Who is this guy?

- **Education:** Bachelor of Science degrees in Criminal Justice, Psychology and Nursing. Finishing Master of Science in Finance in December

- **Professional:** 11 years as a nurse in Cardiac Telemetry, Cardiac ICU, Adult Cardiothoracic ICU, Trauma Surgical ICU, ECMO and Pediatric Cardiothoracic ICU
Hemodynamic review: Cardiac Output

* Represents the amount of blood pumped by the heart in one minute
* Measured as SV X HR
* Measured in L/min with “normal range” of 4-8
* Cardiac Index: Adjust for patient size by dividing cardiac output by BSA. Normal Range is 2-4 L/min
Systemic Vascular resistance is a measure of afterload resistance.

Calculated as \( \frac{\text{MAP} - \text{CVP}}{\text{CO}} \)

Normal range is 700-1500

Indirectly affects stroke volume of the heart
The first line treatment of hypertension and hypotension is fluid management. Use of medications without treating hypo or hypervolemia will be ineffective and potentially dangerous.
Assessing Fluid Needs

- SVR
- CVP
- Heart Rate
- Blood Pressure
- How does the patient look?
Colloids vs. Crystalloids

Colloids: Blood Products and Albumin

Colloids have higher tonicity allowing them to stay in the vasculature

Crystalloids consist of fluids like D5W, NS or LR

have lower tonicity causing more of the volume to “third space”.

Some controversy surrounding Albumin
Alpha 1 Receptor Cells- Work on smooth muscle. Causes vasoconstriction on the blood vessels supplying the skin, GI tract, kidneys and brain.

Alpha 2 Receptor Cells- Undifferentiated smooth muscle relaxation

Beta 1 Receptor Cells- Stimulation of Beta 1 receptor cells cause positive inotropy (cardiac output) and positive chronotropy (heart rate). Also stimulates the kidneys to secrete renin which activates the renin-angiotensin-aldosterone system causing systemic vasoconstriction to increase blood pressure.

Beta 2 Receptor Cells- Smooth muscle relaxation more pronounced in bronchioles
An Agonist agent stimulates the effect of the receptor cell. For example, a Beta agonist increases heart rate, cardiac output and blood pressure.

An Antagonist agent inhibits the effect of the receptor cell. For example, a Beta antagonist decreases heart rate, cardiac output and blood pressure. AKA beta blocker.
This group of medications are made up of drugs that are both Alpha 1 and Beta 1 agonists.

These medications have differing amounts of stimulation provided to each receptor cell. Some have more Alpha stimulation and others have more Beta stimulation.

Medications that more strongly affect Alpha cells are often called pressors.

Medications that more strongly affect Beta cells are often called inotropes.

Most institutions require these medications to be given via central line.

Use of these drugs is typically restricted to the ICU setting.
## Catecholamine Chart

<table>
<thead>
<tr>
<th>Agent</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
<th>Dopaminergic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dobutamine</td>
<td>+</td>
<td>+</td>
<td>++++</td>
<td>++</td>
<td>0</td>
</tr>
<tr>
<td>Dopamine</td>
<td>++++/++++</td>
<td>?</td>
<td>+++</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Epinephrine</td>
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<td>+++</td>
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<td>0</td>
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<tr>
<td>Norepinephrine</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>/++</td>
<td>0</td>
</tr>
<tr>
<td>Phenylephrine</td>
<td>++++/++++</td>
<td>+</td>
<td>?</td>
<td>0/0</td>
<td>0</td>
</tr>
</tbody>
</table>

$\alpha$, $\alpha$ adrenergic receptors; $\beta$, $\beta$ adrenergic receptors, DA, dopamine receptors.
Activity ranges from no activity (0) to maximal activity (+++++) or ? when activity is not known.

Source: Semin Respir Crit Care Med © 2004 Thieme Medical Publishers
Medication to increase blood pressure: Phenylephrine (Neosynephrine)

- An alpha agonist causing blood pressure to rise through peripheral vasoconstriction
- Lacks Beta component so it has minimal effect on heart rate or contractility
- Normally used in patients with mild or early shock or hypotension caused by sedation
- Typically dosed from 20-200 mcg/min. Not typically weight based dosed. Titrated in 10-20 mcg/min increments
- Due to lack of cardiac implications can be used as an IVP bolus to quickly raise blood pressure in the severely acute hypotension
- Safe to use through a peripheral IV site.
Pressor Catecholamine- Norepinephrine (Levophed)

- Has moderate to strong Alpha and Beta stimulation.
- Increases blood pressure through peripheral vasoconstriction through alpha stimulation
- Provides some improvement of cardiac output but is mild due to higher SVR caused by vasoconstriction. Mild heart rate increases seen as well
- Most often seen with patient experience septic shock
- Dosing: Normally dosed by weight starting at .02 mcg/kg/min. Non weight based usually start at 2 mcg/min. Maximum doses by institution and unit.
- Titration usually starts in .02mcg/kg/min intervals based on patient effect.
Strong Alpha and Beta response.
Increases heart rate, vasoconstriction and contractility.
Used primarily in cardiac settings with severe cardiogenic shock.
Typically a last line drug in adults due to increased myocardial oxygen consumption that results from its affects (heart is beating faster and stronger against more resistance)
Not typically used in other shock syndromes due to stronger constriction of GI blood flow.
Tends to be used less cautiously in pediatric patients who normally have healthier hearts that can tolerate the increased myocardial oxygen demand.
Dosing: 0.01 mcg/kg/min to 0.2 mcg/kg/min or 2-10 mcg/min for non weight based dosing
Also part of the ACLS algorithm for asystole, VT, Vfib and PEA. 1 mg for adults and 0.1 mg/kg for peds
A versatile drug that changes properties depending on dosing.
1-2 mcg/kg/min stimulates dopaminergic receptors causing vasodilation that increases renal and mesenteric blood flow. This dose is frequently referred to as renal dose dopamine
2-5 mcg/kg/min stimulates beta cells which causes increases in cardiac output and heart rate
5-10 mcg/kg/min stimulates alpha cells causing increases in blood pressure
Dosing: 1-20 mcg/kg/min. Dosing dependent on goal effect of Dopamine
Can cause profound tachycardia particularly at higher doses. Rarely see doses higher than 10 mcg/kg/min. Additional medications usually added at this point.
**Inotrope Catecholamine: Dobutamine**

- Strong Beta cell agonist.
- Most pronounced effect is inotropic support. Can cause dysrhythmias and tachycardia due to strong Beta stimulation.
- Most commonly used in CICU and cardiac stepdown floors for adults with CHF.
- Dosing: 2.5 -7.5 mcg/kg/min
- Titration usually occurs in 2.5 mcg/kg/min steps and is titrated to cardiac index.
Milrinone is a phosphodiesterase inhibitor which inhibits the breakdown of cyclic AMP which ultimately causes calcium channels in the myocardium and arterial vasculature to allow more calcium to move in to intracellular level

- Increases myocardial contractility (inotrope)
- Causes vasodilation of arterial vasculature especially in the pulmonary artery which aids in right sided heart failure
- Used an IV drip mostly in ICU’s for the treatment of CHF exacerbation.
- Blood pressure decrease is low to moderate as inotropic and vasodilation effect cancel one another
- Dosing: 0.125 mcg/kg/min to 0.75 mcg/kg/min
Medications to increase blood pressure: Vasopressin

- Naturally occurring hormone secreted by the pituitary gland that helps regulate fluid status.
- Stimulates receptor cells in the kidneys causing an increase in systemic vasoconstriction.
- Early in the shock cycle Vasopressin secretion is increased. This supply is quickly depleted though. This is where the concept of physiologic dose Vasopressin comes from.
- Minimal effect on heart rate or cardiac output.
- Should be used cautiously in patients with renal insufficiency or failure.
- In adults it is generally dosed in units/hr or units/min. Physiologic dosing is 2.4 units/hr (.04 units/min).
- Pediatric dosing: .0003-.001 units/kg/min.
- Titration occurs in one unit/hr increments or .003 units/kg/min for pediatrics.
Hypertension or cardiac dysrhythmias are usually treated with one and/or a combination of different drug classes:

- Diuretics
- Vasodilators/Nitrates
- Calcium Channel Blockers
- ACE Inhibitors/ARBS
- Beta Blockers
- Anti-Arrhythmics
Diuretics

* Decrease hypertension by decreased circulating volume in the blood which decreases preload and afterload
* Decrease of preload is useful in treating patient with congestive heart failure and afterload reduction is useful in treating patients with HTN
* Multiple dosing strategies depending on type of diuretic, clinical setting and severity of fluid overload.
Diuretics

* **Thiazides**
  * First line drugs for the treatment of hypertension
  * Work by inhibiting sodium reabsorption in the distal renal tubules.
  * Chlorothiazide most commonly used in the acute care setting.
  * Commonly dosed as PO in step down setting and intermittent IVP in ICU settings

* **Loop Diuretics**
  * Inhibits sodium reabsorption in the Loop of Henle
  * Can be dosed as PO or IVP in step down settings or as continuous infusion in ICU setting.
  * Most commonly used Loop drugs are Furosemide (Lasix) and Bumetadine (Bumex)
  * Most common and dangerous side effect for both versions is hypokalemia
Vasodilators: Nipride

- Extremely potent and fast acting vasodilator. Causes vasodilation of arteries and veins but with stronger effect on arteries. Half life is 2 minutes.
- Nipride goes through a complex chain of interactions to produce NO, cyanide and methaemoglobin.
- Requires close monitoring of cyanide levels to avoid cyanide toxicity. Newer mixes have an additive that binds to cyanide to protect against cyanide toxicity.
- Use is restricted to the ICU setting and is only used as a continuous drip.
- Used most commonly in patients with HTN crisis situations and/or patients with aneurysms.
- Dosing 0.1 mcg/kg/min to 10 mcg/kg/min though higher doses are rare due to fear of cyanide toxicity.
- Titration is usually done in .1 mcg/kg/min increments.
Nitroglycerin

* Vasodilator used mostly in the treatment of angina
* Centrally acting vasodilator that increases blood flow to the heart relieving angina symptoms. Most vasodilation occurs in the venous vasculature causing a decrease in cardiac work load.
* Most common setting for inpatient use is step down unit and CICU.
* Infrequently used as a treatment for hypertension
* Comes in a variety of forms: IV, Sublingual tablets, paste and oral tablet.
* Headache is a common side effect
Clonidine

- Alpha 2 agonist that cause central venous and arterial vasodilation
- Tends to be used in chronic HTN rather than acute HTN
- PO only with dosing generally in the 0.1 to 0.3 mg range
Anti-hypertensives: Calcium Channel Blockers

* Works by preventing calcium from passing through calcium channels in myocardial cells and arterial smooth muscle.
* Myocardial blockage leads to decreased heart rate and contractility
* Vascular blockage leads to vasodilation arterial vasculature (no effect on venous vasculature) to decrease afterload.
* Typically have a “pine” ending to generic name
* Used in variety of inpatient settings for treatment of HTN and atrial dysrhythmias and tachycardia.
* Commonly used drugs include Amlodipine, Nicardipine, Nifedipine, Diltiazem and Verapamil
* Can be administered PO, IVP or continuous IV infusion.
Renin-Angiotensin-Aldosterone System
ACE Inhibitors

- Prevent the conversion of angiotensin I into angiotensin II to help treat HTN
- Interruption of the Renin-Angiotension-Aldosterone system cause vasodilation, decreased cardiac output and decreased circulation volume
- Used in all inpatient settings as PO medication. Most common usage is for adult patient with CHF
- Most ACE inhibitors have “pril”
- Most commonly used are Captopril, Lisinopril, Enaloporil
- Can be used in a variety of clinical settings (ICU, step down, general care)
- Usage is avoided in patient with renal insufficiency
- Most common side effect is a dry hacking cough
Angiotensin II receptor blockers (ARBs)

- Work very similarly to ACE inhibitors
- Mainly used in patients that cannot tolerate the effects of ACE inhibitors.
- Has all the same attributes as ACE inhibitors
- Most ARBs have “sartan” in their name
Anti-hypertensives: Beta Blockers

- Beta receptor cell antagonist causing decreased cardiac contractility and slowing of the heart rate.
- Reduces amount Renin produced thereby indirectly decreasing afterload.
- Slowing of the heart rate and decreased afterload resistance neutralizes decreased contractility making Beta blockers safe for patients with CHF.
- Seen in all phases of inpatient care as PO, intermittent IVP and Continuous IV drip.
- Most beta blockers have “olol” ending to their pharmaceutical names.
- Common Beta Blockers include Metoprolol, Carvedilol, Esmolol, Atenolol, Labetalol.
- Important ICU application is the treatment of aortic aneurysms.
- Contraindicated for the treatment hypertension caused by cocaine overdose.
Amiodarone

* Anti-Arrhythmic useful in the treatment of atrial and ventricular arrhythmias
* Treats ventricular arrhythmias through decreased blockage of potassium channels
* Treats atrial arrhythmias through the blockage of calcium channels near the SA and AV nodes. Slows rate and can convert patient out of A-fib. Only used in acute cases of Afib
* Part of the ACLS algorithm for VT and V-Fib as a 150 mg IVP/ 5 mg/kg for pediatric patients
* Non emergent loading dose of 150 mg over 10 minutes
* 1 mg/minute drip rate x 6 hours followed by 0.5 mg/min x 18 hours and then transitioned to PO
Digoxin

- Increases contractility of the heart through the potentiation of calcium
- Decreases heart rate through stimulation of the vagal nerve. Makes it useful in treating A-fib
- Can be administered PO or IVP in step down and ICU settings
- Not used frequently due to difficulty in dosing.
- Requires semi regular blood draws.