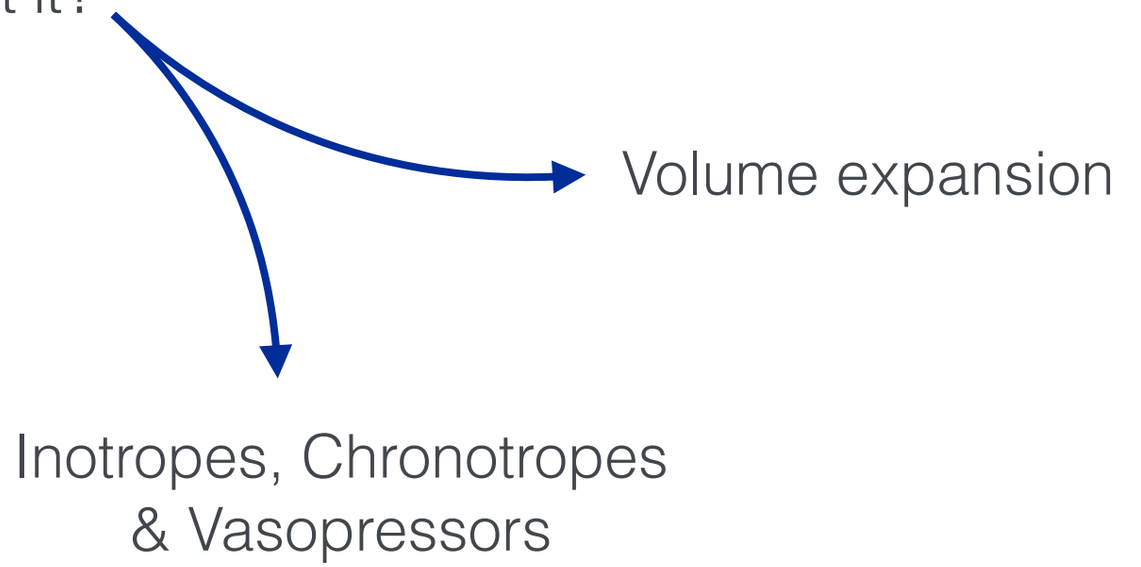
Haemodynamic Support

(getting the blood to go round and round)

Haemodynamic Support

Whats wrong with your patient?

What can we do about it?



Whats wrong with your patient?

Types of Shock

Obstructive	PE Tamponade Hyperinflation
Cardiogenic	Arrhythmia Valve dysfunction Myocardial dysfunction
Hypovolaemic	Haemorrhage Interstitial fluid loss
Redistributive	Sepsis Anaphylaxis Toxic vasodilation Neurogenic vasodilation

Types of Shock

	Preload	Perfusion
Obstructive	↑↑	↓
Cardiogenic	↑	↓
Hypovolaemic	↓↓	↓
Redistributive	↓	↑

Mixed Venous Saturation

↓ < 65%				↑ > 80%
Pain / Anxiety Shivering	↑	O_2 Consumtion	↓	Sedation Hypothermia Cytotoxic dysoxia L → R shunts Microcirculatory shunts
Anaemia Hypoxia Low Cardiac Output	↓	O_2 Delivery	↑	↑ Cardiac Output

What can we do about it?

Interventions

Obstructive	PE Cardiac tamponade Hyperinflation	Pleural decompression Pericardial decompression Pulmonary decompression
Cardiogenic	Arrhythmia Valve dysfunction Myocardial dysfunction	Pacing / defibrillation Chronotropes Valvuloplasty Inotropes
Hypovolaemic	Haemorrhage Interstitial fluid loss	Volume
Redistributive	Sepsis Anaphylactic Toxic vasodilation Neurogenic	Vasopressors

Interventions

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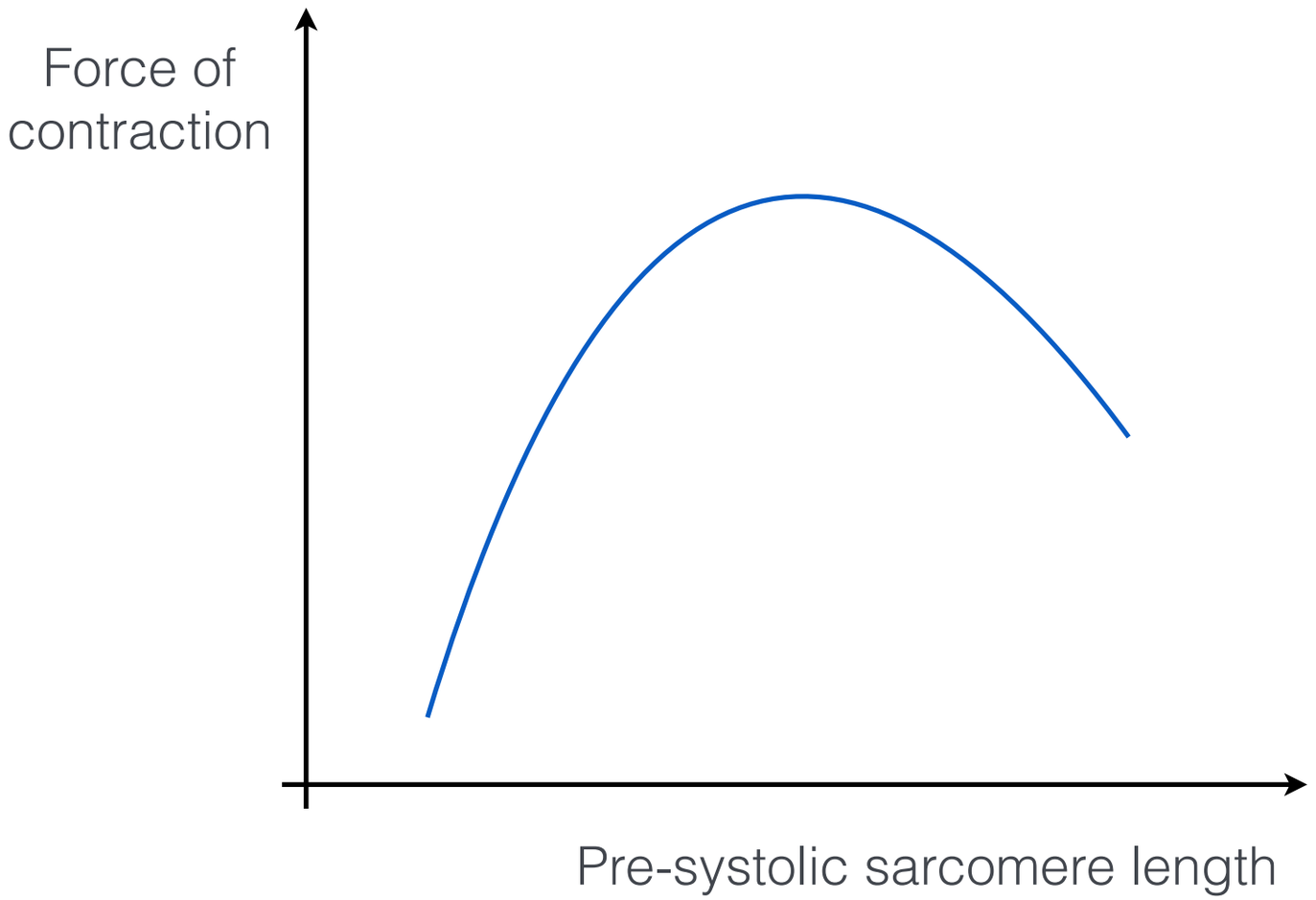
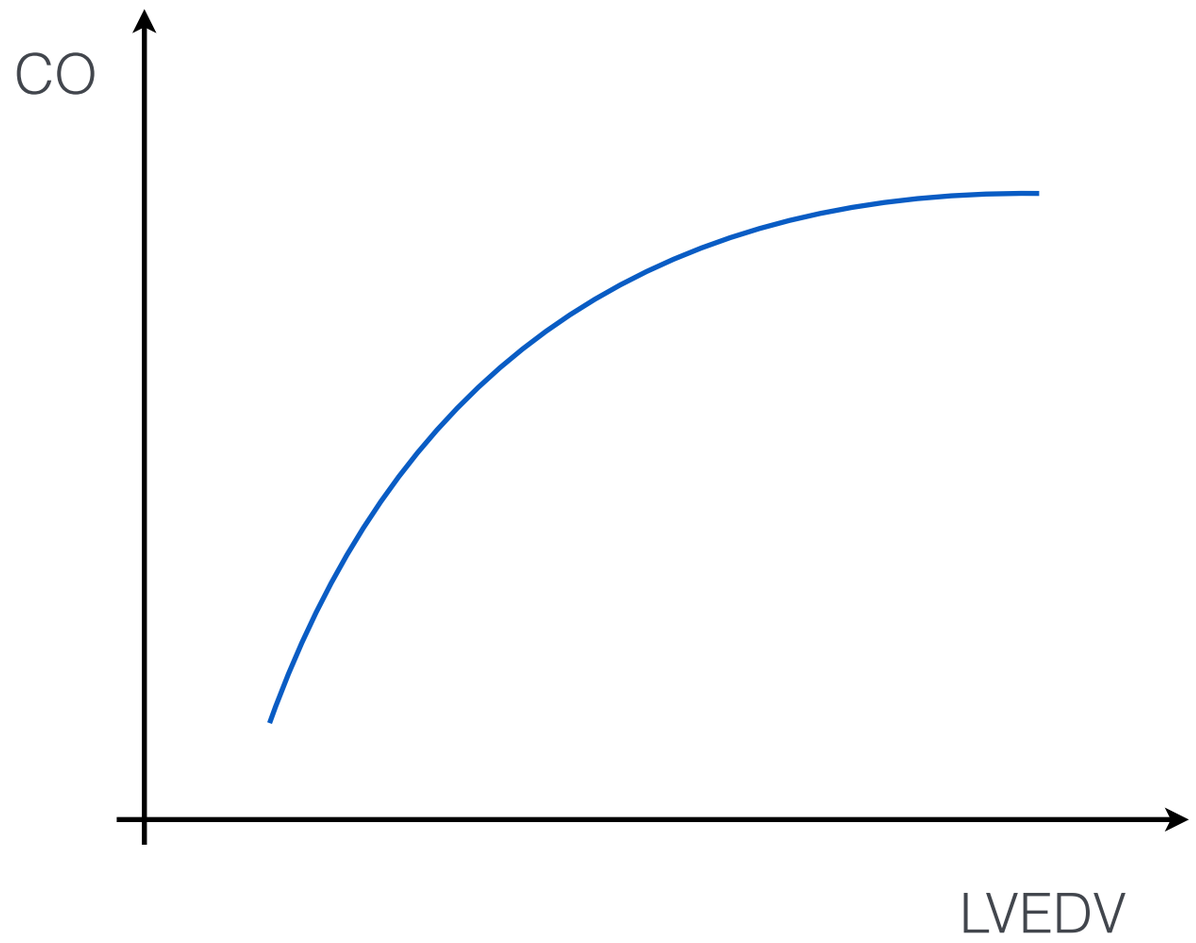
Redistributive	Sepsis Anaphylactic Toxic vasodilation Neurogenic	Vasopressors

Volume Expansion

Preload

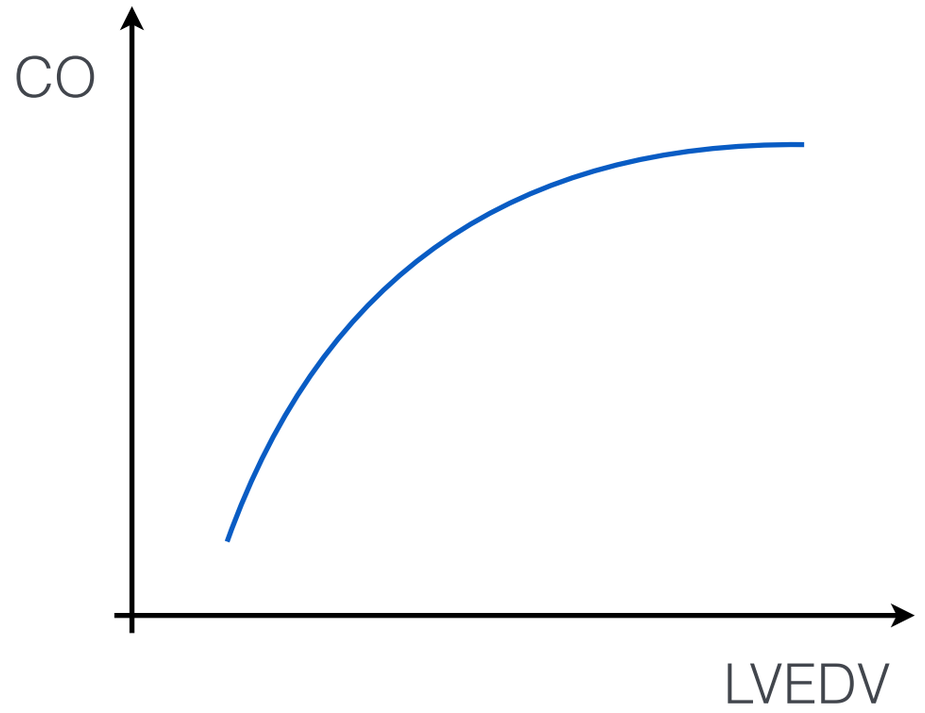


Preload



Intravenous Fluids

- IV fluids don’t stay in the vascular compartment
- IV volume doesn’t necessarily result in preload
- Difficult to determine where a patient is on the curve
- Tissue oedema



Intravenous Fluids

Whole Body 70 Kg

Water 42 L

ECF 17 L

IVF 3 L

1 L crystalloid ≡ 170 ml of plasma expansion

Predicting Fluid Responsiveness

Prediction is very difficult,
especially about the future.

Niels Bohr

Predicting Fluid Responsiveness

Static

Pressure

CVP
RAP
P_{pao}

Volume

GEDV
RVEDA
RVEDV
LVEDA
LVEDV

Dynamic

SPV
ΔDown
PPV
SVV
IVC diameter variation

End-expiratory occlusion test

Pasive leg raise
Fluid bolus

SPACELABS Healthcare

Ultraview SL

ECG

ST= 0.40 * PACED

II A=0 MON

106 ♥

ROW 5

135

40

HELP

MONITOR SETUP

SPECIAL FUNCTIONS

ART

91 50 mmHg

64

ART ALM OFF

ALARM SUSPEND

SPO2

???*

92 %

100

87

RECORD

01:35	124/ 72(88)	mmHg	PR=118	(ECG)
01:40	113/ 63(77)	mmHg	PR= 95	(ECG)
01:42	108/ 67(77)	mmHg	PR=101	(ECG)
01:45	108/ 67(78)	mmHg	PR= 97	(ECG)
01:50	107/ 64(72)	mmHg	PR= 96	(ECG)

STAT

LAST BP=
01:50
02/04

NIBP

107 64 mmHg

(72)

NIBP ALM OFF

PREVIOUS MENU

RESP

* RA-LA

12

RESP ALM OFF

NORMAL SCREEN

09:26

4 FEB 13

Predicting Fluid Responsiveness

Static

Pressure

CVP	0.55
RAP	0.55
P_{pao}	0.58

Volume

GEDV	0.59
RVEDA	
RVEDV	
LVEDA	
LVEDV	0.64

Dynamic

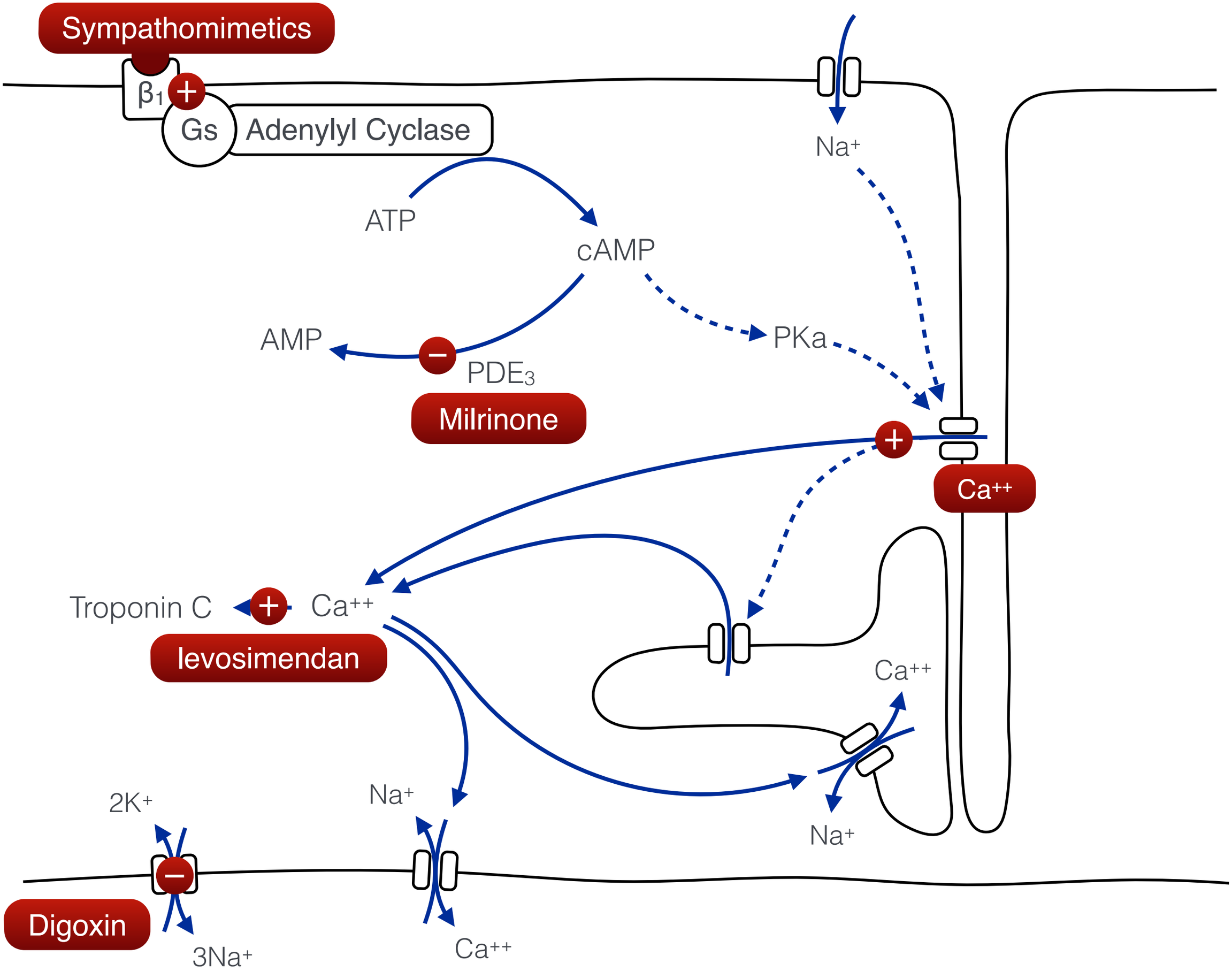
SPV	0.86
ΔDown	
PPV	0.94
SVV	0.84
IVC diameter variation	

End-expiratory occlusion test

Pasive leg raise	0.96
Fluid bolus	

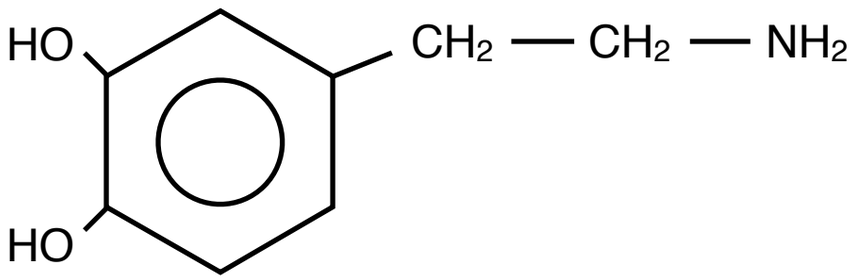
Marik et al. Annals of Intensive Care 2011

Inotropes, Chronotropes & Vasopressors

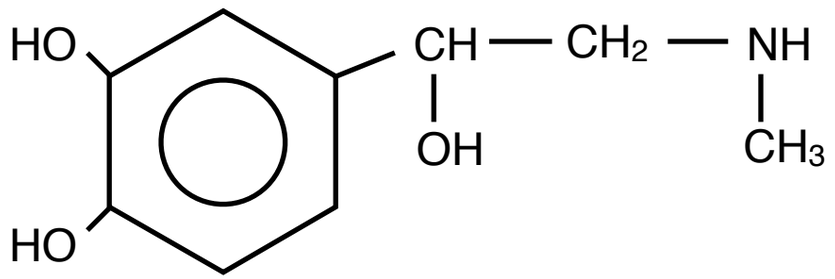

Sympathomimetics
β1
Gs
Adenylyl Cyclase
ATP
cAMP
AMP
PDE3
Milrinone
Na+
PKa
Ca++
Troponin C
Ca++
levosimendan
Ca++
Na+
2K+
Na+
Digoxin
3Na+
Ca++

	α	β_1	β_2	D	V_1	PDE_3	Troponin C
Noradrenaline	+++	++	+				
Adrenaline	++	+++	++				
Dopamine	+	++	++	++			
Dobutamine	+	+++	++				
Isoprenaline		++	++				
Vasopressin					++		
Milrinone						++	
Levosimendan							++
Ca^{++}							++

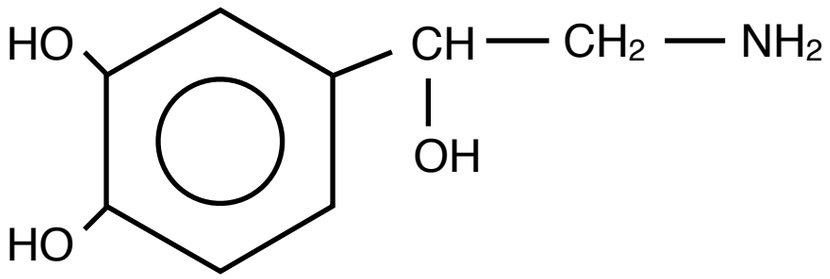
Dopamine



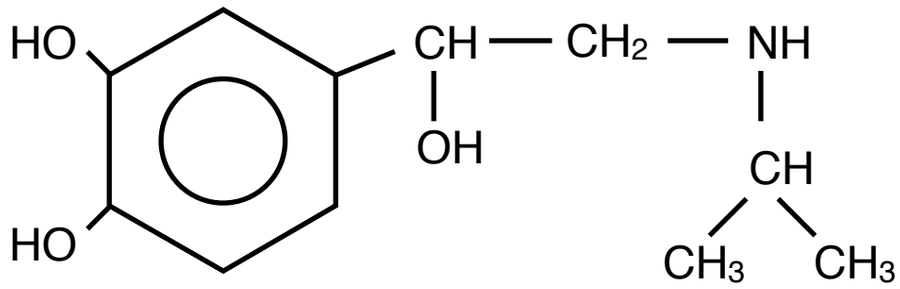
Adrenaline



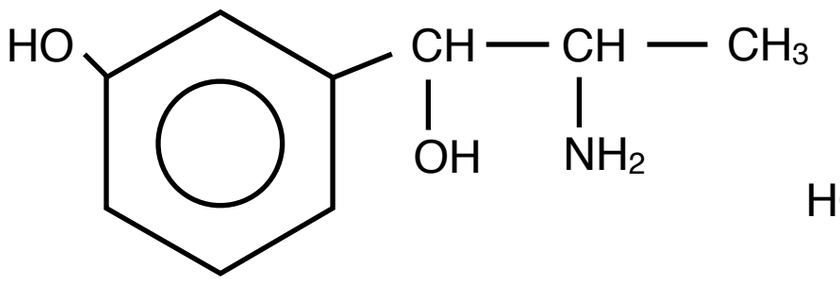
Noradrenaline



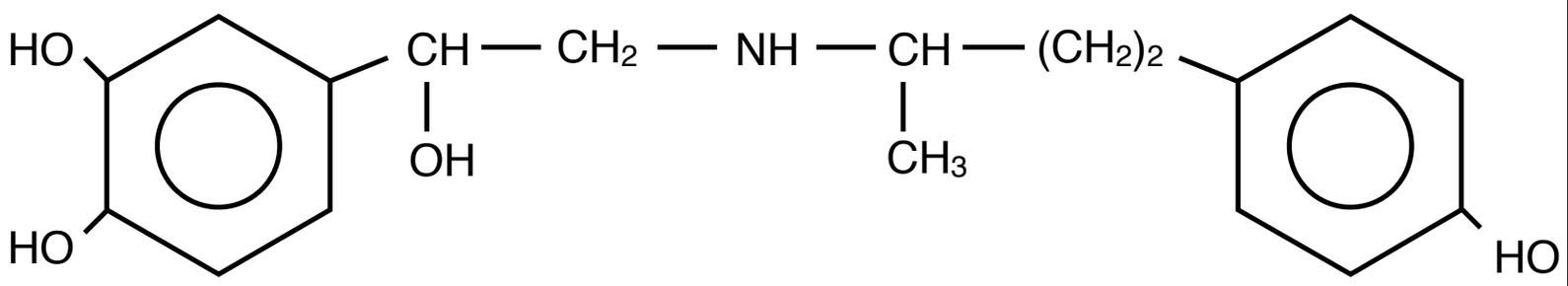
Isoprenaline

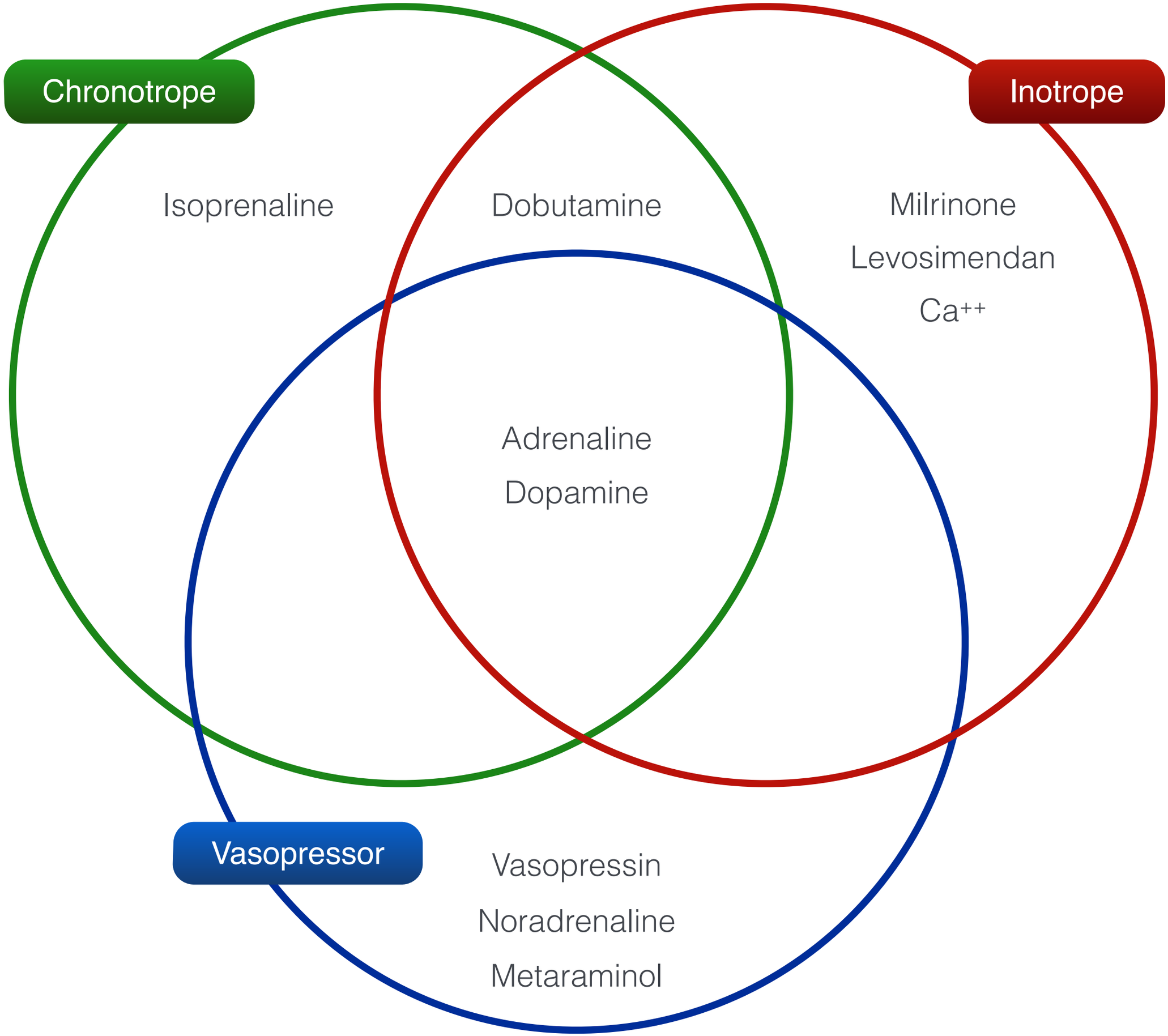


Metaraminol



Dobutamine




Chronotrope
Inotrope
Isoprenaline
Dobutamine
Milrinone
Levosimendan
Ca++
Adrenaline
Dopamine
Vasopressor
Vasopressin
Noradrenaline
Metaraminol

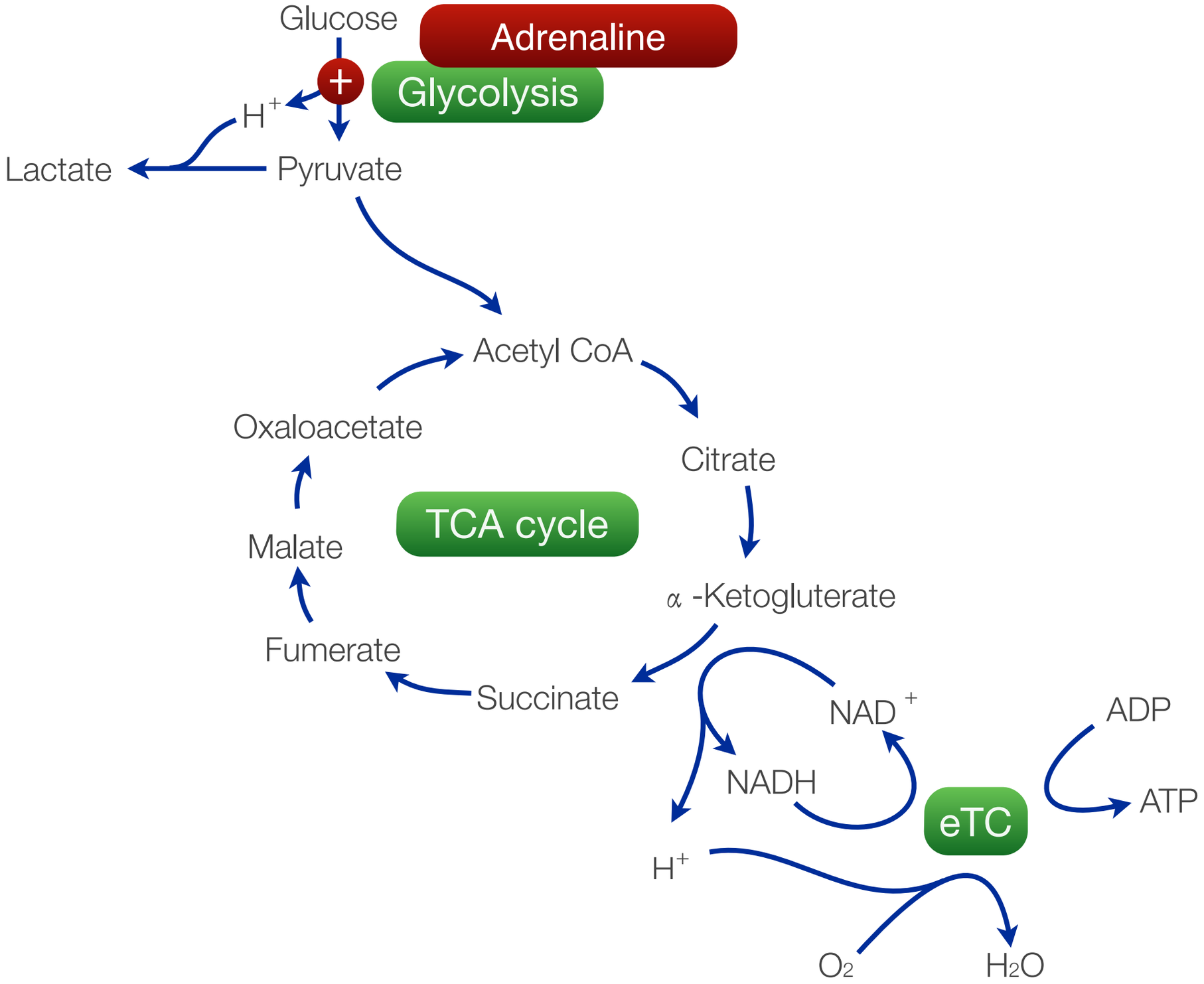
Noradrenaline

↑ Arteriolar tone & ↑ SVR

↑ Myocardial perfusion

↑ Preload

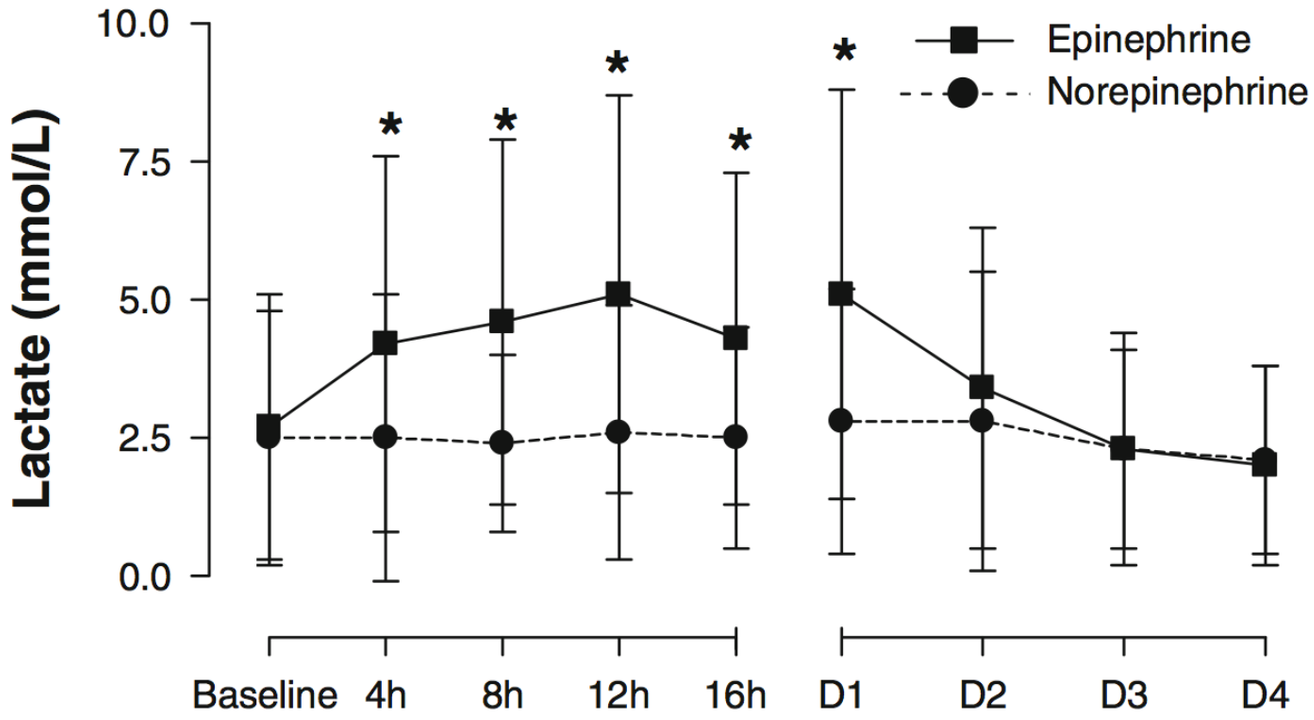
Adrenaline


Glucose
Adrenaline
+
Glycolysis
H+
Lactate
Pyruvate
Acetyl CoA
Oxaloacetate
Citrate
TCA cycle
Malate
α -Ketogluterate
Fumerate
Succinate
NAD +
ADP
NADH
ATP
eTC
H+
O2
H2O

Noradrenaline vs Adrenaline in Shock

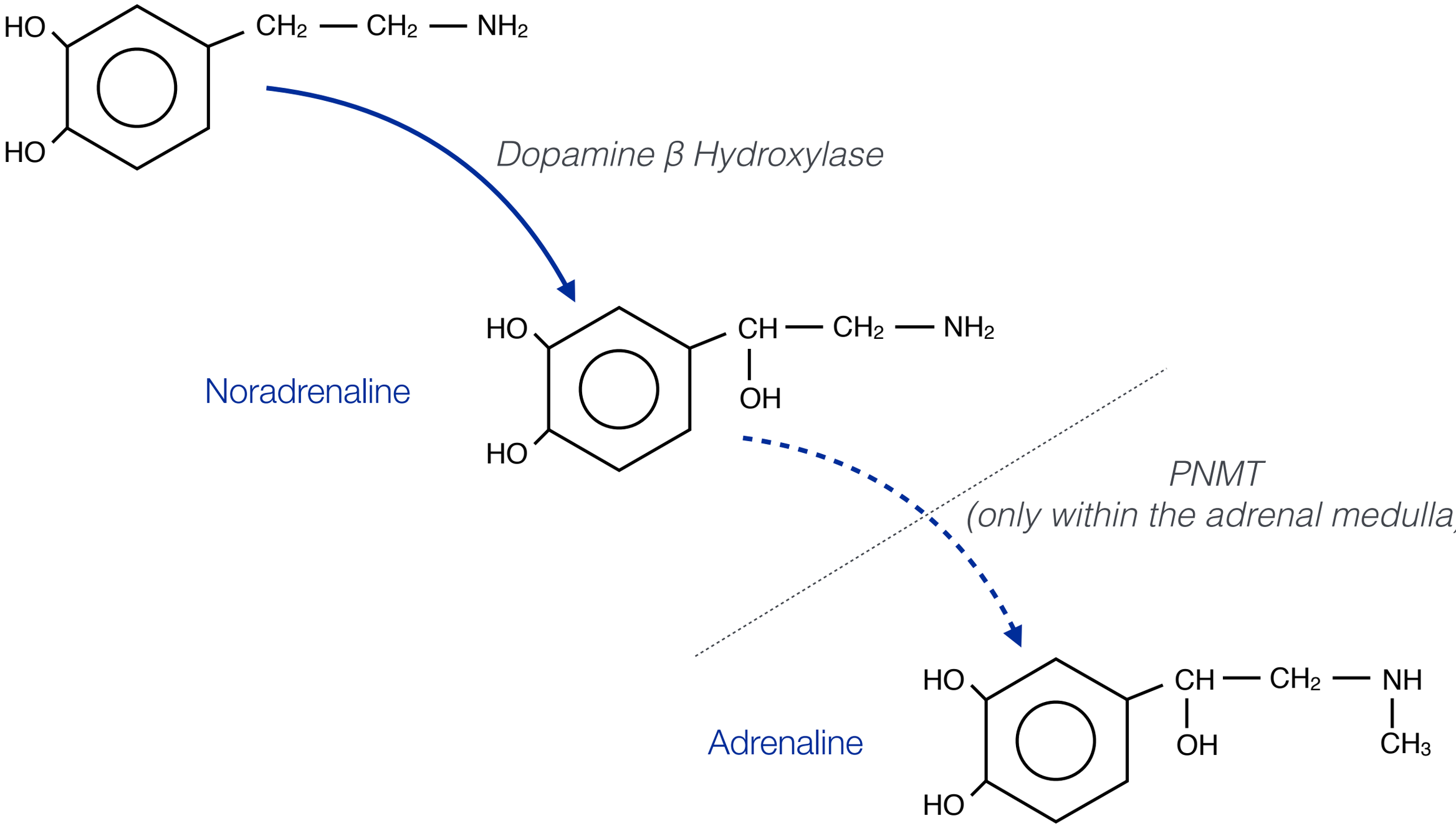
- n = 280 RCT

- No difference in 28 and 90 day mortality



Myburgh et al. Intensive Care Medicine 2008

Dopamine


HO
HO
CH2 — CH2 — NH2
Dopamine β Hydroxylase
Noradrenaline
HO
HO
CH — CH2 — NH2
OH
PNMT
(only within the adrenal medulla)
Adrenaline
HO
HO
CH — CH2 — NH
OH
CH3

Dopamine vs Noradrenaline in Shock

SOAP I

- n = 3147 observational study
- Dopamine associated with higher in-hospital mortality (49.9% vs. 41.7%, p = .01)

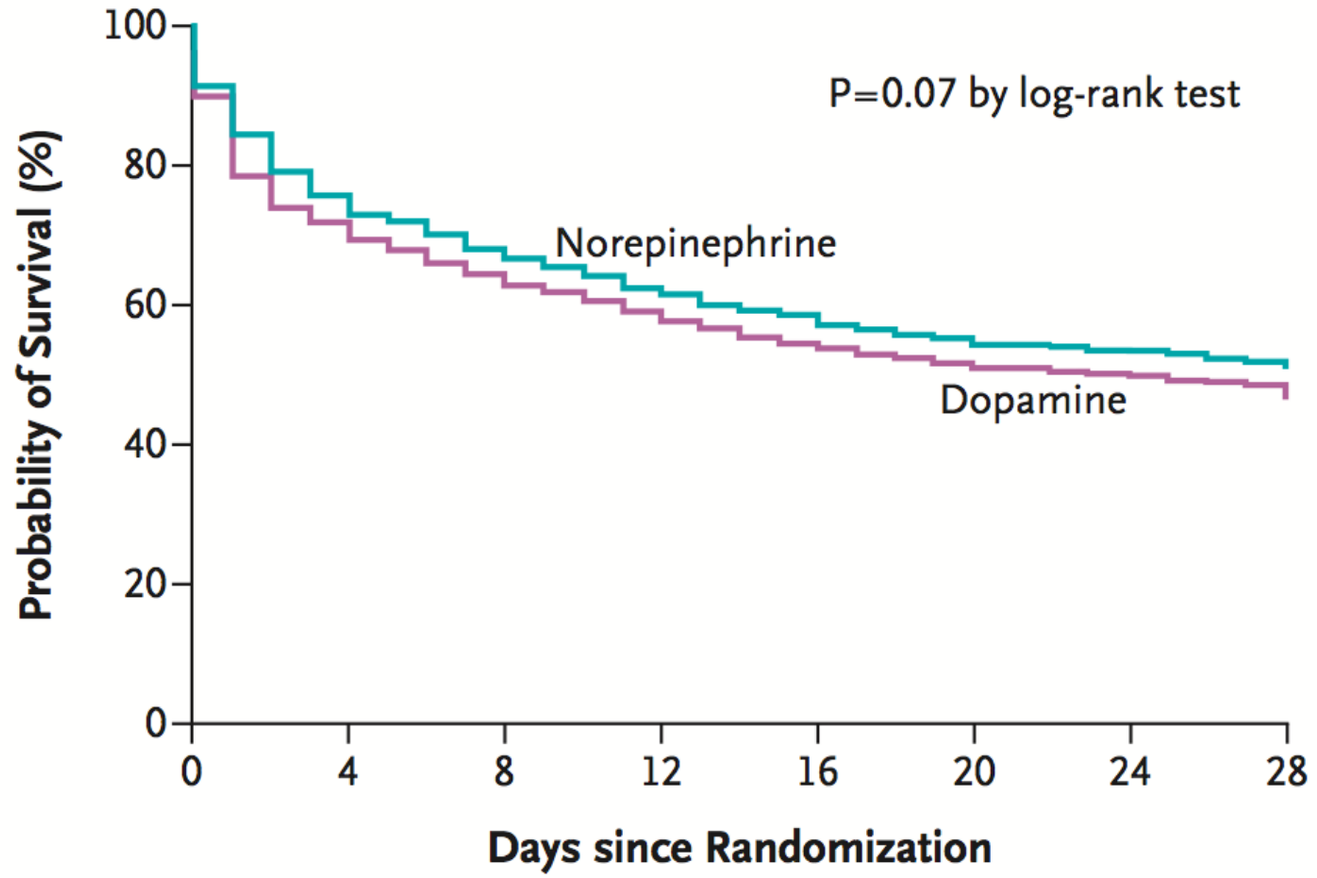
Sakr et al. (SOAP) NEJM 2010

SOAP II

- n = 1679 multicenter RCT

de Backer et al. (SOAPII) NEJM 2010

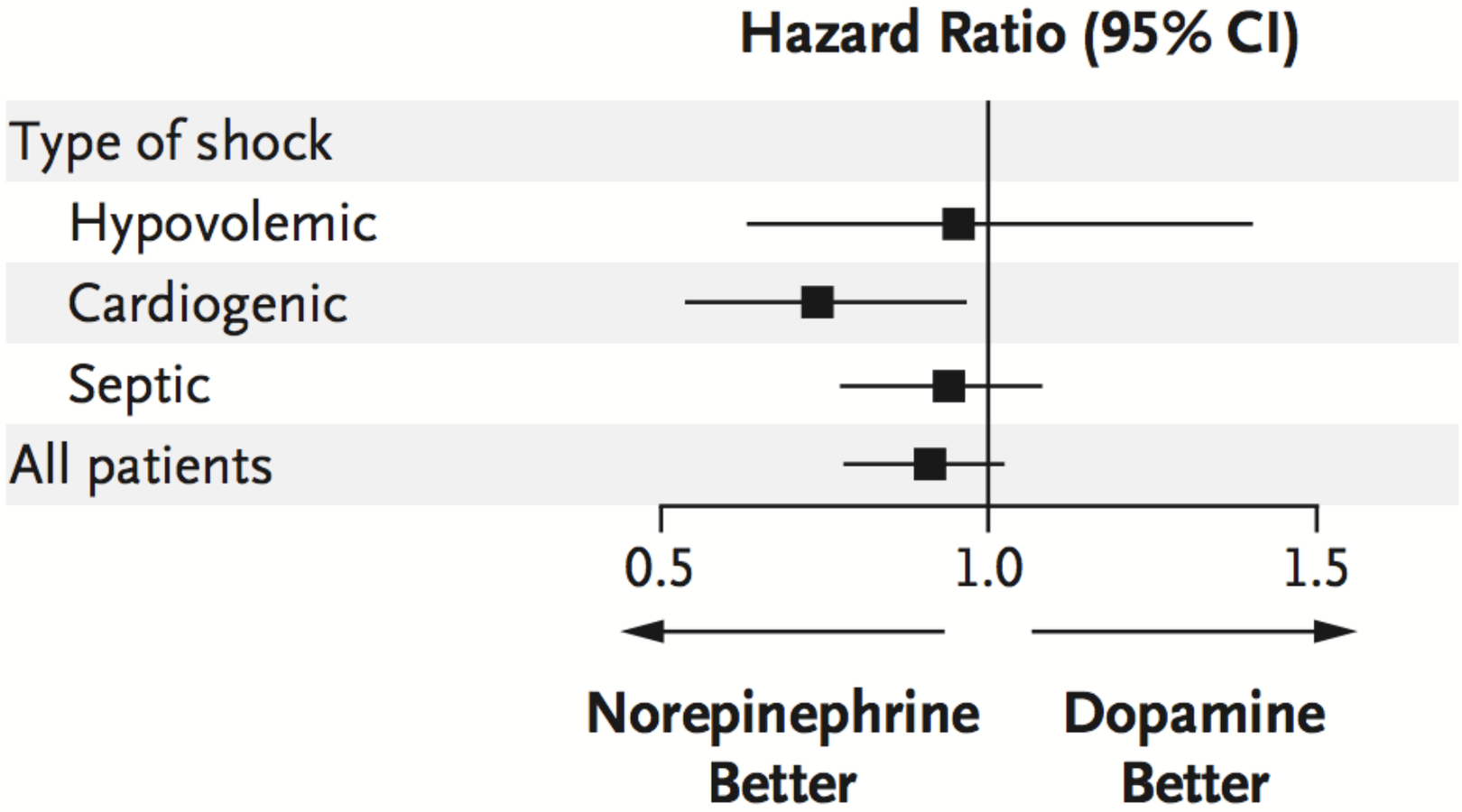
Dopamine vs Noradrenaline in Shock



No. at Risk								
Norepinephrine	821	617	553	504	467	432	412	394
Dopamine	858	611	546	494	452	426	407	386

de Backer et al. (SOAPII) NEJM 2010

Dopamine vs Noradrenaline in Shock



de Backer et al. (SOAPII) NEJM 2010

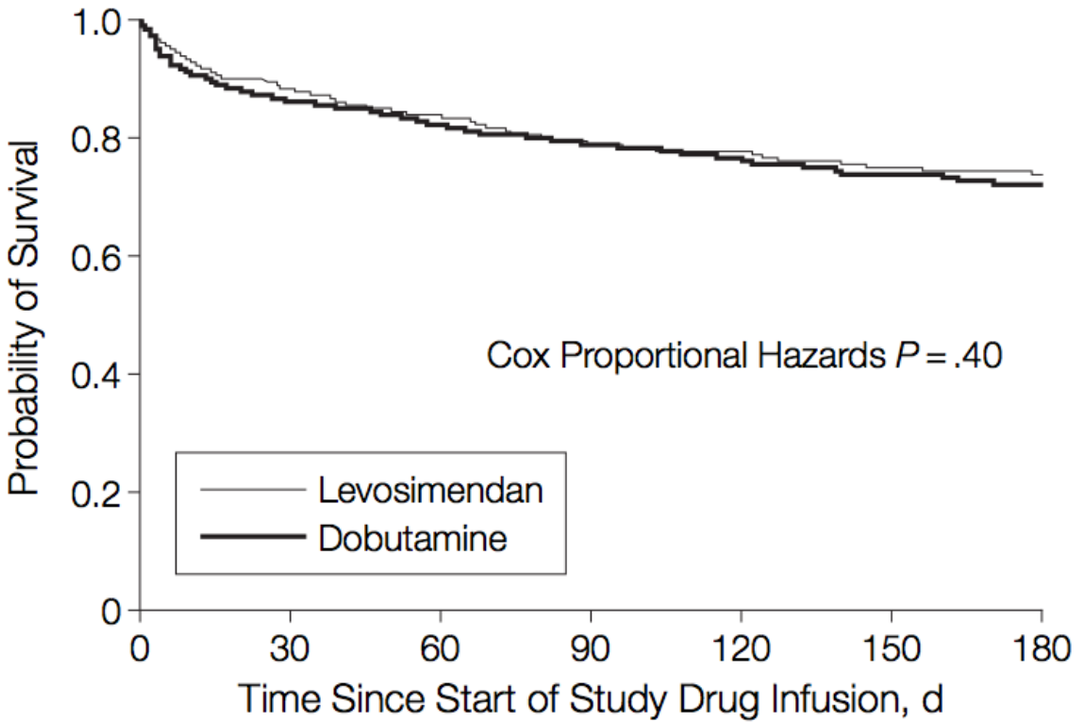
Dopamine vs Noradrenaline in Shock

Adverse events			
Arrhythmias — no. (%)	207 (24.1)	102 (12.4)	<0.001
Atrial fibrillation	176 (20.5)	90 (11.0)	
Ventricular tachycardia	21 (2.4)	8 (1.0)	
Ventricular fibrillation	10 (1.2)	4 (0.5)	

de Backer et al. (SOAPII) NEJM 2010

Levosimendan vs Dobutamine in Heart Failure

- n = 1320 multicenter multinational double blind RCT

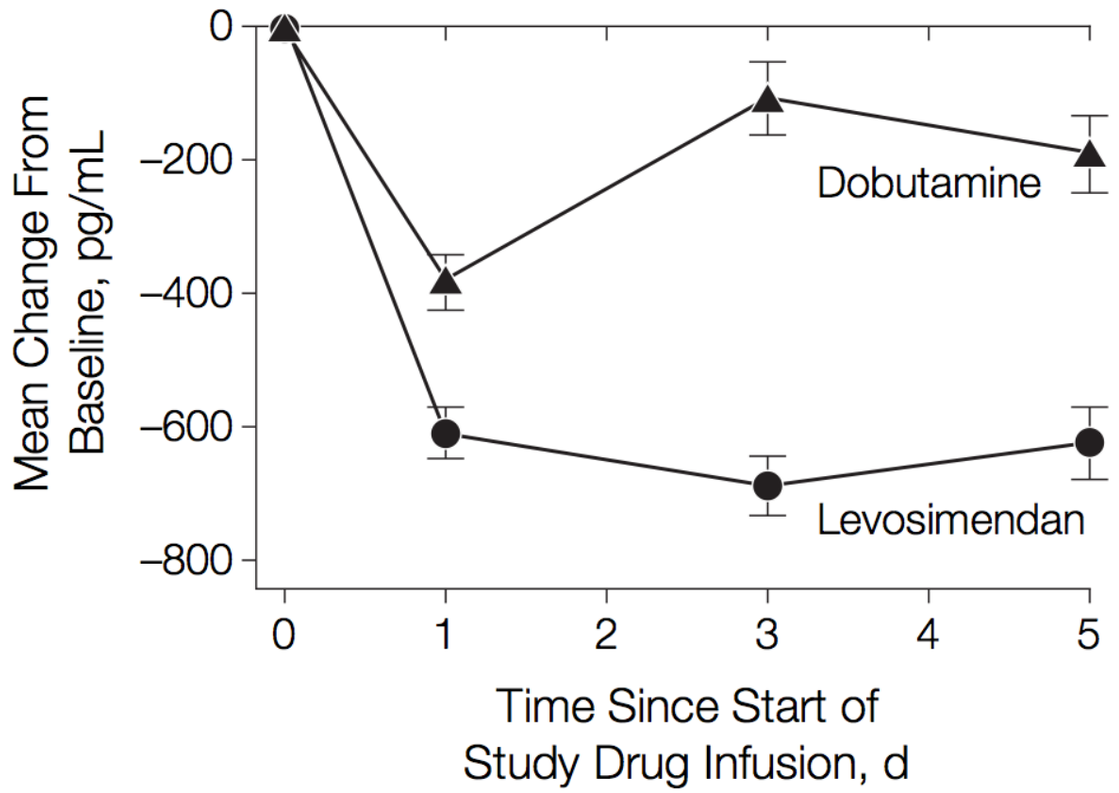


No. at Risk					
Levosimendan	664	608	586	525	462
Dobutamine	663	596	568	519	454

Mebazza et al. (SURVIVE) NEJM 2010

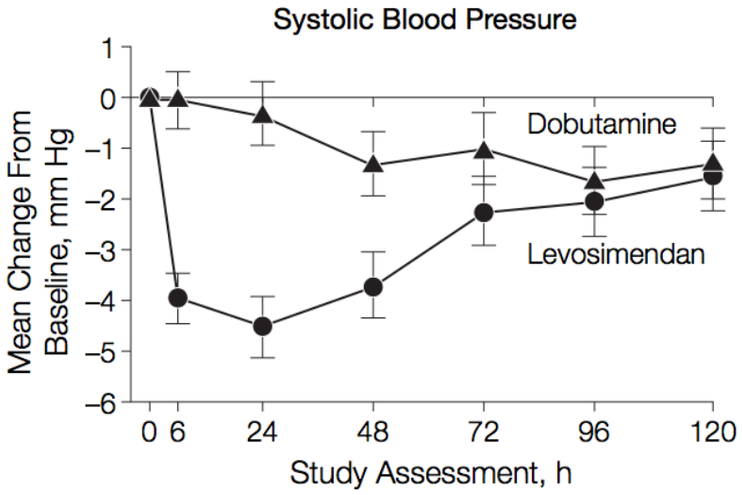
Levosimendan vs Dobutamine in Heart Failure

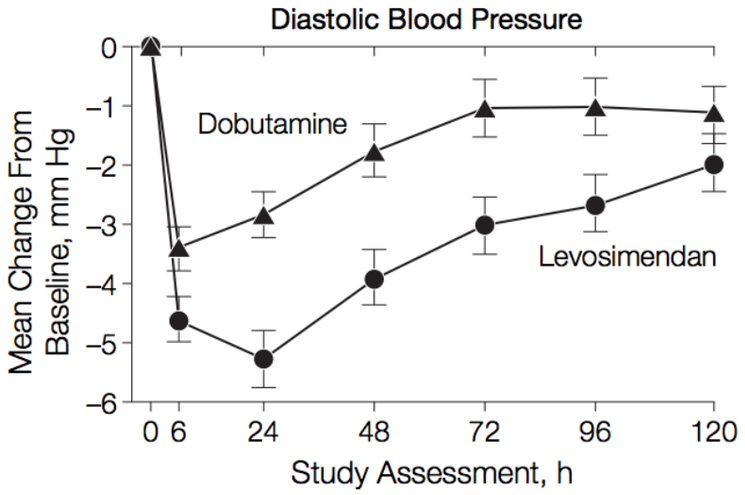
Figure 3. Mean Change From Baseline in B-Type Natriuretic Peptide Levels at 1, 3, and 5 Days by Treatment Group

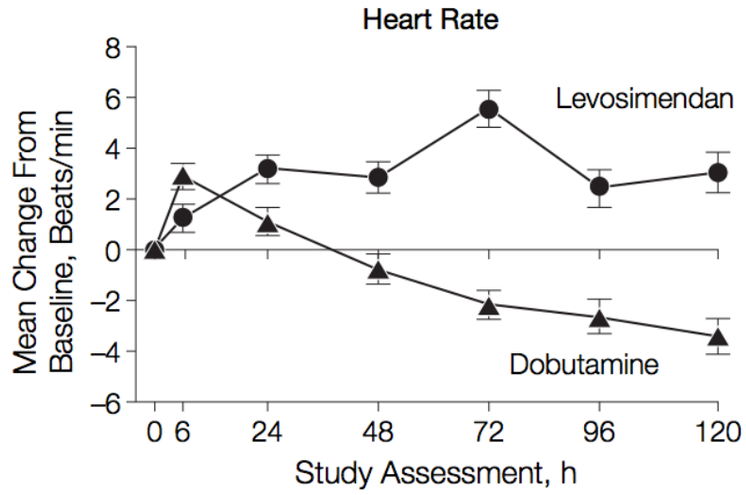


Mebazza et al. (SURVIVE) NEJM 2010

Levosimendan vs Dobutamine in Heart Failure







Mebazza et al. (SURVIVE) NEJM 2010

Vasopressin in Septic Shock

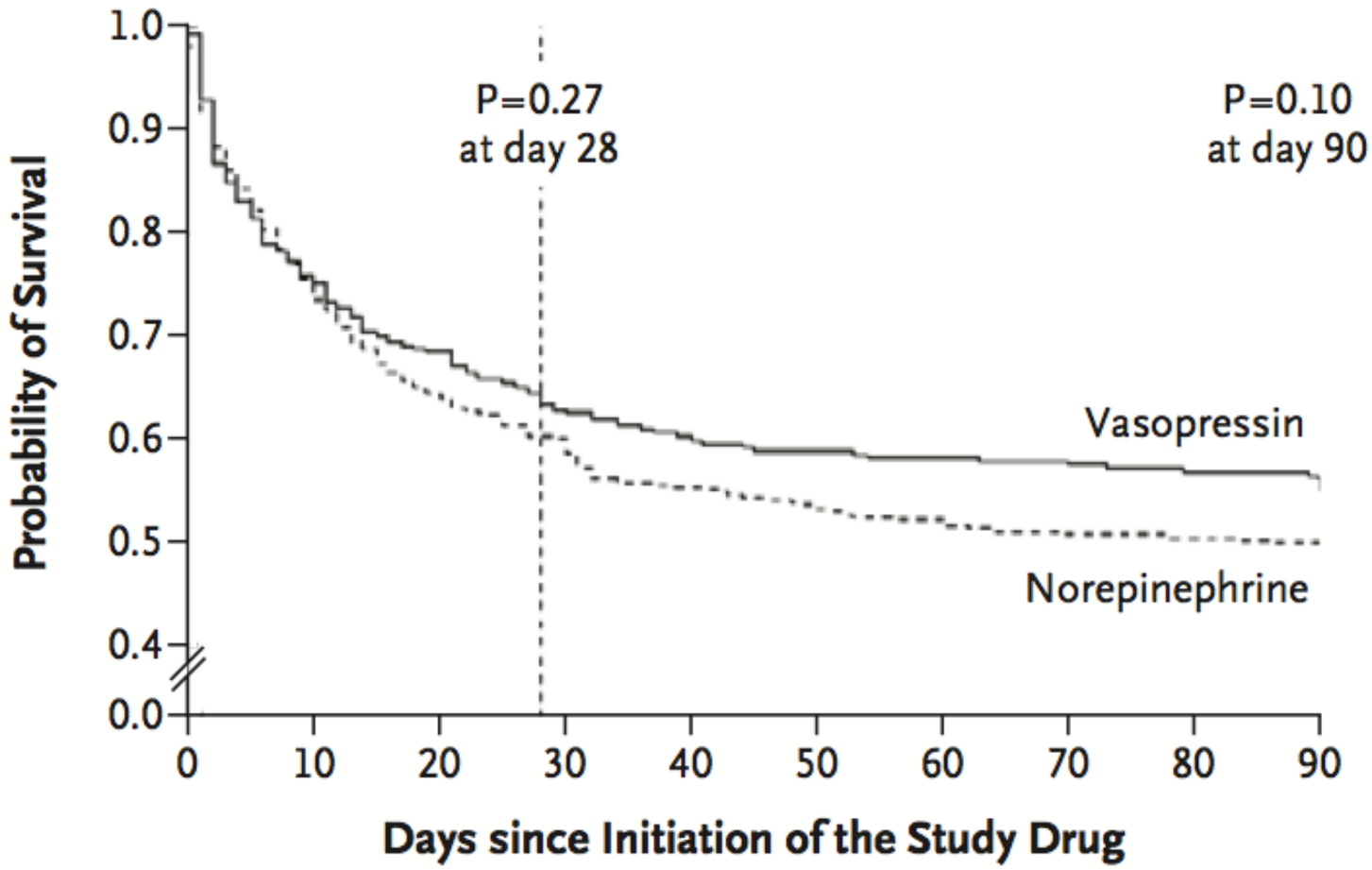
Health volunteer	4 pg/ml
Cardiogenic shock	20 pg/ml
Haemorrhagic shock	100 – 1000 pg/ml
Septic shock	3 – 12 pg/ml

Vasopressin vs Noradrenaline in Septic Shock

- n = 779 multicenter RCT
- Low fixed dose vasopressin (0.03 units/min)
- Increased plasma concentration from 3 pg/ml to 70 pg/ml

Russell et al. (VASST) NEJM 2008

Vasopressin vs Noradrenaline in Septic Shock



No. at Risk

Vasopressin	397	301	272	249	240	234	232	230	226	220
Norepinephrine	382	289	247	230	212	205	200	194	193	191

Russell et al. (VASST) NEJM 2008

Vasopressin vs Noradrenaline in Septic Shock

Stratum	Norepinephrine Group	Vasopressin Group	P Value†	Absolute Risk Reduction (95% CI)	Relative Risk (95% CI)
	no./total no. (%)			%	
More severe septic shock					
28-day mortality	85/200 (42.5)	88/200 (44.0)	0.76	–1.5 (–11.2 to 8.2)	1.04 (0.83 to 1.3)
90-day mortality	105/199 (52.8)	103/199 (51.8)	0.84	1.0 (–8.8 to 10.8)	0.98 (0.81 to 1.18)
Less severe septic shock					
28-day mortality	65/182 (35.7)	52/196 (26.5)	0.05	9.2 (–0.1 to 18.5)	0.74 (0.55 to 1.01)
90-day mortality	83/180 (46.1)	69/193 (35.8)	0.04	10.4 (0.4 to 20.3)	0.78 (0.61 to 0.99)

Russell et al. (VASST) NEJM 2008

Vasopressin vs Noradrenaline in Septic Shock

Variable	Norepinephrine Group (N=382)	Vasopressin Group (N=396)	P Value*
	no. (%)		
At least one serious adverse event	40 (10.5)	41 (10.3)	1.00
Acute myocardial infarction or ischemia	7 (1.8)	8 (2.0)	1.00
Cardiac arrest	8 (2.1)	3 (0.8)	0.14
Life-threatening arrhythmia	6 (1.6)	8 (2.0)	0.79
Acute mesenteric ischemia	13 (3.4)	9 (2.3)	0.39
Hyponatremia†	1 (0.3)	1 (0.3)	1.00
Digital ischemia	2 (0.5)	8 (2.0)	0.11
Cerebrovascular accident	1 (0.3)	1 (0.3)	1.00
Other‡	2 (0.5)	5 (1.3)	0.45

Russell et al. (VASST) NEJM 2008

Steroids in Septic Shock

- 80's studies on high dose methylprednisolone
- 90's small studies on low dose hydrocortisone
- Annane 2002
- CORTICUS 2008
- ADRENAL study ongoing.

Noradrenaline / Adrenaline Concentrations

Single	2 mg	40 mcg/ml
Single	4 mg	80 mcg/ml
Double	8 mg	160 mcg/ml
Oct	16 mg	320 mcg/ml

Noradrenaline / Adrenaline Concentrations

Single	2 mg	40 mcg/ml
Single	4 mg	80 mcg/ml
Double	8 mg	160 mcg/ml
Oct	16 mg	320 mcg/ml

5 mls/hr ≃ 0.1 mcg/Kg/min in a 70 Kg patient

Haemodynamic Support

- Start by determining your patient's problem
- Give fluids with great care
- Vasopressors also give you preload
- Dopamine = trouble
- No inotrope has an evidence based throne
- Remember Ca^{++}