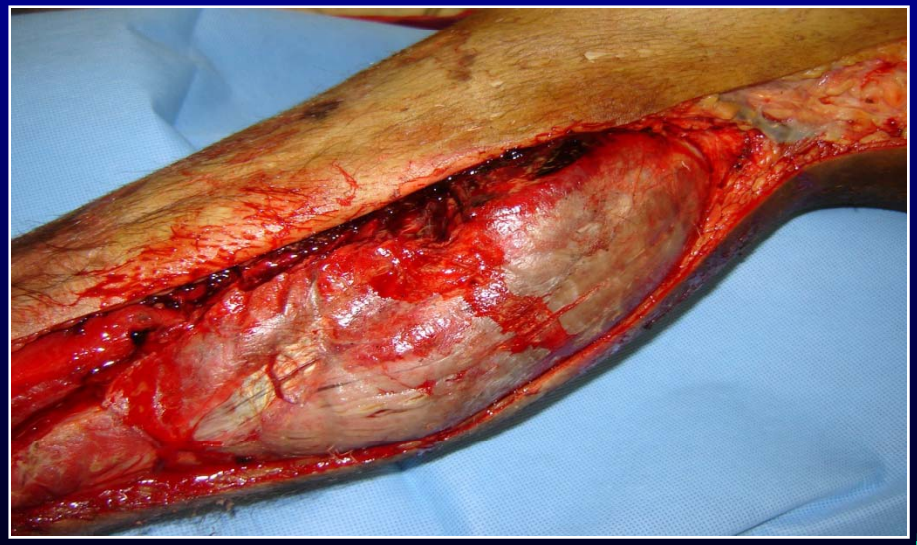
Kevin K. Chung, MD, Steven E. Wolf, MD, Leopoldo C. Cancio, MD, Ricardo Alvarado, MD, John A. Jones, BS, BBA, Jeffery McCorcle, PA, Booker T. King, MD, David J. Barillo, MD, Evan M. Renz, MD, and Lorne H. Blackbourne, MD

J Trauma 2009;67:231-237.



Over-resuscitation Morbidity





Abdominal Compartment Syndrome

- Over-resuscitation = ACS
- Overall 78% mortality
  - >45% TBSA
    - 97% Mortality

Ivy et al. J Trauma 2000;49:387-91
Markell et al. J Am Coll Surg 2009;208:940-7.