Shock Index and Injury Severity Score: Predictors of Mortality After Multi-System Trauma

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Purpose

- To compare calculated pre-hospital shock index and calculated ED shock index with the Injury Severity Scores reported in the National Trauma Data Bank in their ability to predict death within 48 hours of sustaining traumatic injuries

Death from Injury

Trauma Mortality

- Unintentional injury is the 5th leading cause of death in the US, at 38.4/100,000
- MVC deaths, 11.2/100,000
- All injury deaths 57.7/100,000
- Leading cause of death ages 1-44
- Leading cause of death in males, ages 1-44
- Leading cause of death in females, ages 1-34

Assessing Injury Severity

- Multiple, complex injuries
- Often not fully manifested at time of initial examination
- Limits of time and resources pre-hospital
- Transport issues

Injury Severity Scoring

- Anatomic Scores
  - Abbreviated Injury Scale (AIS): probability of threat to life based on individual injury, describes type, location and severity of injury
  - Injury Severity Score (ISS): sum of the squares of the AIS for the 3 most severely injured regions
- Physiologic Scores
  - Revised Trauma Score (RTS): physiologic scoring system, includes GCS, SBP and RR, range 0 to 4
- Combined Score
  - Trauma Score-Injury Severity Score (TRISS): mathematic model of probability of survival

AIS

- Anatomical scoring system
- Provides a reasonably accurate ranking of injury severity
- Represents the 'threat to life' associated with an injury
- Not meant to represent a comprehensive measure of severity.

AIS Score	Injury
1	Minor
2	Moderate
3	Serious
4	Severe
5	Critical
6	Unsurvivable

ISS

- Anatomical scoring system that provides an overall score for patients with multiple injuries
- Each injury is assigned an AIS score allocated to one of six body regions (Head, Face, Chest, Abdomen, Extremities, External)
- Only the highest AIS score in each body region is used
- The 3 most severely injured body regions have their score squared and added together to produce the ISS score.

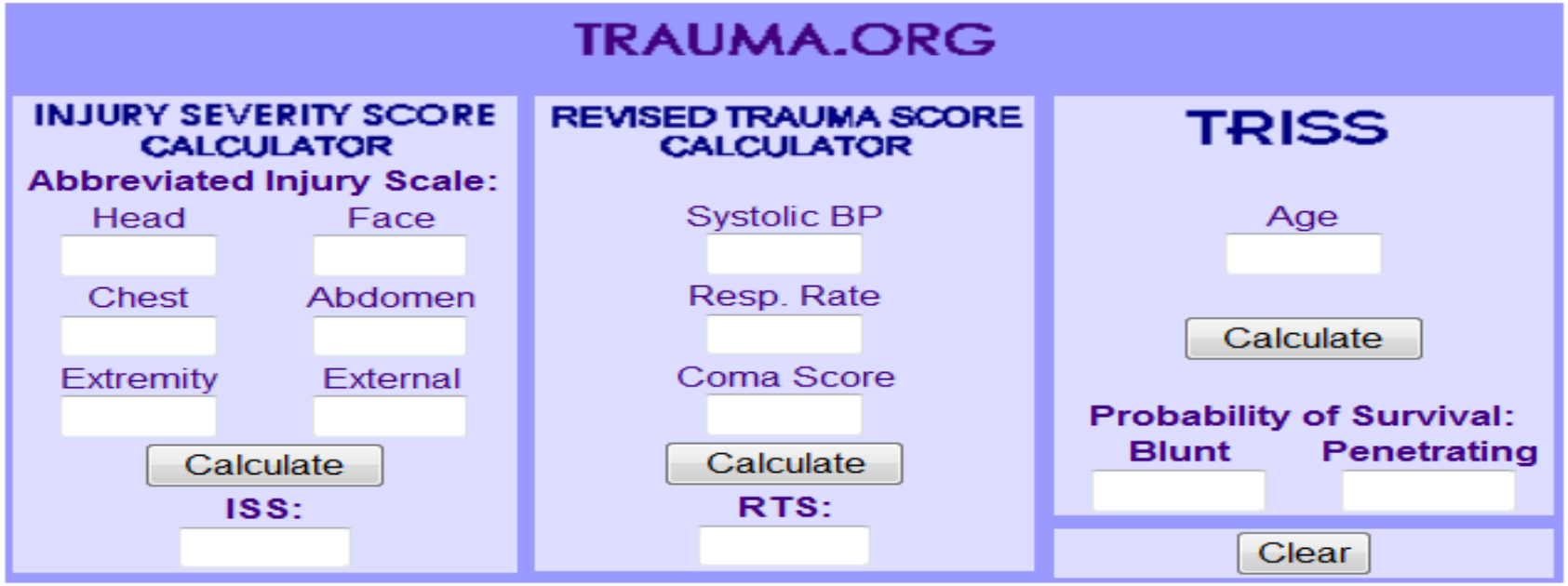
RTS

- Physiologic scoring system
- High inter-rater reliability
- Demonstrated accuracy
- Scored from first set of data obtained
- Heavily weighted toward GCS
- Does not account for compensated shock

GCS	SBP	RR	Coded Value
13-15	>89	10-29	4
9-12	76-89	>29	3
6-8	50-75	6-9	2
4-5	1-49	1-5	1
3	0	0	0

TRISS

- TRISS determines the probability of survival (Ps) of a patient from the ISS and RTS using a mathematical formula
- The TRISS calculator determines the probability of survival from the ISS, RTS and patient's age



NTDB ISS Reported

- ISSLOC – reflects the patient injuries as calculated by the receiving hospital
- ISSICD – derived by converting ICD-9 codes to an AIS then calculating ISS
- ISSAIS – ISS calculated from the AIS by the receiving facility

The Problem

- These scores cannot be calculated on the scene by EMS personnel to make transport decisions
- These scores are not easily calculated in the ED
- ISSICD requires addition of ICD-9 codes to the score

Searching for a Solution

- Identify a major cause of early trauma death
- To determine a field expedient, accurate scoring system
- To use that system to ensure the right patient is taken to the right place in the right amount of time
- Goal: to improve outcomes in trauma care
- To provide the right care, right now

Clinical Outcome of Interest

- Shock
- Hemorrhagic Shock
- Hemorrhagic Shock in Trauma

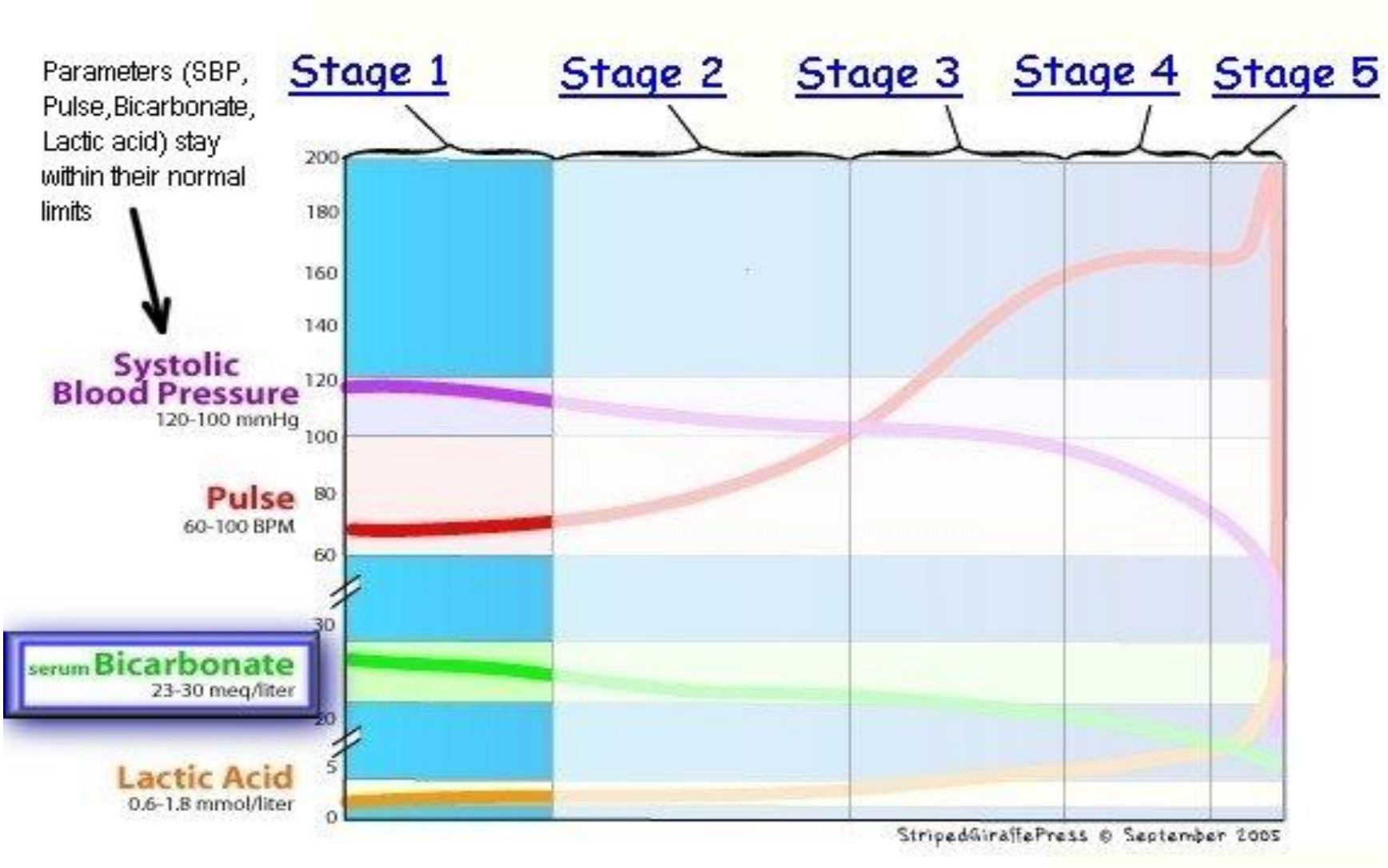
Shock

- Inadequate tissue oxygenation to meet tissue oxygen requirements
- Condition of the inadequate delivery of oxygen and nutrients necessary for normal tissue and cellular function
- State of inadequate tissue perfusion in which delivery of oxygen to tissues and cells is insufficient to maintain normal aerobic metabolism

ANTICIPATION STAGE

- The disease has started but remains local.
- You should already suspect that shock could appear if the underlying disease is left undiagnosed and untreated.
- Parameters are stable and within normal limits.
- There is usually enough time to diagnose and treat the underlying condition.

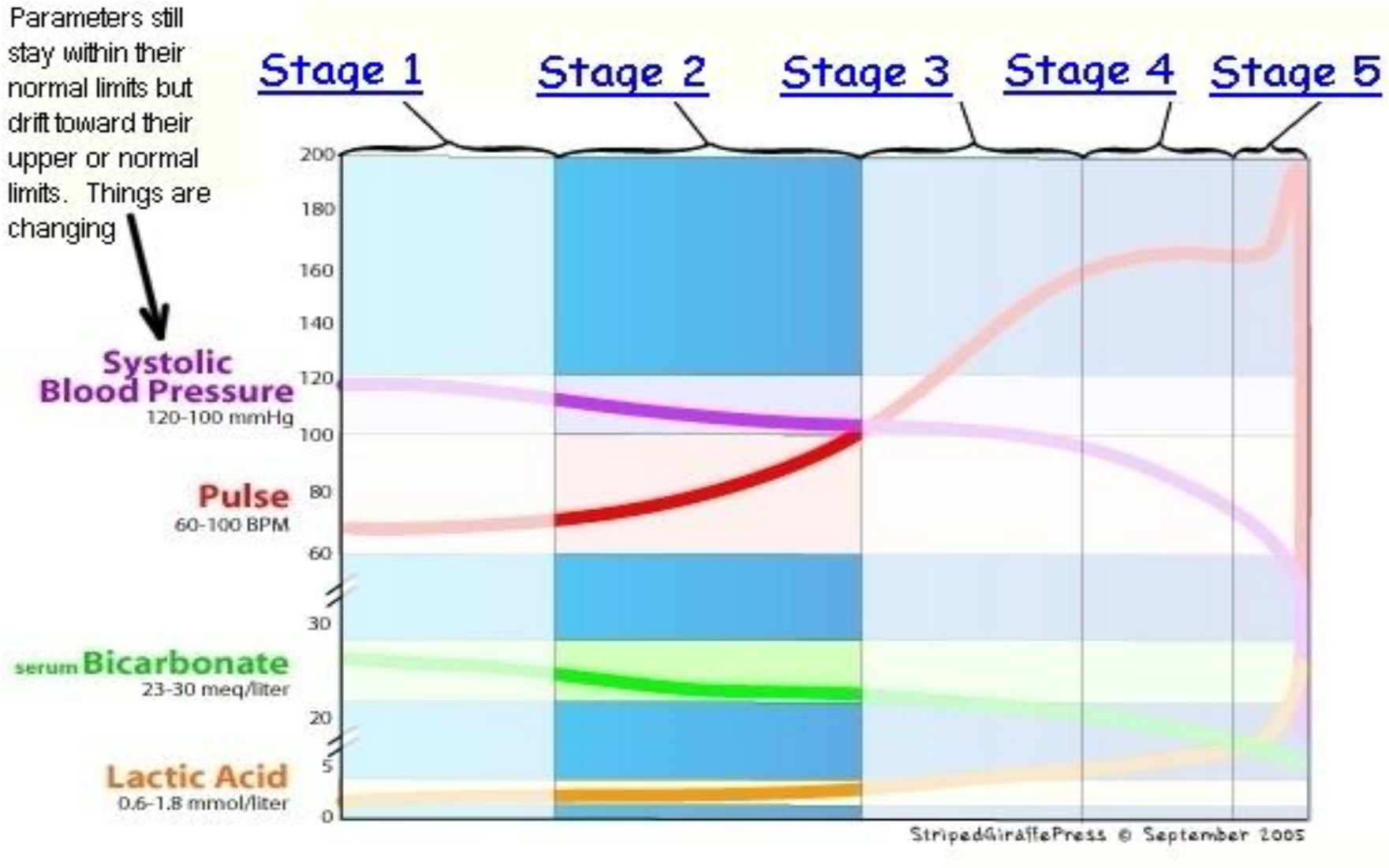
Anticipation Stage



Pre-Shock

- The disease is now systemic.
- Parameters drift, slip and slide and start hugging the upper or lower limit of their normal range, but there is no shock yet!
- The absence of shock is due to the fact that compensatory mechanisms are at play.
- The condition of pre-shock is, sadly, completely missed by many clinicians

Pre-Shock


Parameters still stay within their normal limits but drift toward their upper or normal limits. Things are changing
Stage 1
Stage 2
Stage 3
Stage 4
Stage 5
Systolic Blood Pressure
120-100 mmHg
Pulse
60-100 BPM
serum Bicarbonate
23-30 meq/liter
Lactic Acid
0.6-1.8 mmol/liter
200
180
160
140
120
100
80
60
30
20
5
0
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Compensated Shock

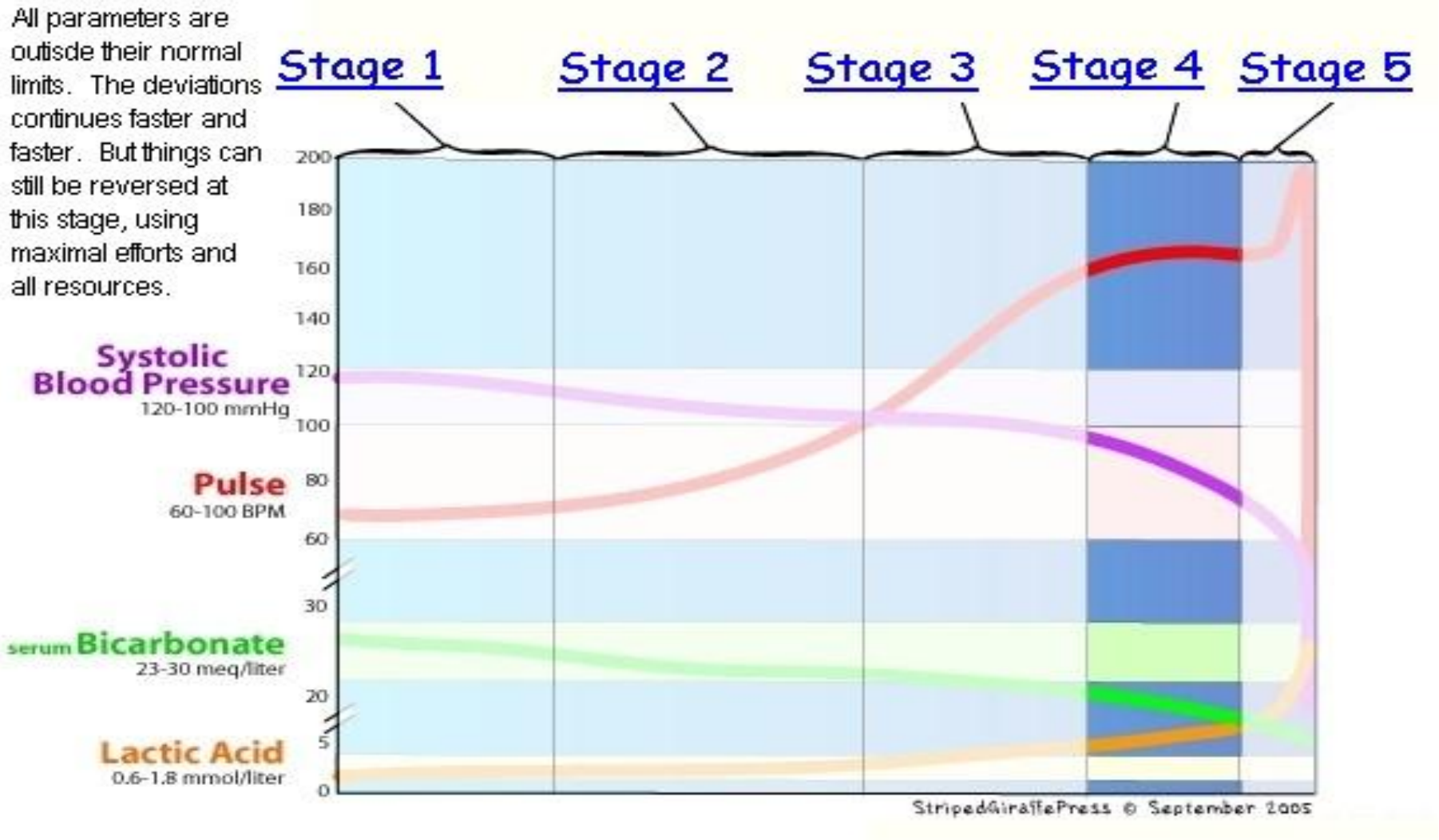
- Compensated shock can start with low normal blood pressure
- The proof that a patient is in shock with normal blood pressure is the appearance of metabolic acidosis due to some organ hypoperfusion.
- The reason for normotension is that blood pressure is maintained initially due to marked activation of many compensatory mechanisms (including the sympathetic nervous system).
- However, because organs suffer from inadequate perfusion, it is already a state of shock.

Compensated Shock

Decompensated Shock, Reversible

- Everybody call this "SHOCK" because hypotension is always present at this stage.,
- Normotension can only be restored with intravenous fluid (if indicated) and/or vasopressors.
- If you have not diagnosed the cause of shock by now, it will be very difficult to treat your patient
- Organs now suffer MODS and acidosis is becoming rapidly more and more severe.
- This systemic suffering worsens shock itself (vicious cycles) and leads to catastrophic microvascular damage, DIC and SIRS.

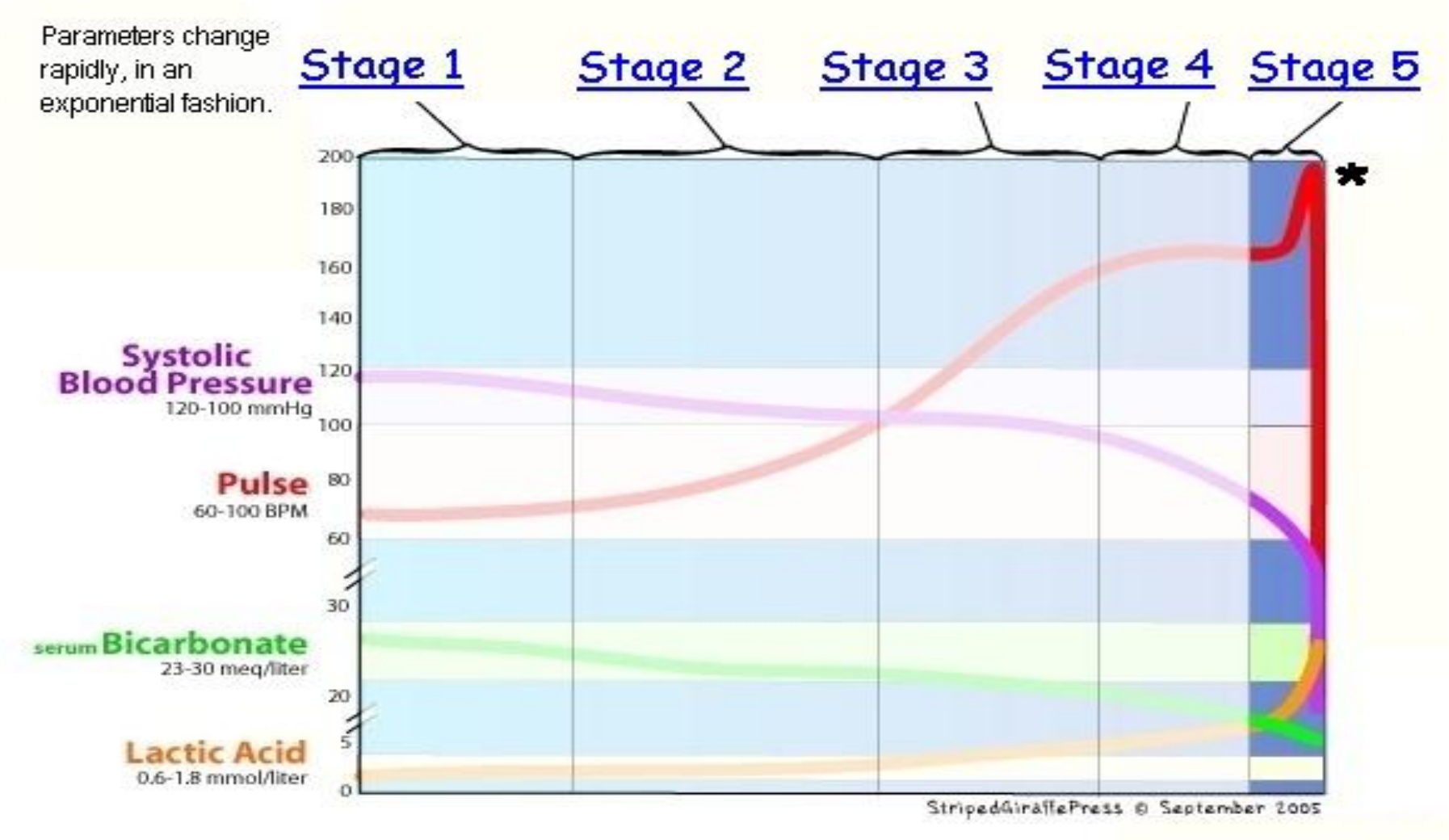
Decompensated Shock, Reversible



Decompensated Shock, Irreversible

- Microvascular and organ damage are now irreversible
- There is often a "last ditch" effort from the ischemic midbrain with an enormous discharge of endogenous catecholamines and this can create a last spike of sinus tachycardia
- This is the "whoops! stage" --- too late to be able to turn things around.

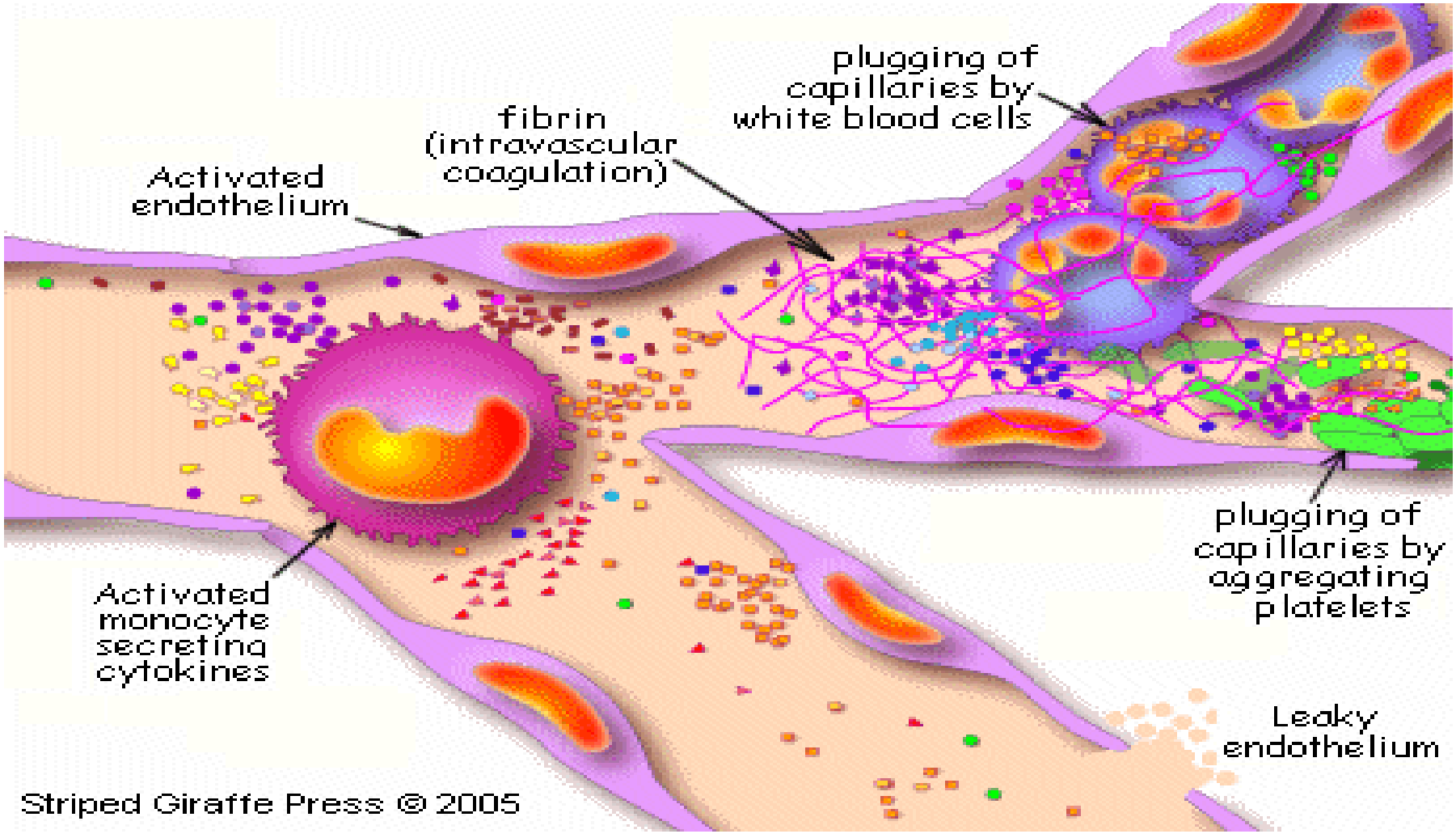
Decompensated Shock, Irreversible



Microvascular Changes in Shock

- The changes are mainly due to a "cytokine storm" induced by severe tissue ischemia
  - (1) the endothelium is activated (vasodilates, becomes pro-coagulant, expresses adhesion molecules)
  - (2) monocytes are activated (and discharge numerous cytokines)
  - (3) white blood cells obstruct some capillaries
  - (4) disseminated intra-vascular coagulation and platelet aggregation plug microcirculation as well
- With so much deterioration to the microcirculation, perfusion to organs worsens rapidly
- Systemic shock also worsens extremely rapidly

Microvascular Changes in Shock



Shock as a Causative Factor

- Blunt injuries lead to organ damage with potential for hemorrhage
- Penetrating injuries damage and sever vessels with potential for hemorrhage
- Mixed type injuries include both organ damage and vessel damage with potential for hemorrhage

Shock Index

- Measures of Shock
- Heart rate divided by systolic blood pressure, normal range 0.5 to 0.7
- Since HR and SBP alone are insensitive indicators in instability due to compensatory mechanisms of the body shock index provides a more sensitive indicator of the hemodynamic instability
- Shock index is a marker of hemodynamic instability not influenced by compensation.

Specific Aims

- To determine if SI recorded by EMS at the scene and reported injury severity scores are independent predictors of mortality
- To determine if SI recorded in the ED and reported injury severity scores are independent predictors of mortality
- To determine the best predictive model of the probability of mortality

Methods

- Secondary data analysis of 2009 National Trauma Data Bank
- Logistic regression applied to evaluate the predictive ability of the variables of interest

Demographics of Sample

- *n* = 516,156
- Mean age: 43 years (16-80)
- Gender: 68% male
- Ethnicity: 70% white

Results Specific Aim 1

- To determine if SI recorded by EMS at the scene and reported injury severity scores are independent predictors of mortality
- EMS SI, ISSAIS and ISSICD were significant predictors of the probability of death within 48 hours
- ISSAIS produced the strongest likelihood of predicting death within 48 hours

EMS SI and ISS (n= 516,156)

Variable	OR	p value	Lower CI	Upper CI
EMS SI	1.03	<0.001	1.028	1.032
ISSLOC	1.02	0.08	0.998	1.047
ISSAIS	1.07	<0.001	1.043	1.094
ISSICD	1.01	<0.001	1.010	1.018

Results Specific Aim 2

- To determine if SI recorded in the ED and reported injury severity scores are independent predictors of mortality
- ED SI, ISSAIS and ISSICD were significant predictors of the probability of death within 48 hours
- ISSAIS produced the strongest likelihood of predicting death within 48 hours

ED SI and ISS (n= 516,156)

Variable	OR	p value	Lower CI	Upper CI
ED SI	1.103	<0.001	1.071	1.135
ISSLOC	1.015	0.20	0.994	1.036
ISSAIS	1.077	<0.001	1.056	1.099
ISSICD	1.018	<0.001	1.015	1.021

Results Specific Aim 3

- To determine the best predictive model of the probability of mortality
- EMS SI, ED SI, ISSAIS and ISSICD were significant predictors of the probability of death within 48 hours
- ED SI produced the strongest likelihood of predicting death within 48 hours

EMS SI, ED SI and ISS (n= 516,156)

Variable	OR	p value	Lower CI	Upper CI
EMS SI	1.019	<0.001	1.016	1.022
ED SI	1.168	<0.001	1.125	1.212
ISSLOC	1.008	0.558	0.982	1.034
ISSAIS	1.082	<0.001	1.054	1.110
ISSICD	1.016	<0.001	1.011	1.020

Results

- ED Shock Index was the strongest predictor of death within 48 hours of admission
- For each unit increase in calculated ED Shock Index, the odds of death within 48 hours increased by 17%

Discussion

- While ISSAIS and ISSICD are significant predictors of the probability of death within 48 hours, they are not easily calculated in the field or in the ED
- Shock Index is easily calculated any time clinicians have access to heart rate and systolic blood pressure

Future Steps

- To identify a group of measures, available on admission to the Emergency Department, that are early markers of morbidity and mortality in a population of patients with multiple trauma injuries.
- To develop a clinical instrument using those markers to identify high-risk patients earlier in the course of treatment and evaluation

Questions