Basics of Shock

Supplementary Educational Material

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         2. Note: increasing the systemic vascular resistance will increase the afterload, thereby making it worse by further decreasing the stroke volume
      ii. 1615 Hypovolemic shock: trouble with preload
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         1. Examples: pulmonary embolism, pneumothorax, tamponade

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      i. Sepsis, adrenal insufficiency, liver failure, anaphylaxis
      ii. 2357 Sepsis- myocardial dysfunction due to cytokine release
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      i. Neurogenic shock (unopposed vagal tone)

Manual

Learning objectives 0030

BE ABLE TO DEFINE SHOCK

BE ABLE TO DISCUSS WHY LACTATE MAY BE ELEVATED IN SHOCK

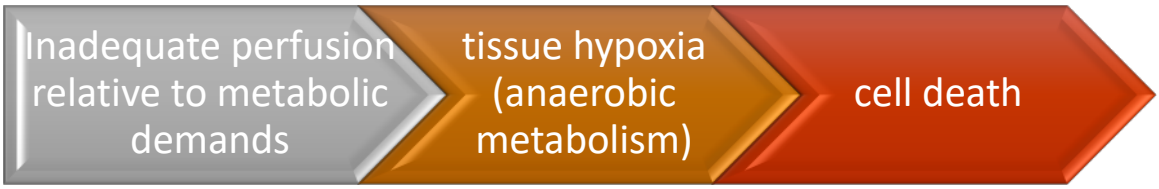
LIST THE MAIN CATEGORIES OF SHOCK

Shock 0045

When supply does not meet demand

The metabolic supply to tissue, and thereby organ systems, does not meet the demand

It is **NOT** defined by a blood pressure

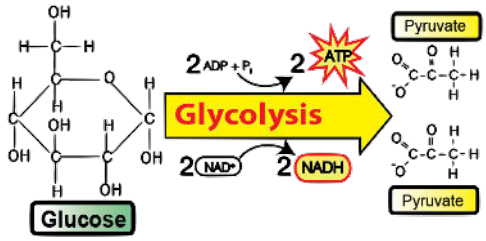


Anaerobic metabolism: Less efficient energy production, lactate production

Lactate Production 0250

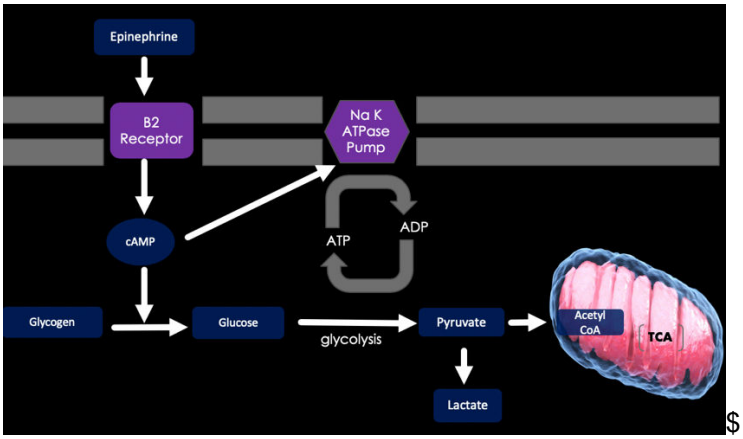
Glycolysis and Pyruvate

Krebs cycle



Lactate production in normal circumstances is due to inadequate oxygen supply

Lactate production in shock is due to adrenergic stimulation of the B2 receptors by epinephrine leading to increased glycolysis



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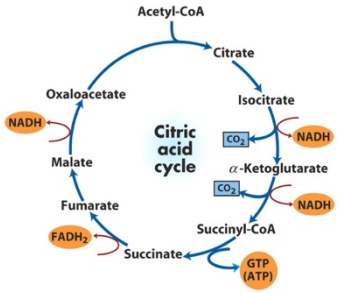


Lactate production as energy source

J Cereb Blood Flow Metab. 2009 Jun;29(6):1121-9. doi: 10.1038/jcbfm.2009.35. Epub 2009 Apr 1.

Blood lactate is an important energy source for the human brain.

van Hall G[1], Strømstad M, Rasmussen P, Jans O, Zaar M, Gam C, Quistorff B, Secher NH, Nielsen HB.

Normally always have low levels of lactate production that is cleared by the kidneys and the liver

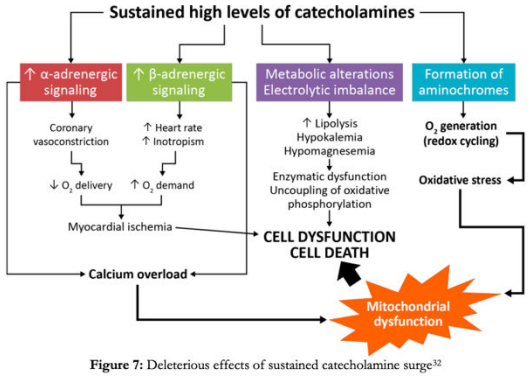


Figure 7: Deleterious effects of sustained catecholamine surge[32]

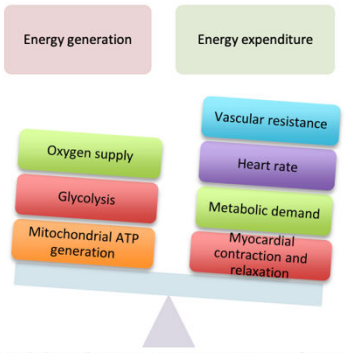


Figure 9: Imbalance between energy generation and expenditure[47]

Causes of Hyperlactermia

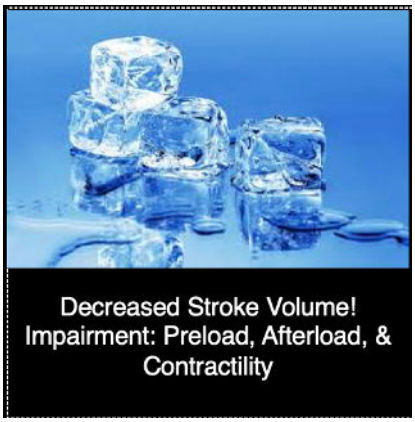
- Liver Disease
- Accelerated glycolysis (increased metabolism): fever, adrenalin, hyperthyroidism, albuterol use
- Mitochondrial dysfunction (inborn errors of metabolism)
- Thiamine deficiency (malnutrition, chronic alcoholism)

- Anaerobic metabolism (ischemic gut)
- Carbon monoxide & cyanide toxicity: alter oxidative phosphorylation
- Metformin
- Hyperventilation (alkalemia)
- Sepsis (multifactorial)

Categories of Shock 0638

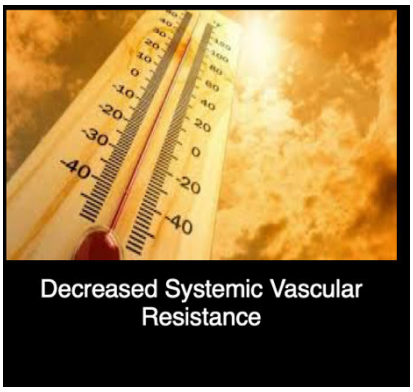
Cold shock 0710

- × Decreased / inadequate stroke volume
- × decreased preload, contractility
- × increased afterload
- × Narrow pulse pressure due to compensatory vasoconstriction and increase in systemic vascular resistance



Warm shock

- × Decreased systemic vascular resistance
- × Movement of blood flow from vital organs to non-vital organs (e.g. skin and muscles)
- × Wide pulse pressure due to the low systemic vascular resistance



Stroke volume 0829

- The amount of blood pumped out of the heart with each heartbeat

Preload:

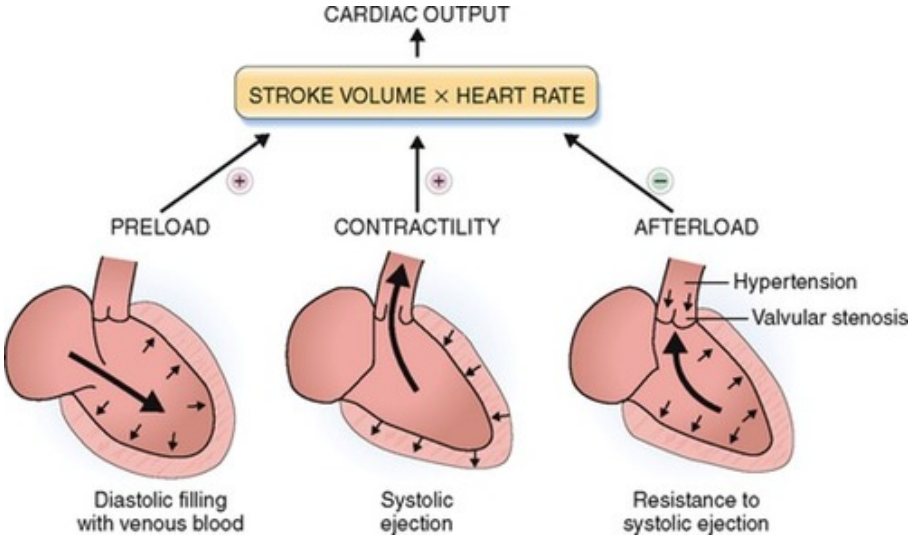
- The volume of blood present in the ventricle at the end of diastole
- Causes for decrease in preload – hypovolemia, hemorrhage or vasodilation

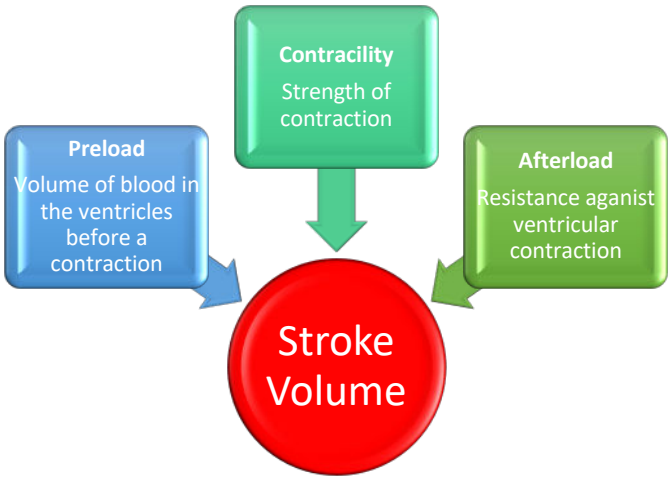
Contractility:

- The strength of contraction
- Causes for decrease contractility- ischemia, toxins, myocarditis, congenital heart disease

Afterload:

- Resistance against the ventricular contraction
- Causes for increase afterload- hypertensive emergency, increased vasocontraction





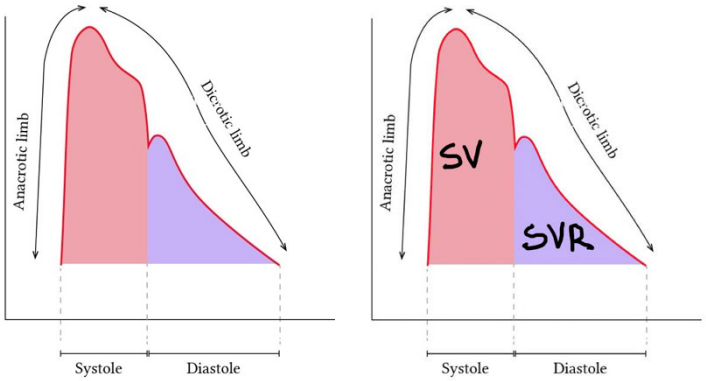
Defining blood pressures 0947

Systolic blood pressure

- Determined by the blood volume in the arteries + aortic compliance
- Systolic blood pressure ~ stroke volume

Diastolic blood pressure

- As the ventricle is relaxing, tissue perfusion determined by systemic vascular resistance
- Diastolic blood pressure ~ systemic vascular resistance



Chronically low diastolic blood pressure, therefore an increased pulse pressure, could be associated with aortic regurgitation

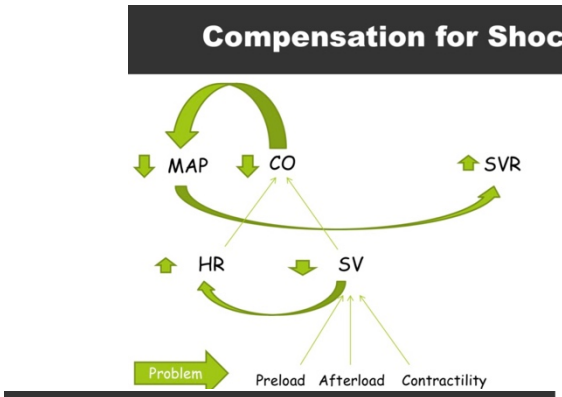
Compensation for shock 1150

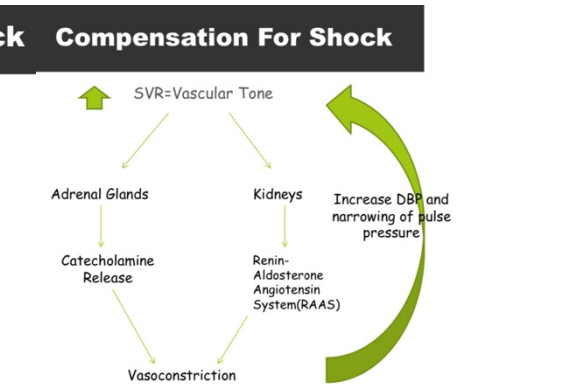
Decreased stroke volume->. low cardiac output state & decreased tissue perfusion

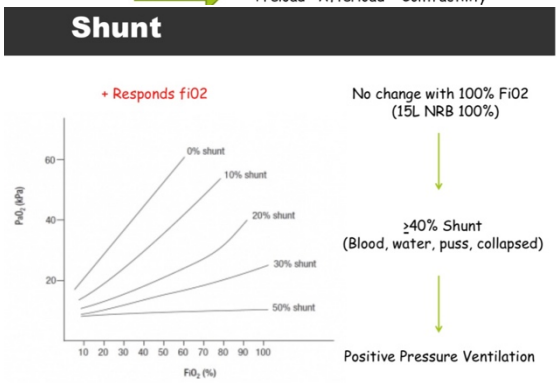
1. Increase heart rate
2. Increase systemic vascular resistance (if heart rate is inadequate)

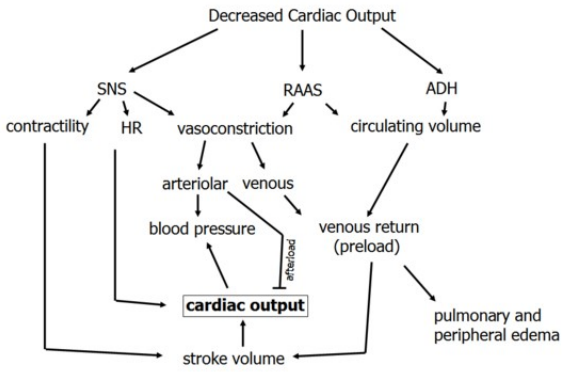
Determinates of vascular tone

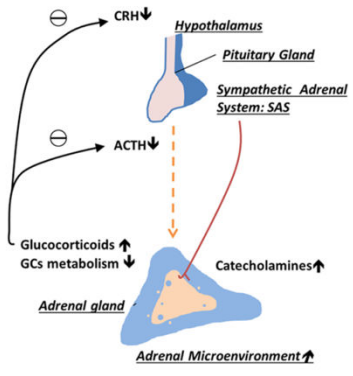
- × Adrenal glands: catecholamines that cause vasoconstriction
- × Kidneys: (+) RAAS -> angiotensin II and aldosterone release

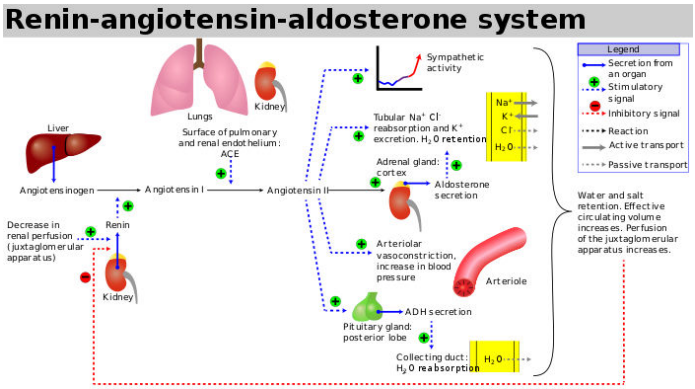












Categories of Shock 1424

Cold shock:

Decrease stroke volume (i.e. decreased SBP) + increased systemic vascular resistance (i.e. increased DBP)=> narrow pulse pressure

Cardiogenic shock:

- Trouble with cardiac contractility
- Examples: ischemia, congenital heart disease, toxins
- Note: increasing the systemic vascular resistance will increase the afterload, thereby making it worse by further decreasing the stroke volume

RV Failure

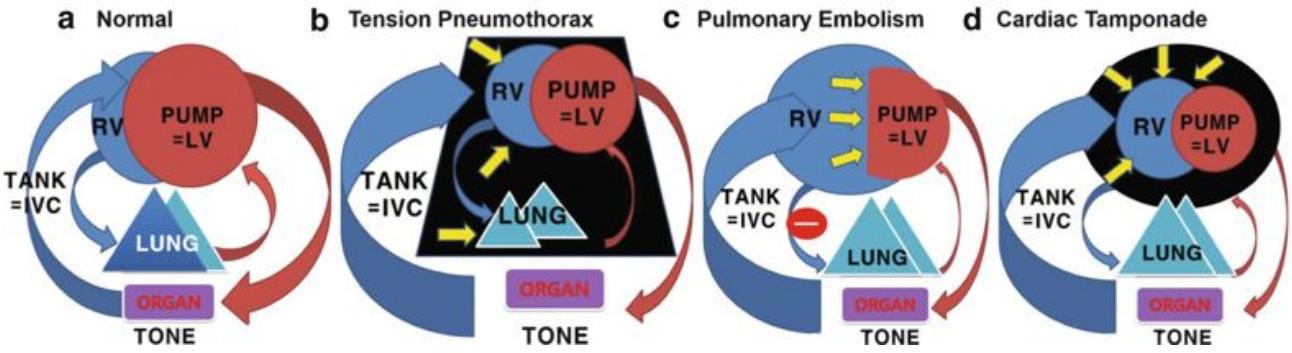
- Signs: elevated JVD, pulmonary heave, loud P2, clear lung
- Causes: Increased pulmonary vascular resistance (as seen in vascular occlusion (PE), PEEP or alveolar hypoxia)
- Bedside echo can help differentiate (e.g. RV dilation in RV failure, LV with poor contractility in LV failure)

Hypovolemic shock:

- Trouble with preload
- Examples: hemorrhage, gastrointestinal losses, venodilation (most of the blood volume is in the venous vasculature) leading to relative hypovolemia

Obstructive shock (SICK):

- Mechanism: Decreased preload/ increased afterload; normal contractility
- Examples: Massive pulmonary embolism, cardiac tamponade, tension pneumothorax, HTN crisis, aortic dissection, restrictive/ constrictive pericarditis, very high positive end expiratory pressure (PEEP), abdominal compartment syndrome



Warm shock:

Distributive shock (meaning the problem is the "distribution" of blood flow) = decreased stroke volume (i.e. decreased SBP) << decreased systemic vascular resistance (i.e. decreased DBP) => widened pulse pressure

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2. Increased capillary permeability - leading to loss of plasma volume into the interstitial space (so has a component of hypovolemic shock)
3. Increased heart rate + increased contractility(compensation)

× Sepsis, adrenal insufficiency, liver failure, anaphylaxis

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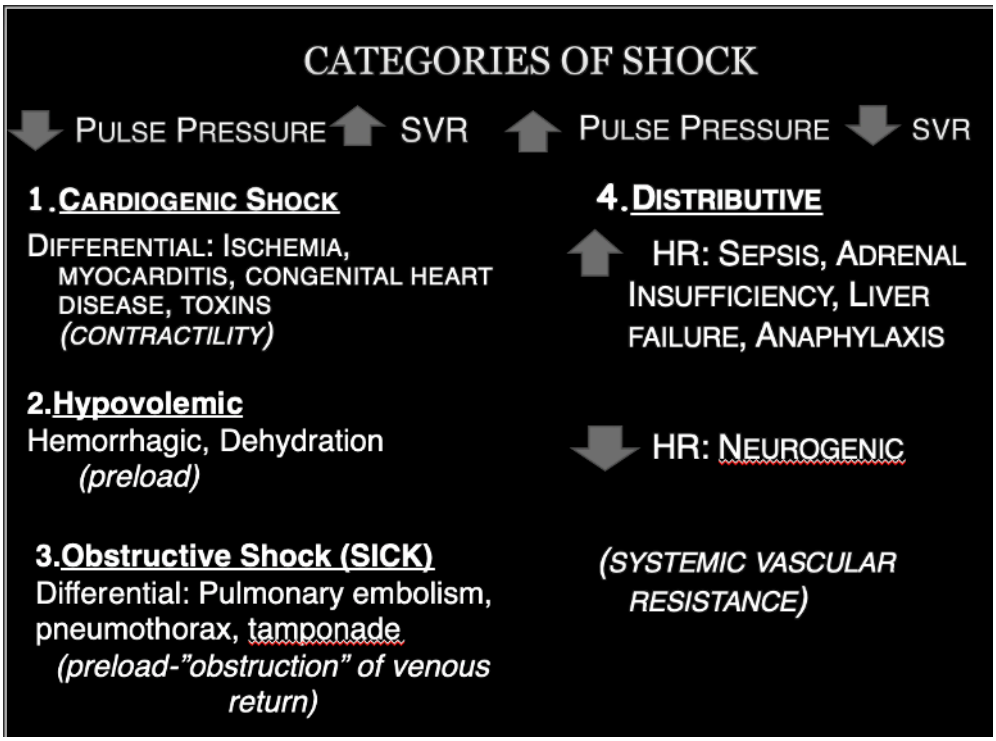
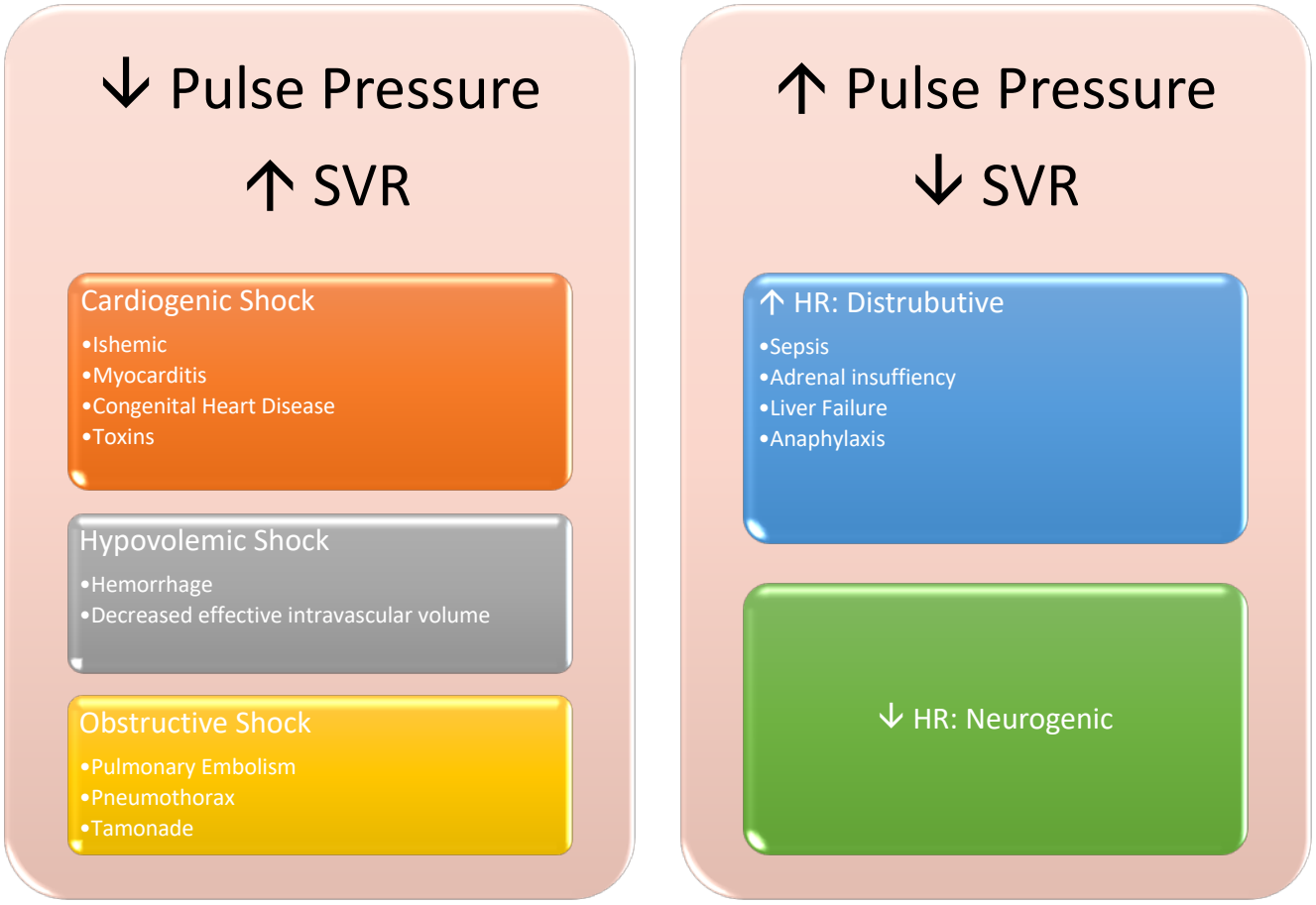
Decreased/ normal heart rate

× Neurogenic shock (unopposed vagal tone)




↓ Pulse Pressure
↑ SVR
Cardiogenic Shock
•Ishemic
•Myocarditis
•Congenital Heart Disease
•Toxins
Hypovolemic Shock
•Hemorrhage
•Decreased effective intravascular volume
Obstructive Shock
•Pulmonary Embolism
•Pneumothorax
•Tamonade
↑ Pulse Pressure
↓ SVR
↑ HR: Distrubutive
•Sepsis
•Adrenal insuffiency
•Liver Failure
•Anaphylaxis
↓ HR: Neurogenic