PROSPECTIVE STUDY OF CONTINUOUS NON-INVASIVE TISSUE OXIMETRY IN THE EARLY EVALUATION OF THE COMBAT CASUALTY

LTC Alec C. Beekley MD, LTC Matthew J. Martin MD, Teresa Nelson MS, COL Kurt W Grathwohl MD, MAJ Matthew Griffith MD, COL Gregory Beilman MD, COL(Retired) John B. Holcomb MD

Disclosure

- Hutchinson Technology, Inc. provided the InSpectra™ StO2 Tissue Oxygenation Monitors on loan for the conduct of this study.

- I have no financial relationship with Hutchinson Technology, Inc. or any other disclosures.

- The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

Background

- Hemorrhage accounts for ~80% of potentially preventable combat casualty deaths.
- Recognizing patients with significant hemorrhage and shock with clinical predictors alone continues to be challenging.
- These are patients who would benefit from immediate surgical control of hemorrhage.
- Not recognizing these patients may lead to increased mortality/morbidity.*

***Martin MJ, Oh J, et al. An Analysis of In-Hospital Deaths at a Modern Combat Support Hospital. J Trauma, 2009;66:S51-S61.**

STARS AND STRIPES®

Travolta flick sparks reflection on movie coolness

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John Travolta

Accuser's brother contradicts himself in Jackson testimony

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Oakland's NCAA run upsetting to Oral Roberts

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Oral Roberts' Ken Tutt

Volume 2, No.332 © SS 2005 MIDEAST EDITION THURSDAY, MARCH 10, 2005 Free in Deployed Areas

30 American contractors injured in suicide bombing

Rigged garbage truck explodes near Baghdad hotel

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Finding the bomb before it finds you

Page 4

Soldiers from the 1st Battalion, 13th Armor Regiment and the 70th Engineer Battalion found a roadside bomb near the Mushada Bridge in northern Baghdad on Monday and called in explosive ordnance disposal soldiers.

Background

The Journal of TRAUMA® Injury, Infection, and Critical Care

Can Near-Infrared Spectroscopy Identify the Severity of Shock in Trauma Patients?

Bruce A. Crookes, MD, Stephen M. Cohn, MD, FACS, Scott Bloch, BS, Jose Amortegui, MD, Ronald Manning, RN, Pam Li, RN, Matthew S. Proctor, BS, Ali Hallal, MD, Lorne H. Blackbourne, MD, Robert Benjamin, MD, Dror Soffer, MD, Fahim Habib, MD, Carl I. Schulman, MD, Robert Duncan, PhD, and Kenneth G. Proctor, PhD

The Journal of TRAUMA® Injury, Infection, and Critical Care

Tissue Oxygen Saturation Predicts the Development of Organ Dysfunction During Traumatic Shock Resuscitation

Stephen M. Cohn, MD, Avery B. Nathens, MD, PhD, MPH, Frederick A. Moore, MD, Peter Rhee MD, MPH, Juan Carlos Puyana, MD, Ernest E. Moore, MD, Gregory J. Beilman, MD, and the StO_2 in Trauma Patients Trial Investigators

Study Question

- Can the on-admission measurement of NIRS StO2 by the InSpectra™ Tissue Oxygenation Monitor provide detection of compensated shock in combat casualties arriving to a combat support hospital?

Methods

- Single Combat Support Hospital in Baghdad
- Inclusion criteria:
  - Litter-borne patients who sustained battle or non-battle injuries
- NIRS-derived tissue oxygenation (StO2) and Tissue Hemoglobin Index (THI) measured:
  - 1st choice: thenar eminence
  - deltoid
  - anterior thigh
- InSpectra™ StO2 Tissue Oxygenation Monitor
  - Measured throughout ER course (providers blinded)

Methods

- Variables:
  - Minimum (StO2 min)
  - 2 minute averaged StO2 (StO2 ave) and Tissue Hemoglobin Index (THI)
- Outcomes compared:
  - requirement for life-saving interventions (LSI)
    - Emergent airway, breathing, or circulation interventions
    - Emergent transfer to OR
  - any blood transfusion
  - massive transfusion (>10 units in 24 hours)
  - early mortality.

Methods

- Univariate and multivariate regression
- Variables:
  - StO2 variables
  - pulse character, blood pressure, heart rate, respiratory rate
  - hemoglobin, hematocrit, platelets, INR, base deficit, pH and temperature.

Results

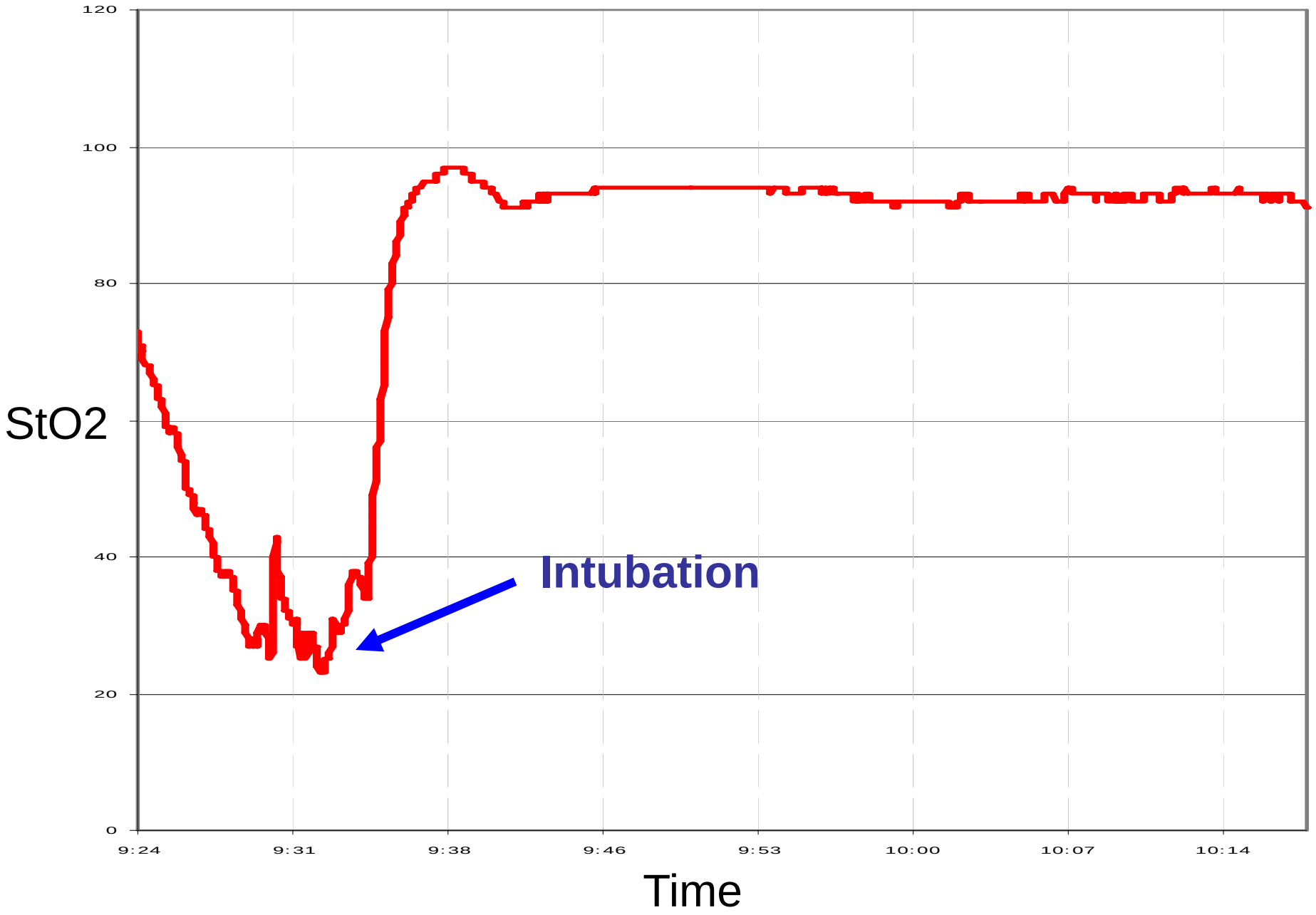
- 147 patients enrolled from August to December 2007
  - 93% male, mean age 27 years
  - 85% had explosion or GSW as mechanism.
  - Mean ISS 11.5 ± 12.3
  - 72 (49%) required a life-saving intervention.
  - 42 (29%) required blood transfusion.
  - 10 (7%) required massive transfusion.
  - 3 (2%) died.

Univariate analysis: LSI

Variable	LSI: Yes N = 72	LSI: No N = 75	P*
Radial Pulse char.	60/72 (83%)	73/74 (99%)	0.001
HR	103 ± 27	92 ± 24	0.003
Hgb	12 ± 2	14 ± 2	<0.0001
INR	1.2 ± 0.31	1.04 ± 0.19	0.001
BD	-3.3 ± 3.4	-0.9 ± 2.9	<0.0001
pH	7.3 ± 0.1	7.4 ± 0.1	0.0005
StO2	**74 ± 19**	**80 ± 13**	**0.016**

*sig., 2-tailed

GSW to left mandible, airway loss, GCS 8

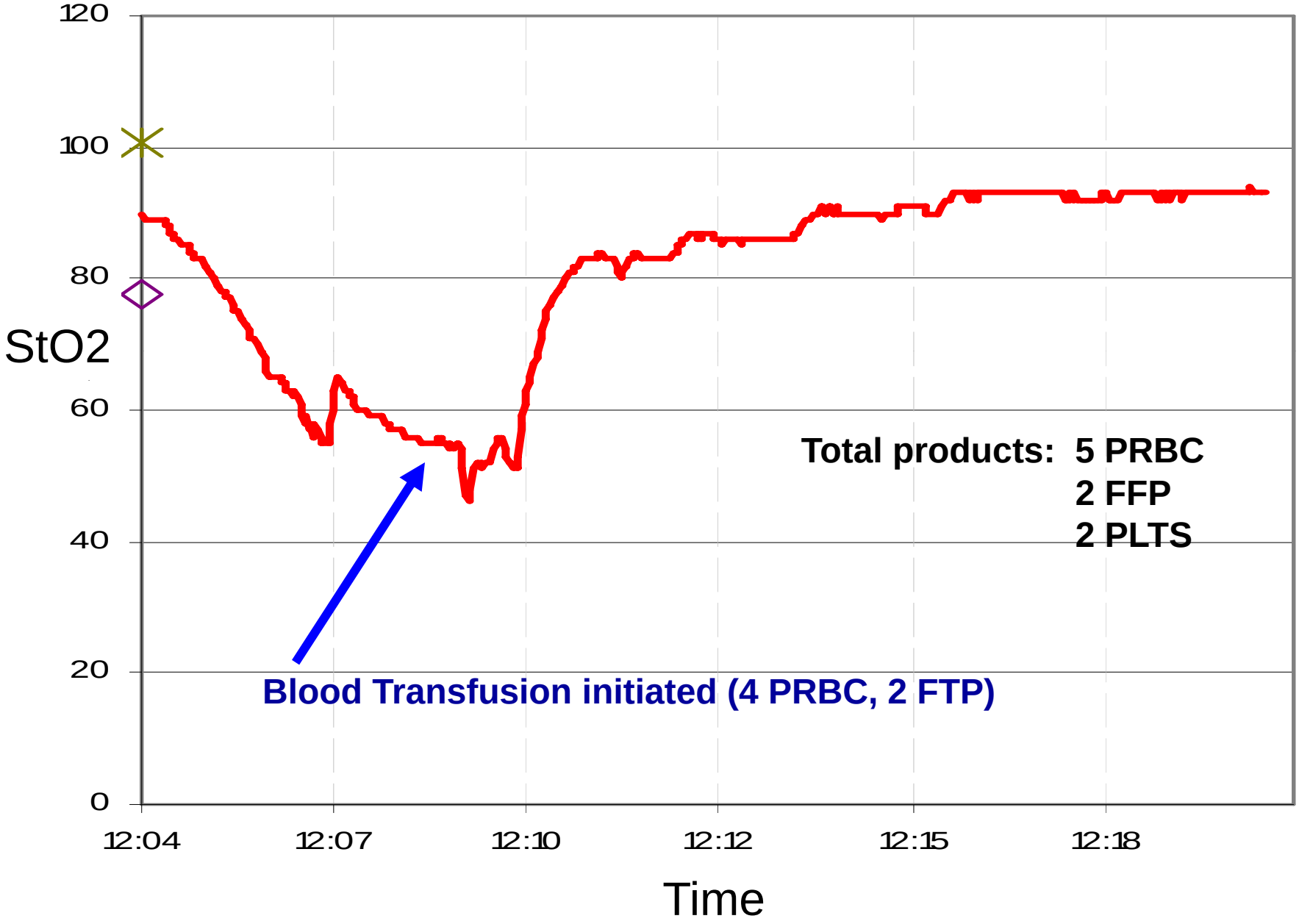


Univariate analysis: Blood transfusion

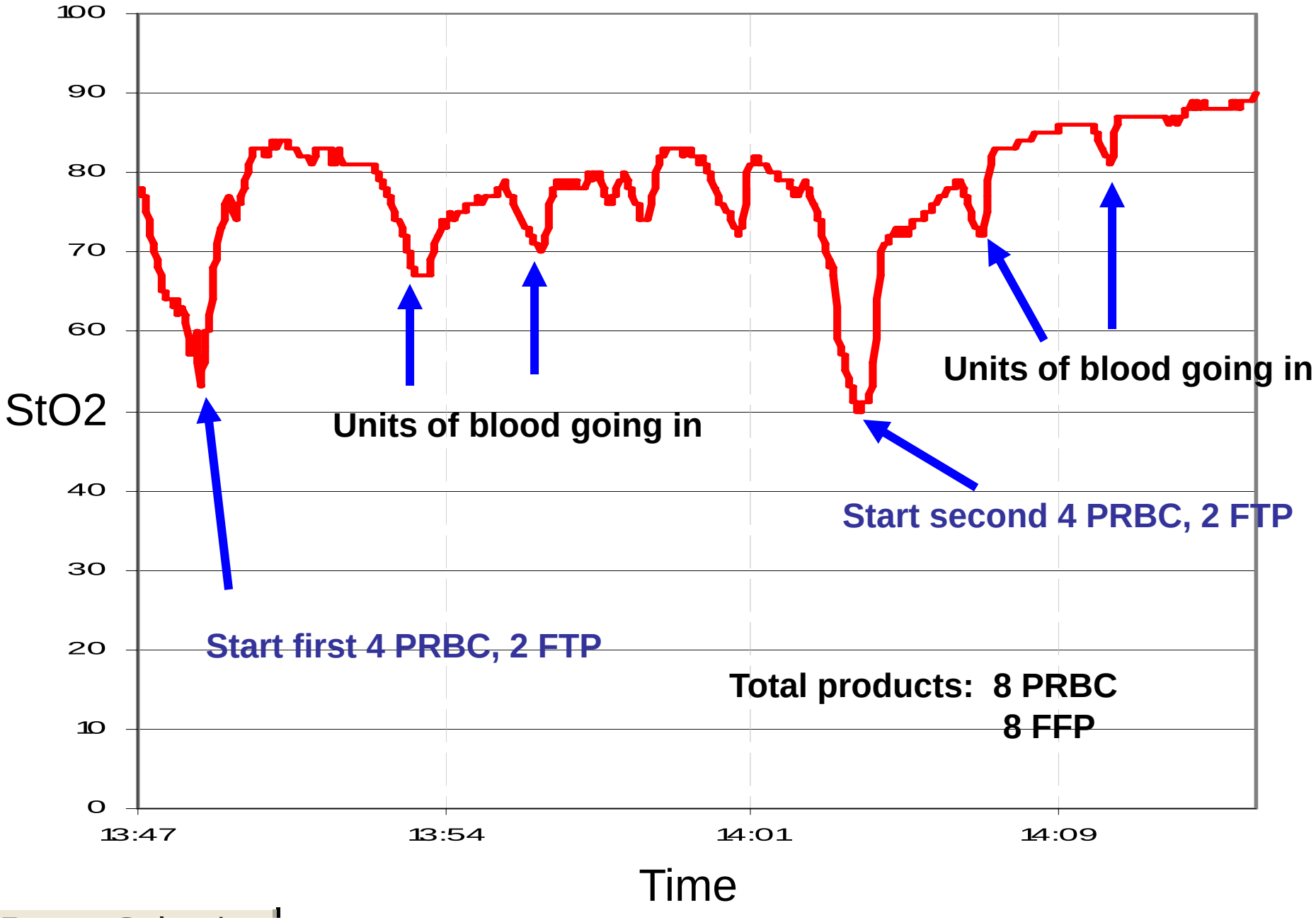
Variable	LSI: Yes N = 42	LSI: No N = 105	P*
Radial Pulse char.	32/42 (76%)	101/104 (97%)	<0.0001
SBP	108 ± 29	133 ± 17	<0.0001
HR	108 ± 29	93 ± 23	0.0009
Hgb	12 ± 2	14 ± 2	<0.0001
INR	1.23 ± 0.37	1.07 ± 0.19	0.001
BD	-3.3 ± 3.4	-0.9 ± 2.9	0.040
pH	7.3 ± 0.1	7.4 ± 0.1	0.0003
StO2	**71 ± 19**	**79 ± 14**	**0.010**

*sig., 2-tailed

GSW to pelvis



Trans-mediastinal GSW with cardiac tamponade

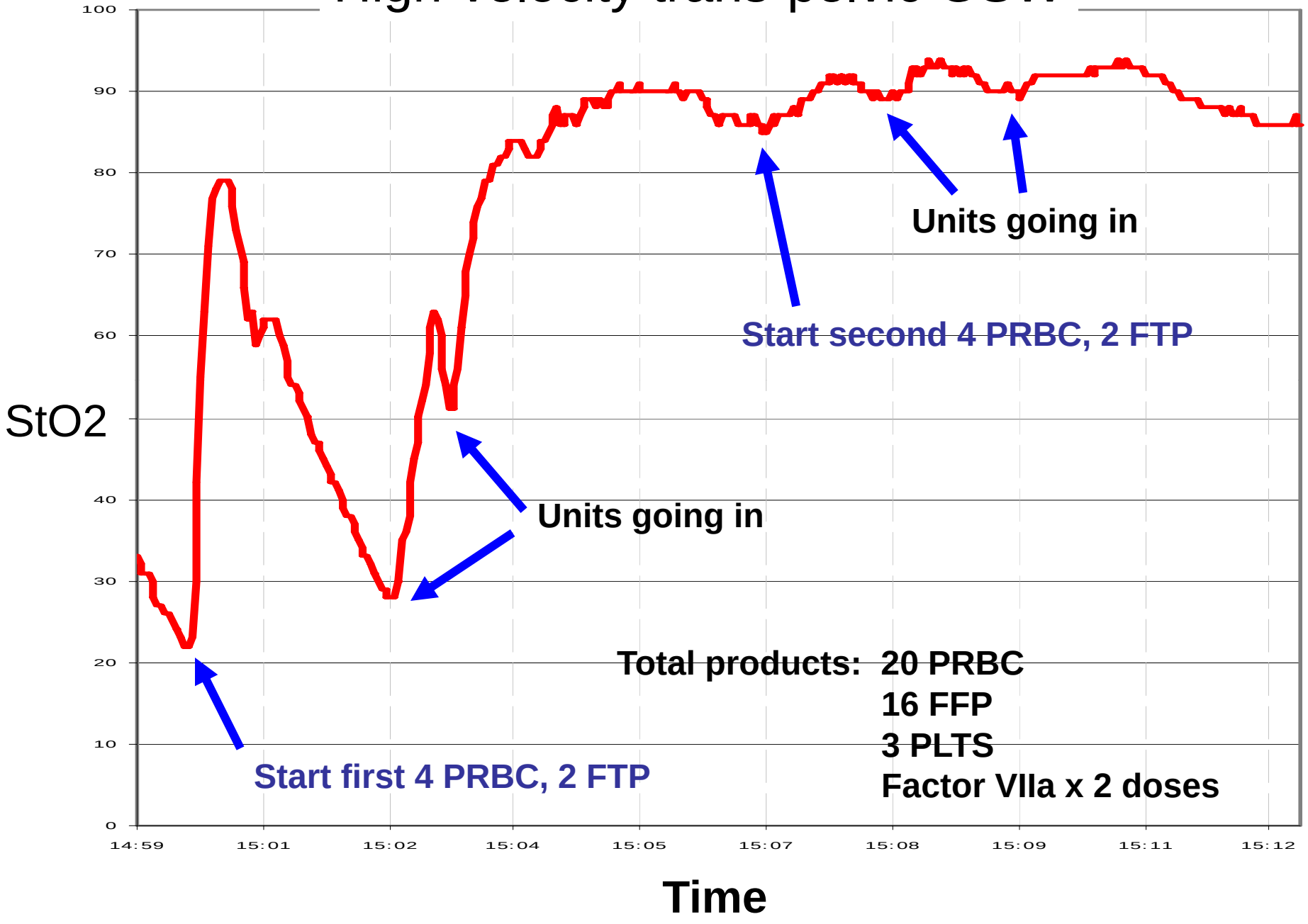


Univariate analysis: Massive transfusion

Variable	LSI: Yes N = 10	LSI: No N = 137	P*
Radial Pulse char.	5/10 (50%)	128/136 (94%)	0.0005
SBP	103 ± 46	127 ± 24	0.034
HR	122 ± 27	96 ± 25	0.0035
Hgb	12 ± 2	14 ± 2	0.010
INR	1.53 ± 0.42	1.09 ± 0.23	0.0002
pH	7.3 ± 0.1	7.4 ± 0.1	0.013
StO2	**62 ± 18**	**78 ± 16**	**0.003**

*sig., 2-tailed

High-velocity trans-pelvic GSW



Multivariate analysis

- StO2 average not retained in any model.
- LSI prediction:
  - INR, hematocrit, base deficit, and BP with an AUC 0.85
- Blood transfusion prediction:
  - SBP, INR, THI, and hematocrit with an AUC of 0.90
- Massive transfusion:
  - INR and hemoglobin with an AUC of 0.91

Univariate analysis of StO2

- AUC from single variable logistic regression models for StO2 average

Outcome	StO2 AUC (95% CI)
LSI	0.61 (0.49, 0.65)
Blood Transfusion	0.64 (0.55, 0.73)
Massive Transfusion	0.78 (0.63, 0.93)

Casualties with SBP > 90 on arrival

- **132 patients, mean arrival SBP 131**
- **30 (23%) received a blood transfusion.**
- **Independent predictors of transfusion:**
  - **StO2 min (OR 1.35)**
  - **hematocrit (OR 2.66).**

Limitations

- Ideally, sample size would be larger--particularly massive transfusion patients (only 10 in this dataset).
- StO2 values not used in clinical decision-making while other variables were.

Conclusions

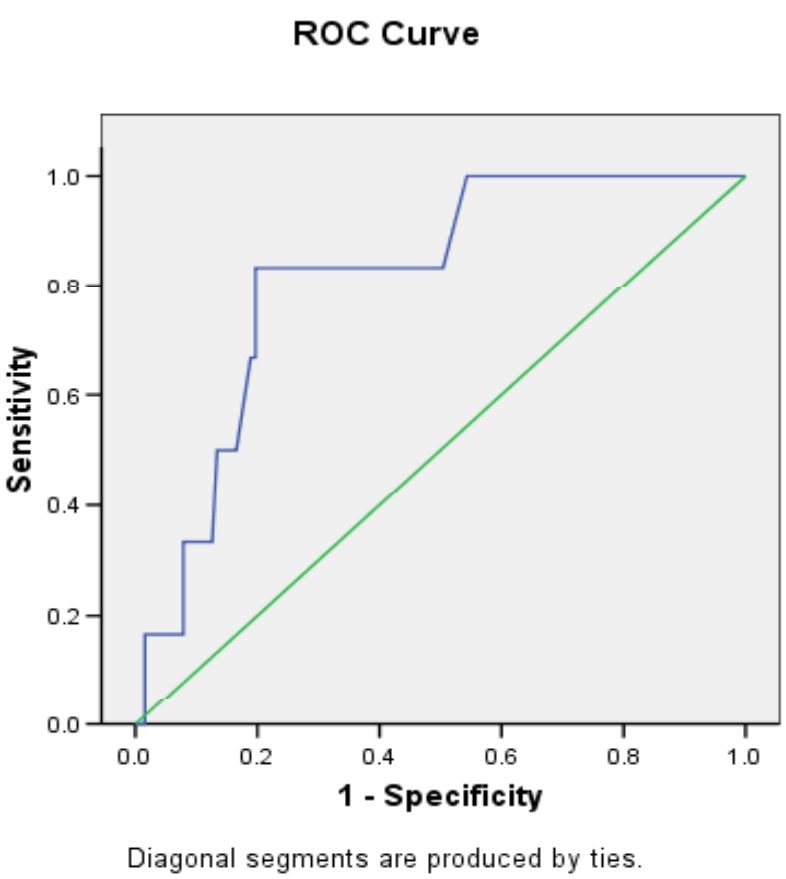
- In this study, StO2 tended to be overshadowed by other powerful predictors of LSI, blood transfusion, and massive transfusion (e.g. INR, hematocrit).
- However, StO2 predicted need for blood transfusion in casualties who appeared stable (arrival SBP > 90).
- Tissue Hemoglobin Index (THI) was retained in multivariate model to predict blood transfusion for the whole group.

Conclusions

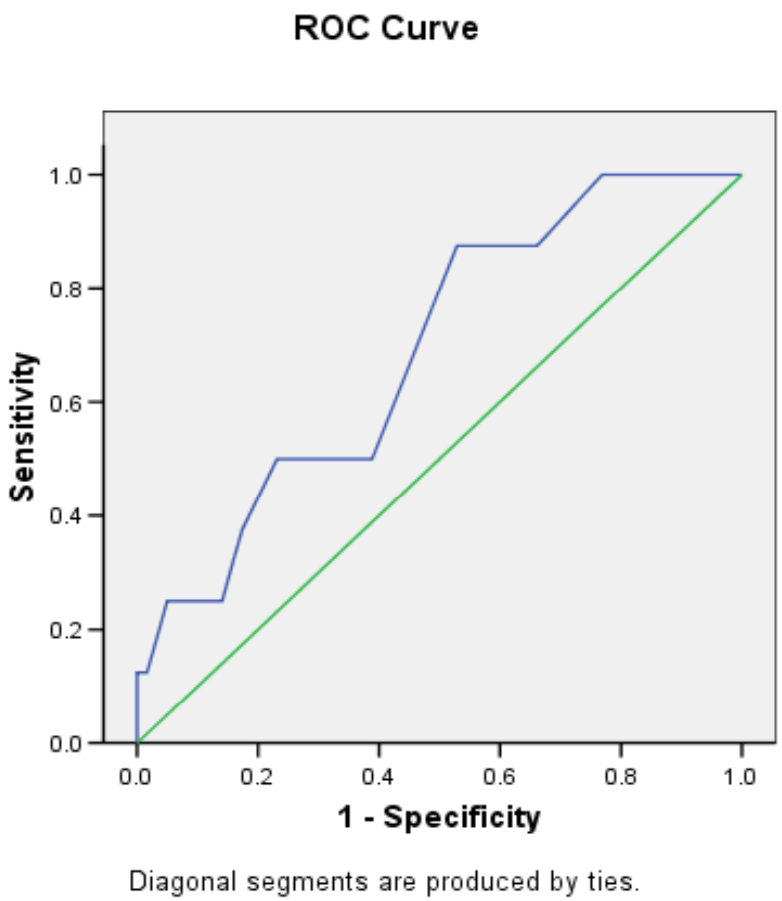
- StO2 has the advantage of being non-invasive and trended, while pH, BD, INR, and Hgb are invasive and discrete.
- Further studies on how to best employ tissue oximetry coupled with continued refinements of the device and software are needed to clarify the utility and indications for this promising technology.

SEA BLOSSO

Massive transfusion

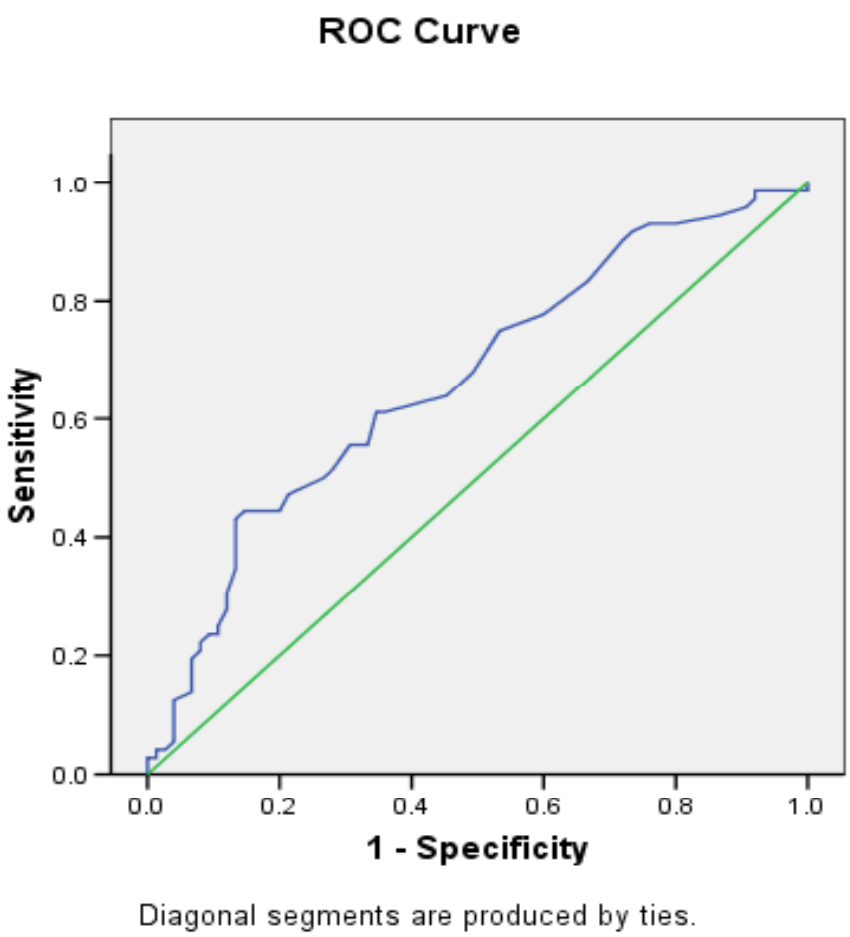


StO2 min AUC = 0.81

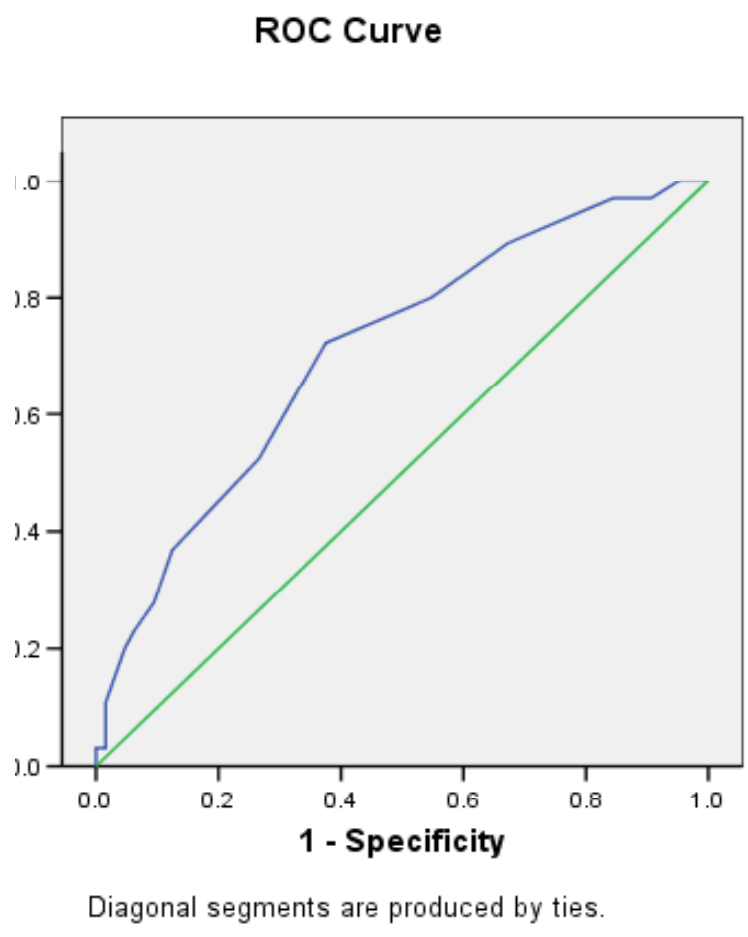


BD AUC = 0.69

Life-saving Interventions



StO2 min AUC = 0.67



BD AUC = 0.71

Accuracy

- For LSI:
  - Cutoff StO2 min: 79
    - Sensitivity: 68%
    - Specificity: 51%
- For blood transfusion:
  - Cutoff StO2 min: 80
    - Sensitivity: 76%
    - Specificity: 40%
- For massive transfusion:
  - Cutoff StO2 min: 75
    - Sensitivity: 90%
    - Specificity: 55%