

# **Are Patients Hypoperfused in the ED?**

## Rapid Perfusion Assessment in the Emergency Department

R. Benjamin Saldaña DO, FACEP  
Associate Medical Director  
Methodist Emergency Care Center, Houston TX

## Disclosure

- Honoraria for speaking
  - Hutchinson Technology Inc.
- No other financial interests

## **Emergency Department Process Improvement Considerations**

Patients often present with various etiologies affecting circulatory status

Common assessments are not always accurate or timely when determining circulatory status

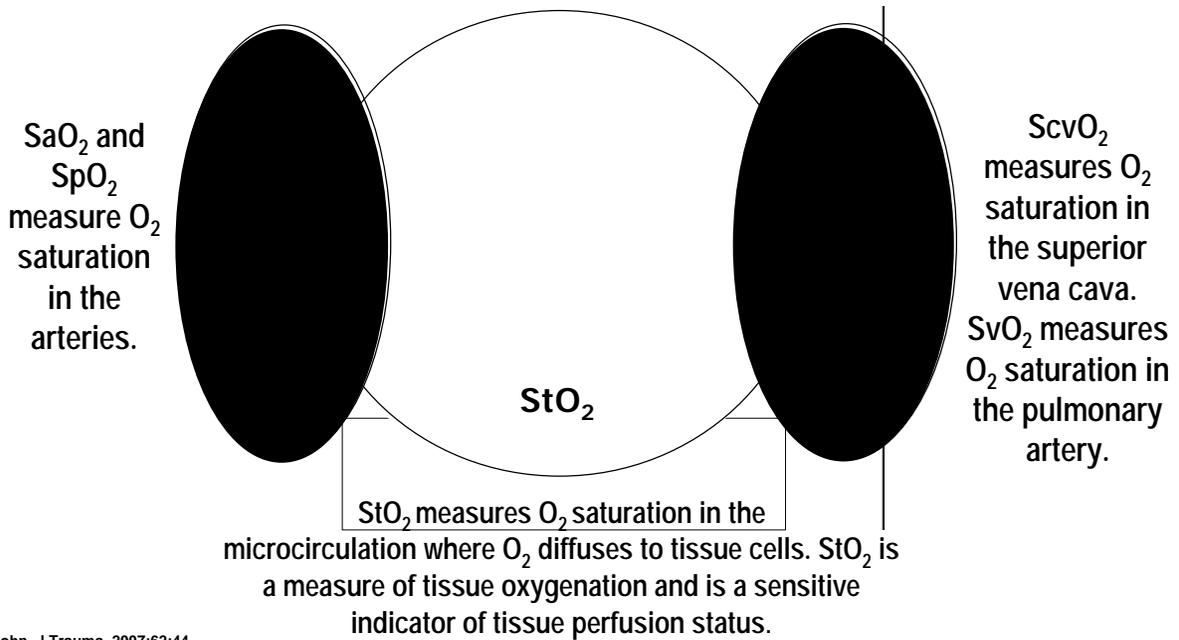
Are hypoperfused patients waiting to be treated and more importantly are some slipping through?

## **StO<sub>2</sub> Tissue Oxygen Saturation**

Rapid, Noninvasive  
Perfusion Assessment

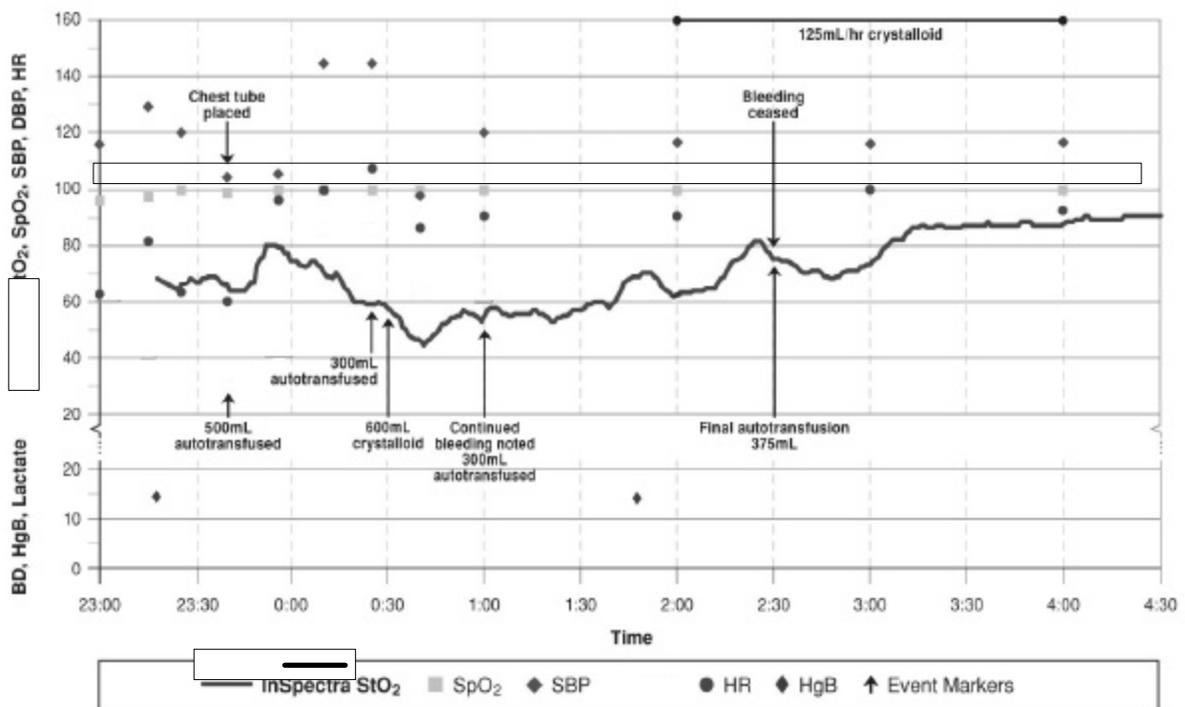
# What is StO<sub>2</sub>?

- StO<sub>2</sub> = hemoglobin oxygen saturation of the microcirculation



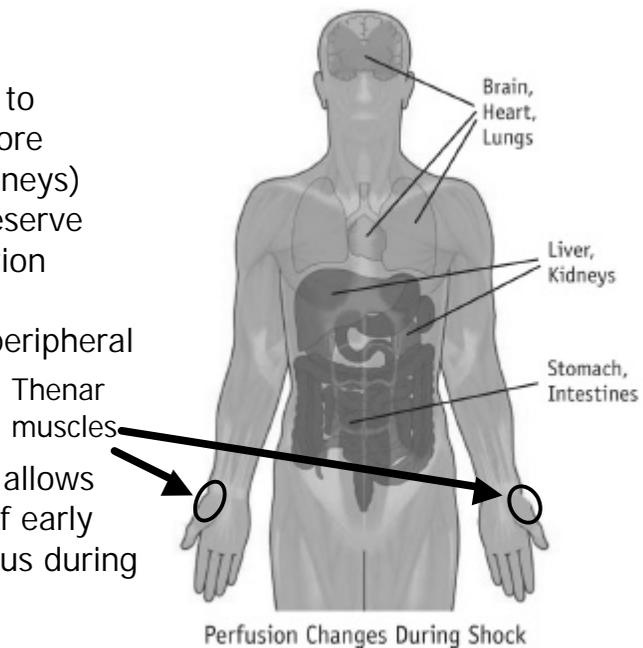
Cohn, J Trauma. 2007;62:44.

# StO<sub>2</sub> is not SpO<sub>2</sub>



# Why Measure Thenar Muscle?

- During shock, blood flow to peripheral muscles and core organs (liver, gut and kidneys) is reduced in order to preserve brain and heart oxygenation
- Thenar muscle group is peripheral muscle
- StO<sub>2</sub> measured in thenar allows noninvasive monitoring of early changes in perfusion status during low perfusion states and resuscitation



Chalmers, J Physiol. 1967;192:561.  
Beilman, Shock. 1999;12:196.

# The Supporting Data

- Published studies have demonstrated that low StO<sub>2</sub> (=75%) is associated with poor outcomes in different patient types:
  - Traumatic shock
  - Septic shock
  - Mixed ICU patient populations
- Monitoring patients with sepsis has clinical utility
- Medical bleeding has similar pathophysiology to trauma

# Trauma Study #1:

Cohn et al

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<sub>2</sub> in Trauma Patients Trial Investigators

- Seven level I trauma centers
- 383 severely injured trauma patients
- Study endpoints: MODS and death
- Conclusions:
  - StO<sub>2</sub> predicted development of MODS or death
  - 75% StO<sub>2</sub> cutoff provided best trade-off of sensitivity/specificity

# Trauma Study #2:

Moore et al

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

## Massive Transfusion in Trauma Patients: Tissue Hemoglobin Oxygen Saturation Predicts Poor Outcome

Frederick A. Moore, MD, Teresa Nelson, MS, Bruce A. McKinley, PhD, Ernest E. Moore, MD, Avery B. Nathens, MD, PhD, MPH, Peter Rhee, MD, MPH, Juan Carlos Puyana, MD, Gregory J. Beilman, MD, Stephen M. Cohn, MD, and the StO<sub>2</sub> Study Group

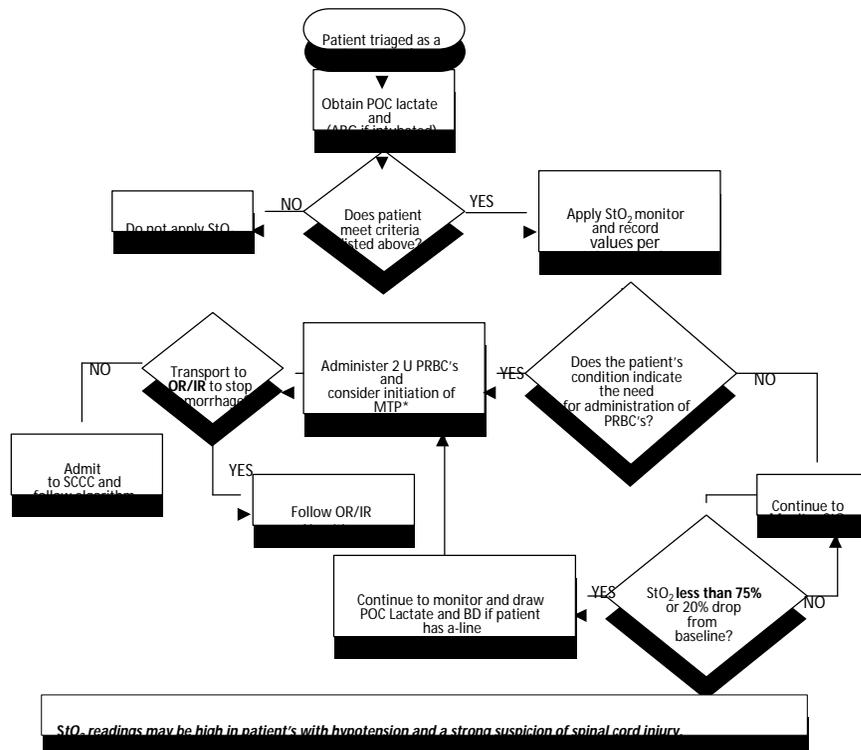
- Same data set as Cohn
- 114 patients (30%) required massive transfusion
- Study endpoints: MODS and death
- Conclusions:
  - Persistent low StO<sub>2</sub> only consistent predictor of poor outcome
  - Knowing this early may change treatment strategies and improve outcome

# Trauma Study #3: Sagraves et al

## Tissue Oxygenation Monitoring in the Field: A New EMS Vital Sign

*Scott G. Sagraves, MD, Mark A. Newell, MD, Michael R. Bard, MD, Frank R. Watkins, RN, BSN,  
Kevin J. Corcoran, MD, Pamela D. McMullen, RN, BSN, and Michael F. Rotondo, MD*

- Pre-hospital, ambulance and helicopter
- 41 patients
- Study endpoints: Mortality
- Conclusions
  - StO<sub>2</sub>, during transport, was significantly different between survivors and non-survivors
  - As StO<sub>2</sub> decreased, the odds of dying increased
    - For every 10% StO<sub>2</sub> drop, odds of death increased 3 times



# Trauma Conclusions

- Low StO<sub>2</sub> is associated with poor outcomes
  - Low StO<sub>2</sub> is a Red Flag and should be investigated
- StO<sub>2</sub> helps guide resuscitation in trauma patients

## ICU Study #1: Leone et al

Anesthesiology 2009; 111:366-71

Copyright © 2009, the American Society of Anesthesiologists, Inc. Lippincott Williams & Wilkins, Inc.

### ***Oxygen Tissue Saturation Is Lower in Nonsurvivors than in Survivors after Early Resuscitation of Septic Shock***

Marc Leone, M.D., Ph.D.,\* Sami Blied, M.D.,† François Antonini, M.D.,\* Bertrand Meyssignac, M.D.,† Sébastien Bordon, M.D.,† Frédéric Garcin, M.D.,‡ Aude Charvet, M.D.,‡ Valéry Blasco, M.D.,\* Jacques Albanèse, M.D., Ph.D.,§ Claude Martin, M.D.||

- Resuscitated ICU septic shock patients
- 42 patients enrolled; 13 (31%) died
- Study endpoint: Relationship of StO<sub>2</sub> to 28-day mortality
  
- Conclusions
  - StO<sub>2</sub> significantly lower in those who died
  - Patients with StO<sub>2</sub> below 78% at increased risk of mortality
  - ScvO<sub>2</sub>, lactate, MAP, UO, CI, cap refill time, nor hemoglobin distinguished survivors from non-survivors

# ICU Study #2:

Lima et al

Available online <http://ccforum.com/content/13/S5/S13>

Research

**Low tissue oxygen saturation at the end of early goal-directed therapy is associated with worse outcome in critically ill patients**

Alexandre Lima, Jasper van Bommel, Tim C Jansen, Can Ince and Jan Bakker

- Critically ill ICU patients
- 22 patients enrolled
- Study endpoint: organ dysfunction and disease severity
- Conclusion
  - Pts who failed to normalize StO<sub>2</sub> had more severe organ dysfunction and disease severity
  - Persistently low StO<sub>2</sub> was associated w/increased mortality

Lima, Crit Care. 2009;13(Suppl 5):S13.

15 of 38

# ICU Study #3:

Veening et al

*A750 - Incidence of a low StO<sub>2</sub> in a mixed population of critically ill patients*

**A Veening ; C Ince ; J Bakker**

*Erasmus MC University Medical Center, Intensive Care Adults, Rotterdam, Netherlands*

- Abstract only; Mixed ICU population
- 41 patients; one-time StO<sub>2</sub> measurement
- Study endpoint; incidence of low StO<sub>2</sub> and mortality
- Conclusion
  - Incidence of abnormal StO<sub>2</sub> in critically ill pts is high despite having first resuscitated the patients
  - Very low StO<sub>2</sub> values are found frequently and may be associated with increased mortality

Veening, Crit Care. 2010;14(Suppl 1):P151.

16 of 38

# Other Bleeders

- GI bleed
- Vaginal bleed
- Nose bleed
- Good data now coming for transfusion
  - Beekley et al. Continuous non-invasive tissue oximetry in the early evaluation of the combat casualty: A prospective study. J Trauma. 2010. 69:1. s14-s24.

# Treatment versus Triage

- Most non ED data is on treatment criteria
- Does StO<sub>2</sub> have promise as a triage tool for a broader range of ED patients

# Limited Research

- One study
- Near infrared spectroscopy to assess systemic perfusion and improve triage in the emergency department and critically ill

– Kierzek et al. Int Care Med. 2008;34(Supp 1):S22.  
Abstract

# The Patients

- 856 patients
- Triaged all incoming patients
- 93 admissions (11%)
- Initial reading did not correlate to admission
- StO<sub>2</sub> did correlate to ICU admission

# The Gestalt

- What does this study mean?
- Very low admission rate?
- What were they studying?
- Is medical admission an accurate endpoint?
- Should they have zoned in on a specific group?

# ED Assumptions

Patients often present to the ED with etiologies which may affect circulatory status

StO<sub>2</sub> can help detect circulatory insufficiency  
(*hypoperfusion, StO<sub>2</sub> = 75%*)

- Despite non-alarming clinical signs
- Despite treatments to achieve target vital signs

# Emergency Department Evaluation Objective

- Identify the incidence of circulatory insufficiency (hypoperfusion) in at risk ED patients
- The At-risk Patient Population
  - All elderly,  $\geq 65$ , high acuity patients
  - Any age, at risk for medical bleeding
  - Any age, high risk for hypoperfusion

## ED Evaluation Methods

- StO<sub>2</sub> Tissue Oxygenation Monitor, applied to the thenar
- Single StO<sub>2</sub> measurement recorded after sensor in place 30 seconds to 2 minutes
- Data collected: StO<sub>2</sub>, vital signs, primary complaint, age, ESI category
  - During initial patient assessment
  - Recorded periodically until patient discharged or admitted
  - StO<sub>2</sub> below 75% reported to physician who could choose to further assess patient

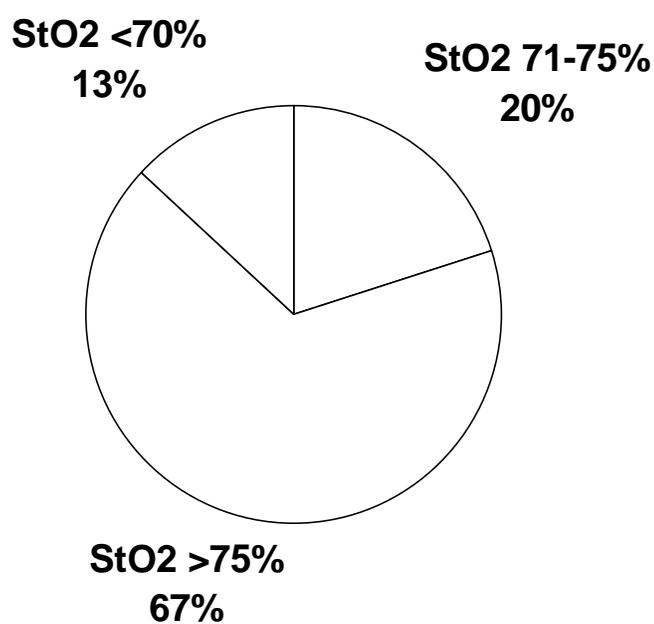
# Results: Multiple Sites

11 sites...n=492

| Hospital | Lowest StO <sub>2</sub> in ER<br><i>Frequency =75%</i> | StO <sub>2</sub> After Treatment<br><i>Frequency =75%</i> |
|----------|--|---|
| 1        | 14%  | 10%   |
| 2        | 17%  | 12%   |
| 3        | 23%  | <i>Not Recorded</i>                                       |
| 4        | 23%  | 10%   |
| 5        | 30%  | <i>Not Recorded</i>                                       |
| 6        | 38%  | 24%   |
| 7        | 38%  | 25%   |
| 8        | <i>Not Recorded</i>                                    | 29%   |
| 9        | 43%  | 25%   |
| 10       | 44%  | 40%   |
| 11       | 68%  | 46%   |

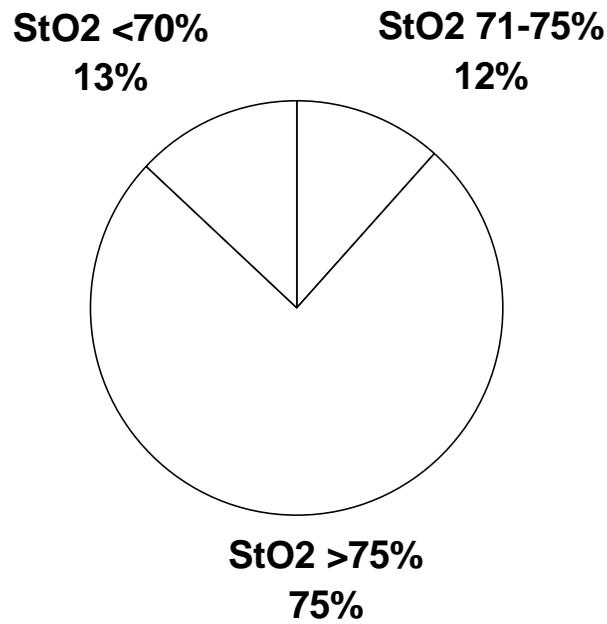
## 11 ER Sites - Lowest StO<sub>2</sub> n=492

33% with StO<sub>2</sub> <75% (range 14-70%)



## 11 ER Sites - StO<sub>2</sub> Post Treatment n=440

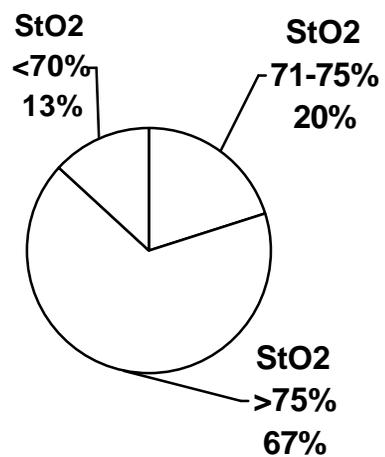
25% with StO<sub>2</sub> <75% (range 10-46%)



## Patient Primary Complaints and Diagnostic Impressions\*

- 13% Shortness of Breath
- 10% Chest Pain
- 7% Abdominal Pain
- 6% Bleeding - GI
- 5% Dizziness
- 5% Fall – Ground Level
- 5% Syncope
- 4% Fever
- 4% Weakness - General
- 3% Vomiting, Nausea, and/or Diarrhea
- 3% Heart Rhythm Irregular (A Fib, palpitations)
- 3% Swelling or Edema (arm, leg, groin)
- 3% Hypotension

33% with StO<sub>2</sub> <75% n=492



\*Partial list of primary complaints

## Evaluation Discussion

- StO<sub>2</sub> identified reduced circulatory status (hypoperfusion) and in some patients hypoperfusion persisted following standard treatments in the ED
  - Elderly patients' fluid status seems to be harder to evaluate
  - StO<sub>2</sub> may find people whose hypoperfusion may have been unaddressed

## The Methodist Experience

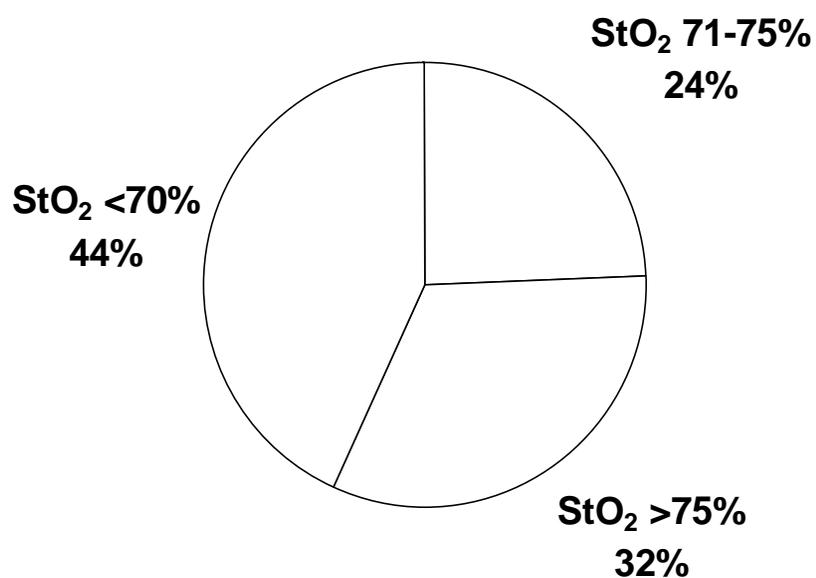
- 1200 bed hospital
- 40,000 ED visits per year
- Admit 46% of all ED visits
- StO<sub>2</sub> measurements taken in ED over four consecutive days

# Results $n=37$

- 68% of the monitored patients had circulatory insufficiency (hypoperfusion) as identified by  $StO_2 = 75\%$ 
  - 44% with  $StO_2 = 70\%$
- Following treatment, 46% continued to have  $StO_2 = 75\%$ 
  - 19% with  $StO_2 = 70\%$

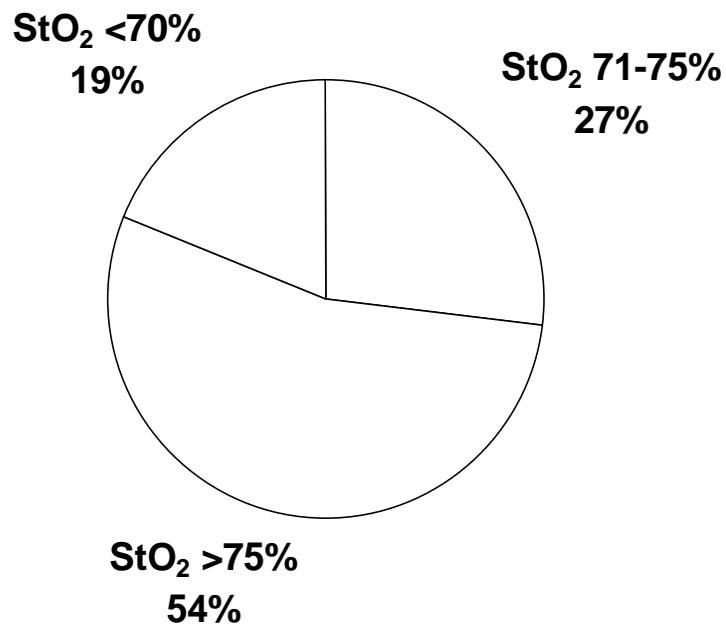
## Lowest Recorded $StO_2$ in ER

68% with  $StO_2 < 75\%$   $n=37$



## StO<sub>2</sub> Following Treatment in ER

46% with StO<sub>2</sub> <75% n=37



## Case Study

- Male > 65 y/o.
- Presented in ER due to hypotension
  - Lactate in ER 2.4
  - 2 liters NS administered

|                  | 12:27  | 13:02  | 14:17  | 15:07  |
|------------------|--------|--------|--------|--------|
| BP               | 103/50 | 121/57 | 101/70 | 117/93 |
| HR               | 80     | 79     | 80     | 80     |
| RR               | 24     | -      | 16     | 25     |
| SpO <sub>2</sub> | -      | 100    | 100    | 97     |
| StO <sub>2</sub> | 78     | 60     | 74     | 66     |

### •Hospital Course:

- Transferred to the floor
- Additional fluids after transfer.

# Case Study

- Male > 65 y/o presented with rectal bleeding which had persisted for 3 days

- Lactate 1.3
- Hgb 9.5
- T 96.8

|                 | 11:00  | 11:25  | 12:15  | 13:40  |
|-----------------|--------|--------|--------|--------|
| BP              | 126/60 | 122/66 | 110/59 | 133/71 |
| HR<br>Pacemaker | 61     | 66     | 60     | 60     |
| RR              | 30     | -      | -      | 21     |
| SpO2            | 99     | 98     | 100    | 99     |
| StO2            | 58     | 69     | 73     | 68     |

- **Hospital Course:**

**Pt transferred to medical floor**

**2 blood transfusions administered day 2**

**1 blood transfusion administered day 3**

**Discharged to home day 5**

## Conclusions

- StO<sub>2</sub> still in its infancy in ED
- Appears to have utility as monitoring tool for critically ill, trauma, bleeding and septic patients
- May have tremendous utility as a screening tool for the elderly

# FINAL CONCLUSION

- ELDERLY PATIENTS HELD IN THE EMERGENCY DEPARTMENT HAVE A VERY HIGH RATE OF HYPOPERFUSION
  - Despite non-alarming vital signs
  - Despite treatment to achieve target vital signs