Cardiovascular Management of Septic Shock

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Septic Shock — A Melting Pot of Shock Etiologies

- Hypovolemic (loss of cardiac filling)
  - Capillary leak (absolute hypovolemia)
  - Venodilatation (relative hypovolemia)
- Cardiogenic
  - Decrease in contractility
- Obstructive
  - Rise in pulmonary vascular resistance
- Distributive (hypoperfusion despite normal/increased cardiac output)

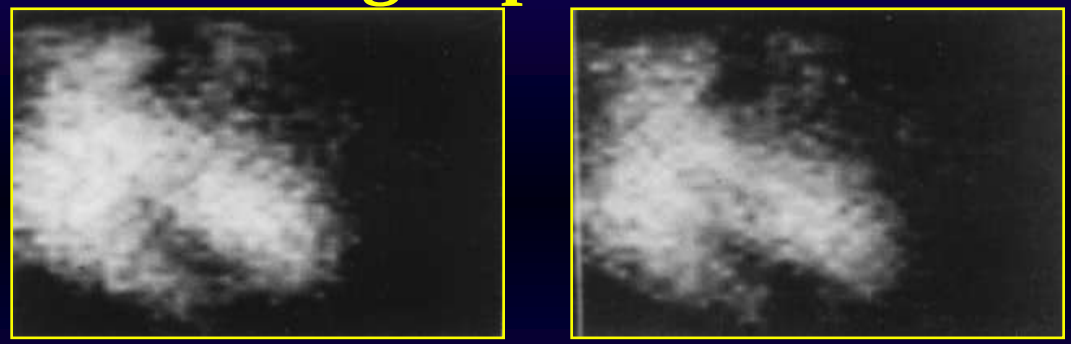
MYOCARDIAL DYSFUNCTION IN SEPSIS

Left ventricular dysfunction

Right ventricular dysfunction

During Septic Shock

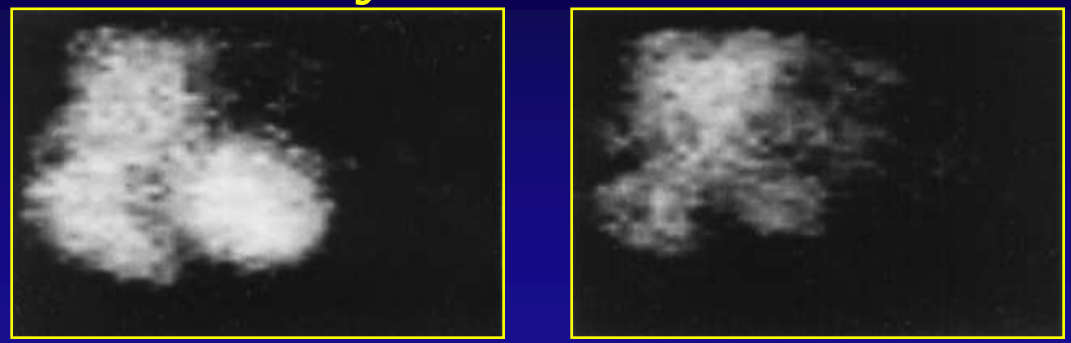
Diastole



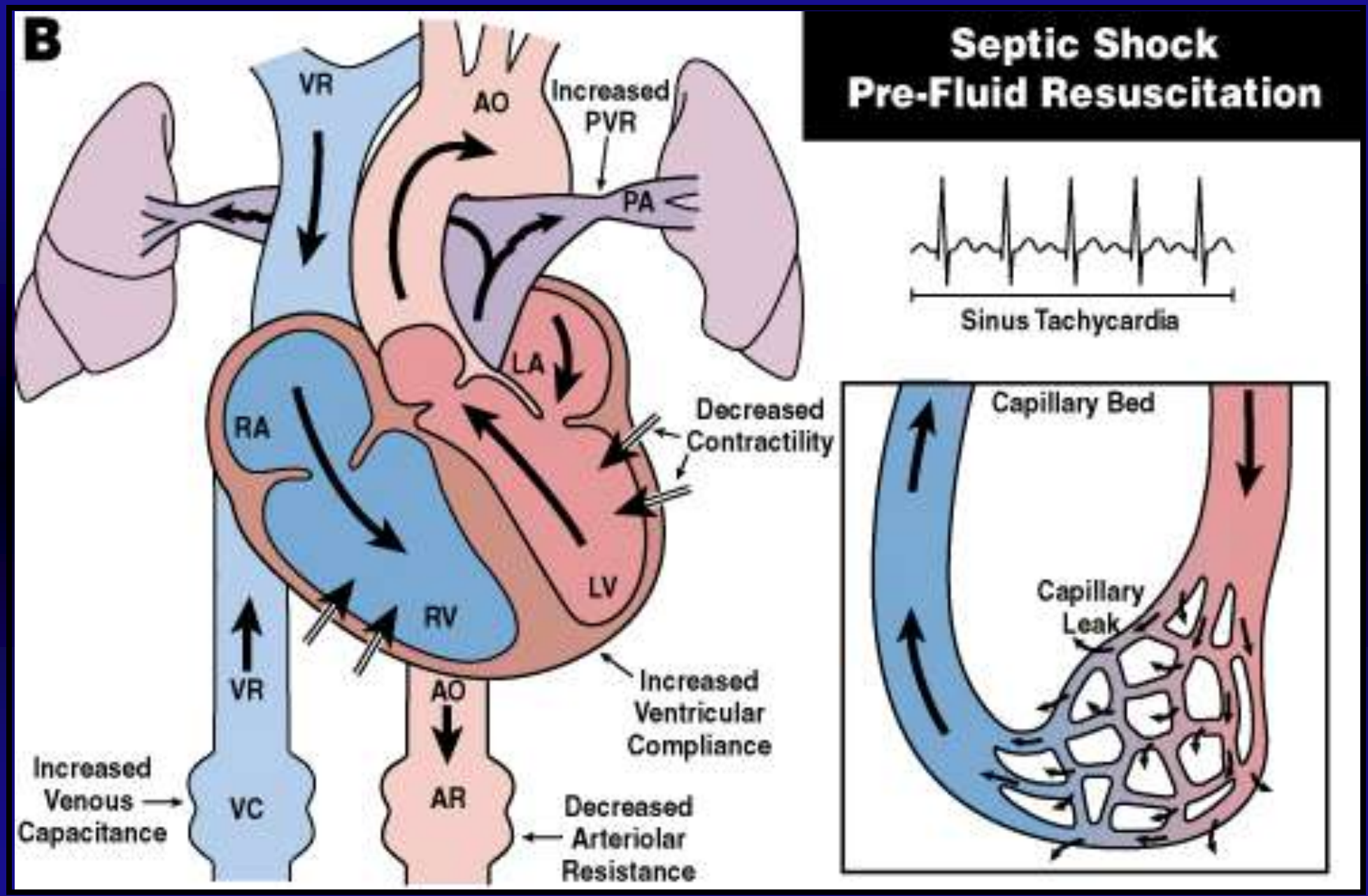
Systole

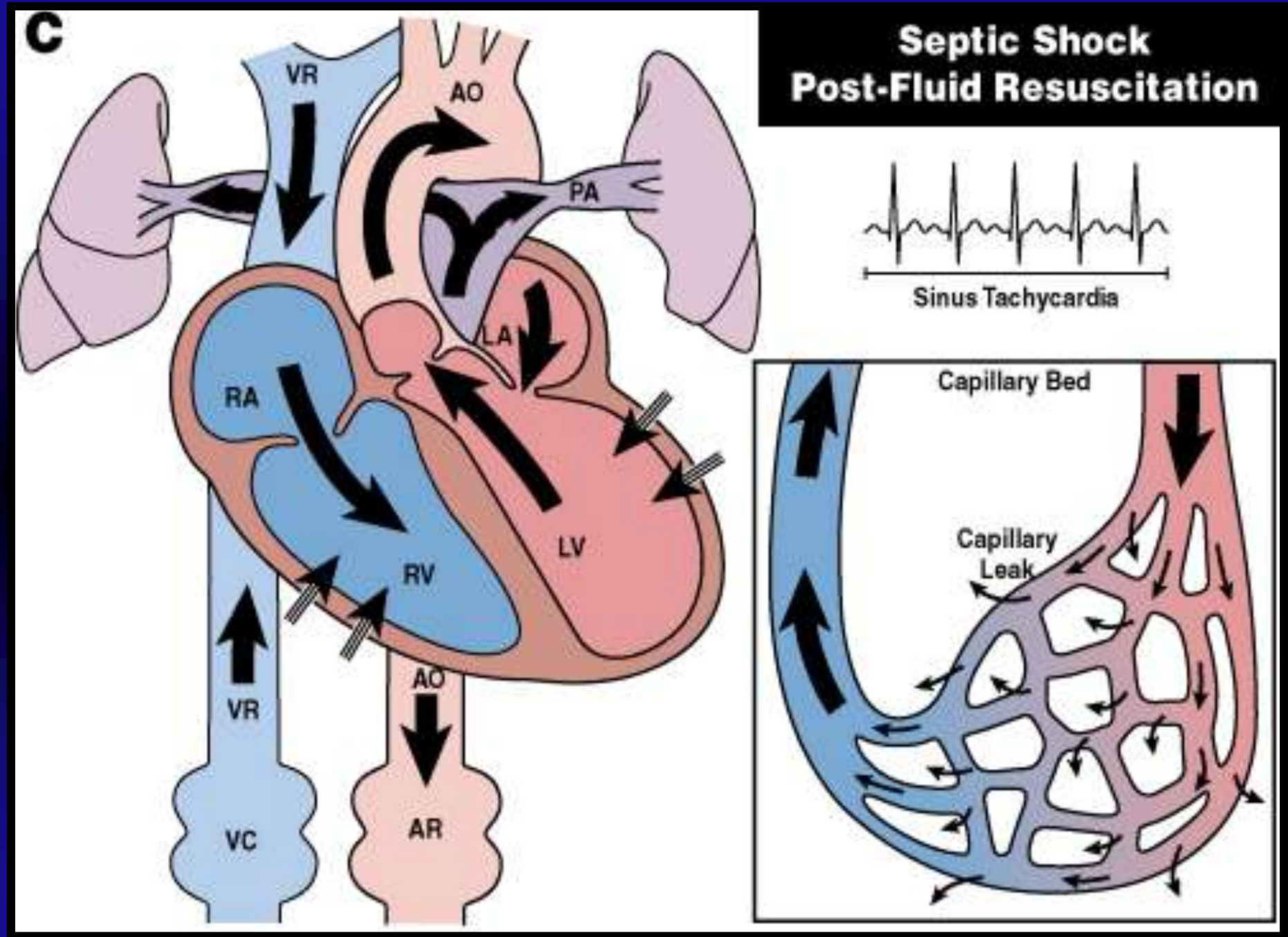
10 Days Post Shock

Diastole



Systole


B
Septic Shock
Pre-Fluid Resuscitation
VR
AO
Increased
PVR
PA
LA
RA
Decreased
Contractility
LV
RV
VR
AO
Increased
Ventricular
Compliance
Increased
Venous
Capacitance
VC
AR
Decreased
Arteriolar
Resistance
Sinus Tachycardia
Capillary Bed
Capillary
Leak


C
Septic Shock
Post-Fluid Resuscitation
VR
AO
PA
LA
RA
RV
LV
VR
AO
VC
AR
Sinus Tachycardia
Capillary Bed
Capillary
Leak

Question:

If ejection fraction (contractility) is decreased in sepsis, why is cardiac output usually increased?

Reasons:

(1) Tachycardia

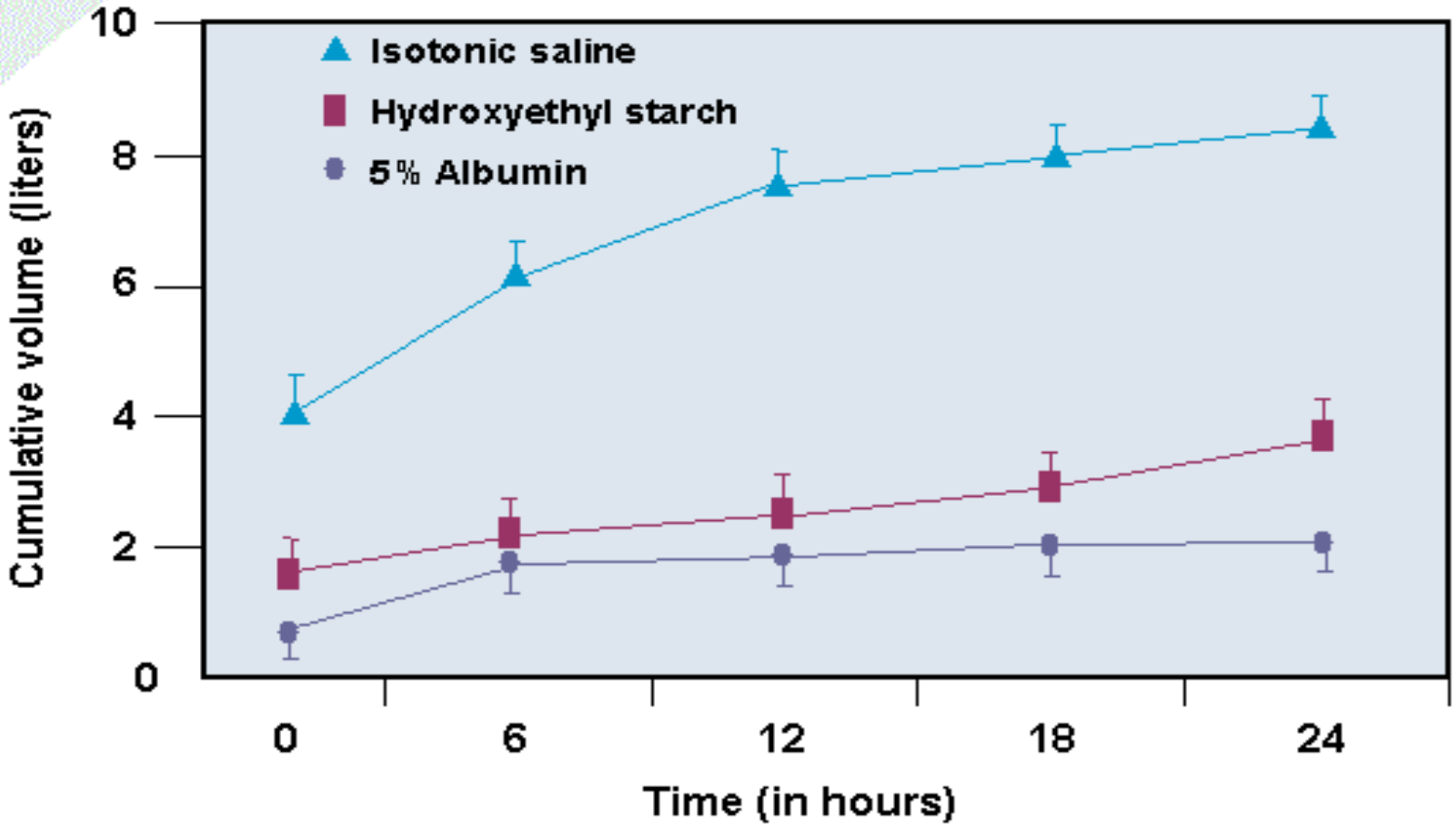
(2) Decreased LV afterload

(3) Increase in LV compliance

Hemodynamic Profile in Severe Sepsis and Septic Shock

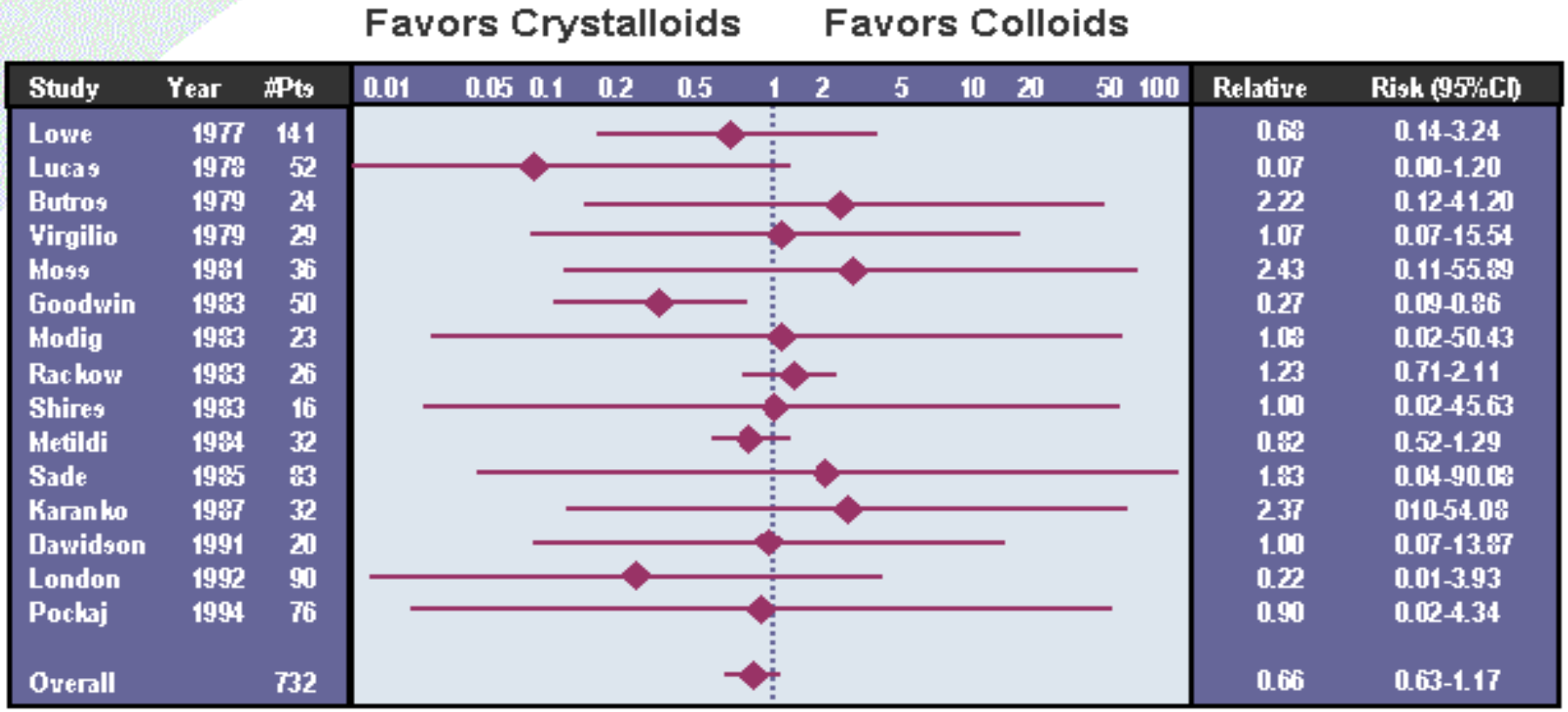
- Following volume resuscitation typically increased cardiac index with decreased systemic vascular resistance

Fluid Requirements in Sepsis



Rackow EC, et al. *Crit Care Med* 1983;11:839-50.

What is the "Best" Fluid:
Crystalloids vs Colloids?



Study	Year	#Pts	Relative	Risk (95%CI)
Lowe	1977	141	0.68	0.14-3.24
Lucas	1978	52	0.07	0.00-1.20
Butros	1979	24	2.22	0.12-41.20
Virgilio	1979	29	1.07	0.07-15.54
Moss	1981	36	2.43	0.11-55.89
Goodwin	1983	50	0.27	0.09-0.86
Modig	1983	23	1.08	0.02-50.43
Rackow	1983	26	1.23	0.71-2.11
Shires	1983	16	1.00	0.02-45.63
Metildi	1984	32	0.82	0.52-1.29
Sade	1985	83	1.83	0.04-90.08
Karanko	1987	32	2.37	010-54.08
Dawidson	1991	20	1.00	0.07-13.87
London	1992	90	0.22	0.01-3.93
Pockaj	1994	76	0.90	0.02-4.34
Overall		732	0.66	0.63-1.17

Choi PTL, et al. *Crit Care Med* 1999;27:200-10; Cook D, et al. *Ann Intern Med* 2001;135:205-8; Schierhout G, et al. *BMJ* 1998 28;316:961-4; Wilkes MM, et al. *Ann Intern Med* 2001;135:149-64.

Monitoring for Excessive Increase in Pulmonary Capillary Pressure

- Physical exam
- Central venous pressure
- Pulmonary artery occlusion pressure

Hypotension Persists Despite Adequate Left Ventricular Preload

No PA Cath

- Combined inotrope/vasopressor

PA Cath

- Confirm adequate preload
- Inotrope targeted to maintain cardiac index 3.0
- Vasopressor targeted to maintain MAP 65 mm Hg

CVP catheter?

LeDoux D, Astiz ME, Carpati CM, Rackow EC

Effects of perfusion pressure on tissue perfusion in septic shock

Crit Care Med 2000; 28:2729-2732

MAP

	65 mm Hg	75 mm Hg	85 mm Hg	F/LT
HR (beats/min)	97 ± 4	101 ± 4	105 ± 5	.02/.02
MAP (mm Hg)	65 ± 0.5	75 ± 0.4	86 ± 0.4	.0001/.0001
CI (L/min/m^2)	4.7 ± 0.5	5.3 ± 0.6	5.5 ± 0.6	07/.03
PAOP (mm Hg)	14 ± 1	15 ± 1	16 ±1	.18/.16
LVSWI (g.m/m^2)	45 ± 3	52 ± 5.5	63 ± 7	.01/.01
SVRI (dyne.sec/m^2.cm^5)	998 ± 94	1065 ± 101	1216 ± 159	.09/.046
Norepinephrine (µg/min)	23 ± 22	31 ± 25	47 ± 39	.02/.016

MAP

	65 mm Hg	75 mm Hg	85 mm Hg	F/LT
Urinary output (mL)	49 ±18	56 ± 21	43 ±13	.60/.71
Capillary blood flow (mL/min/100 g)	6.0 ± 1.6	5.8 ± 11	5.3 ± 0.9	.59/.55
Red Cell Velocity (au)	0.42 ± 0.06	0.44 ±016	0.42 ± 0.06	.74/.97
$Pico_2$ (mm Hg)	41 ± 2	47 ± 2	46 ± 2	.11/.12
Pa-$Pico_2$ (mm Hg)	13 ± 3	17 ± 3	16 ± 3	.27/.40

Traditional Vasopressor Therapy of Septic Shock

- Dopamine
- Norepinephrine
- Phenylephrine
- Epinephrine

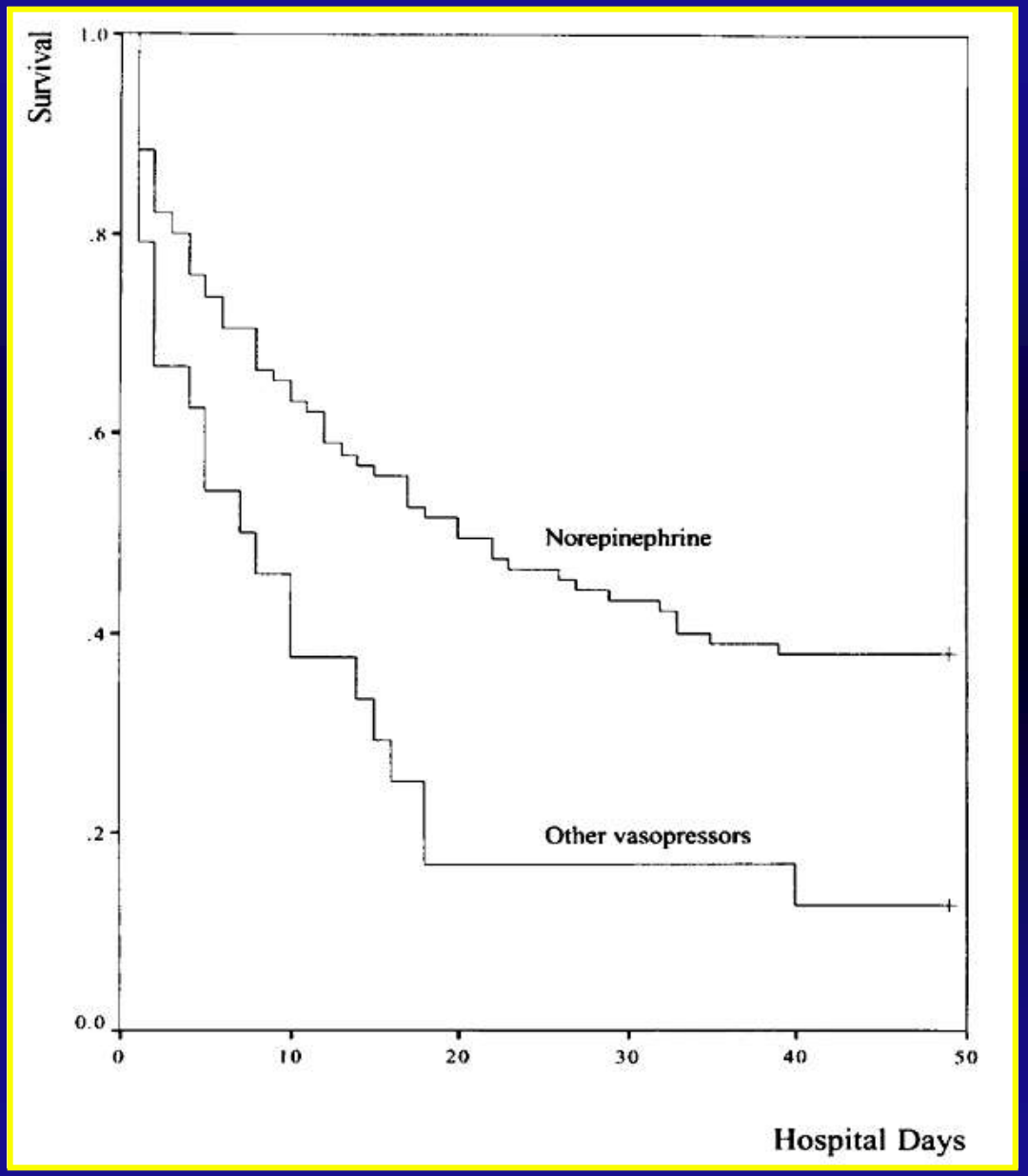
Norepinephrine vs Dopamine

Norepinephrine

- **Greater effect on efferent as opposed to afferent glomerular arteriolar resistance**
- **Better preserved splanchnic perfusion?**
- **Venous bed constriction**
  - **less ADH release**
  - **less tachycardia**
- **No effect on hypothalamic – pituitary axis or intracranial pressure**
- **More suppression of tumor necrosis factor**

Martin C, Viviand X, Leone M, Thirion X. **Effect of norepinephrine on the outcome of septic shock.** *Crit Care Med 2000; 28:2758-2765*

NE had significantly lower hospital mortality (62% vs 82%) p<.001

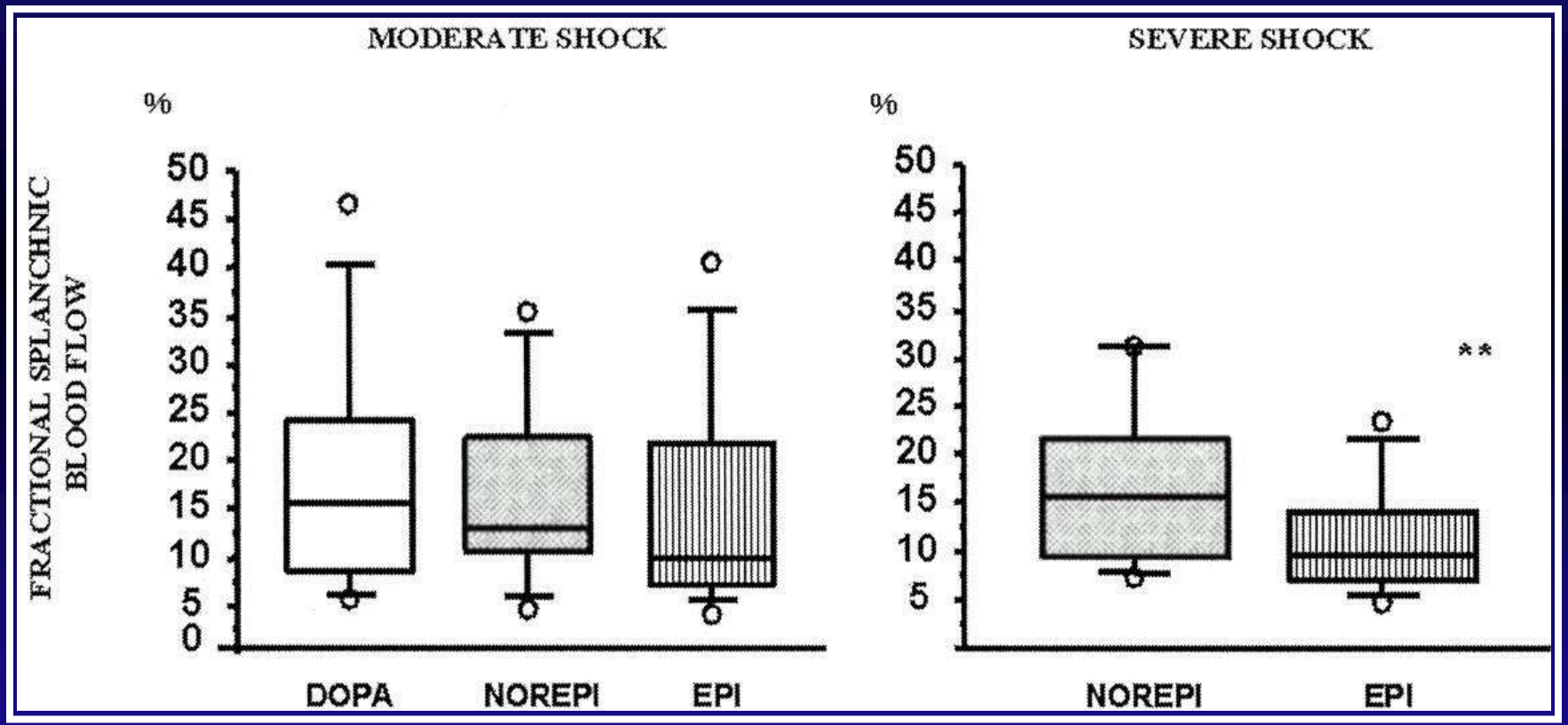


Utility of Vasopressin in Septic Shock

Vasopressin and Shock

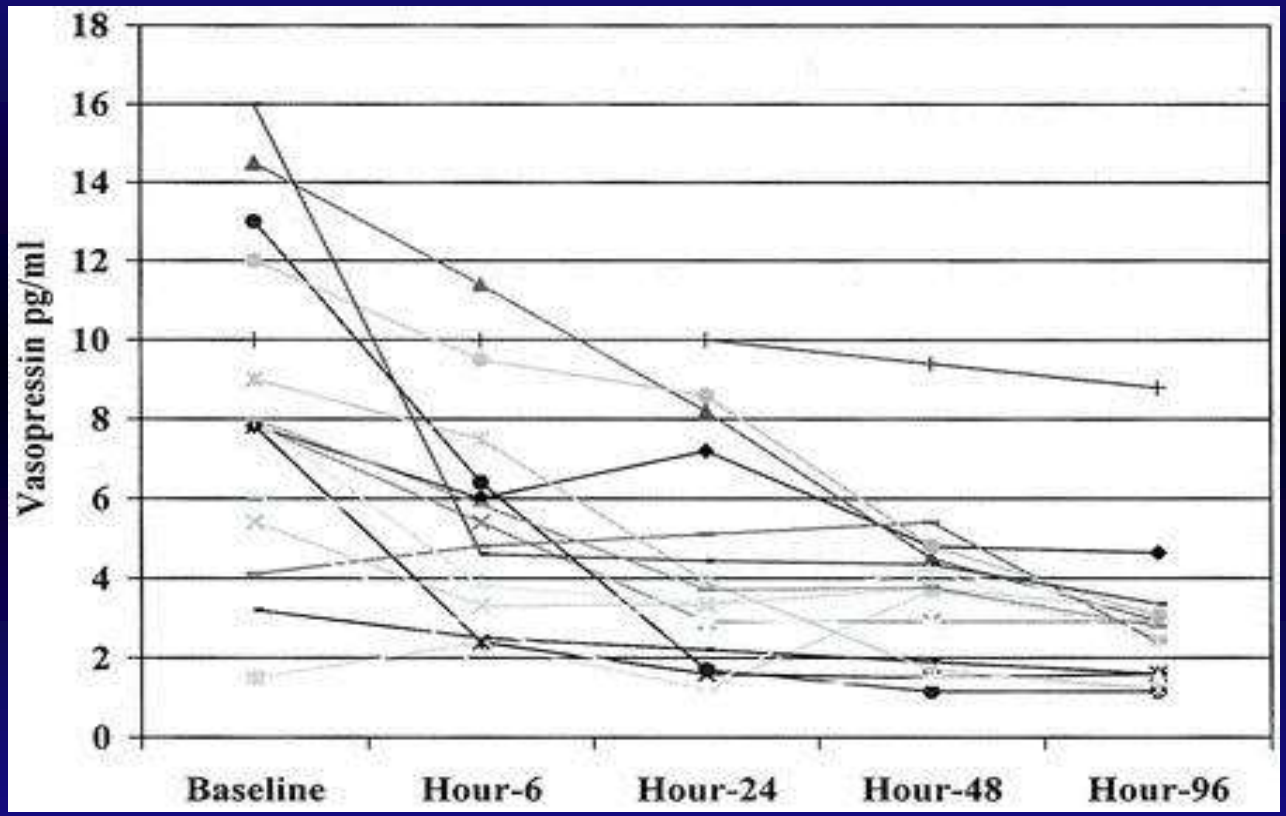
- Animal models of septic shock
- Septic versus cardiogenic shock

Effects of Dopamine, Norepinephrine, and Epinephrine on the Splanchnic Circulation in Septic Shock: Which is Best?



De Backer D, et al. *Crit Care Med* 2003; 31:1659-1667

Circulating Vasopressin Levels in Septic Shock



Sharshar T, et al. *Crit Care Med* 2003; 31:1752-1758

Vasopressin and Septic Shock

- Human septic shock studies with low rates of infusion (.01-.04 units minute) decrease traditional vasopressor requirements.

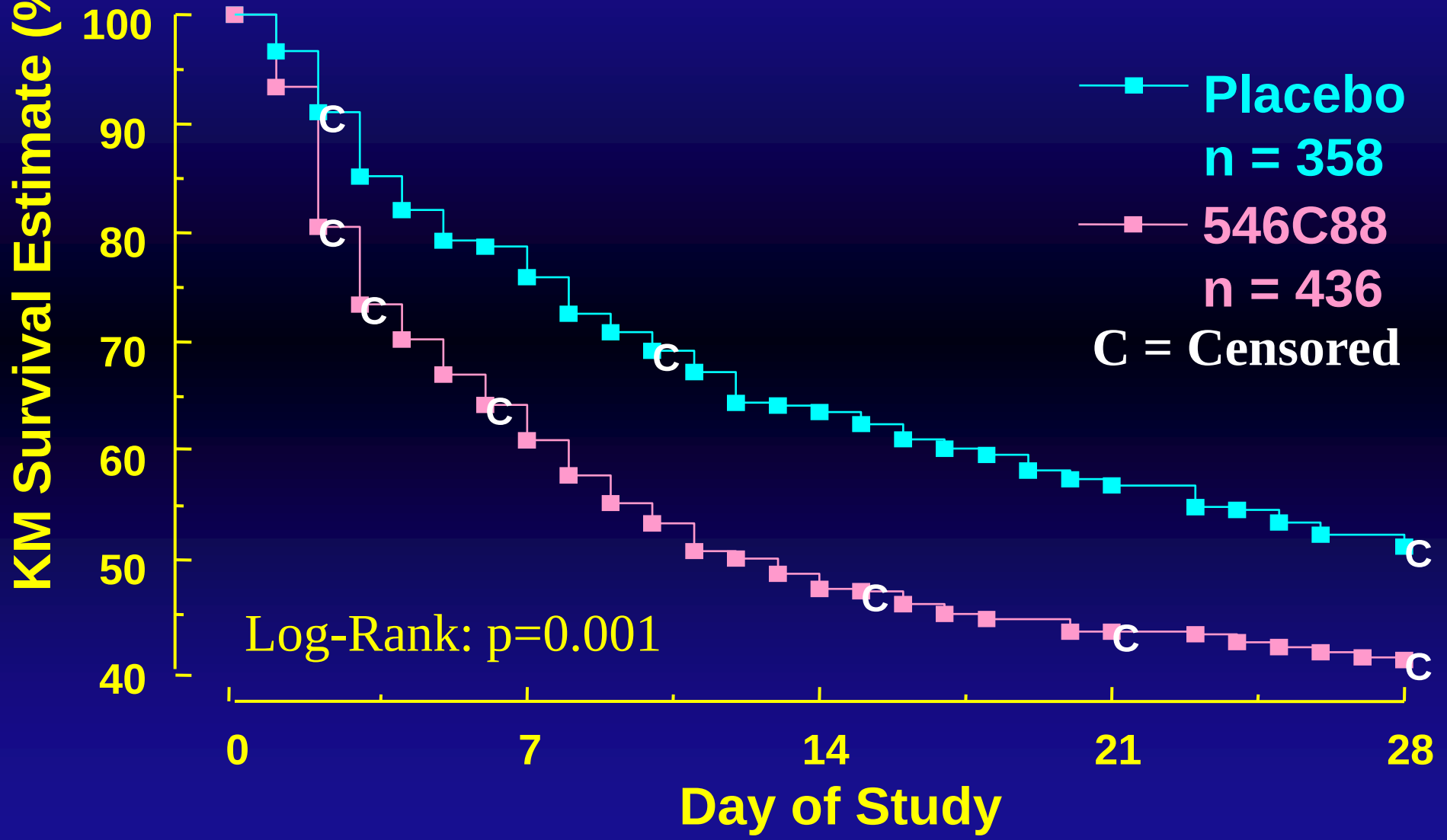
So where do we stand with vasopressin therapy?

- Low dose vasopressin is very effective in decreasing or eliminating requirements of other vasopressors in septic shock

Concerns with routine use of vasopressin

- Effect on splanchnic circulation
- Effect on stroke volume and cardiac output

LMAB3001 - Kaplan-Meier Survival Curves
All Patients (Stages 1 & 2 combined)



Discussed in SSC Guidelines Presentation

- Early goal directed resuscitation
- Steroid therapy
- Recombinant Activated Protein C

Reasonable Therapeutic Goals in Severe Sepsis with Hypoperfusion

- Mean arterial pressure of 60–65 mm Hg
- Urine output of ≥0.5 ml/kg/hr
- ScvO2 ≥ 70%
- Reversal of lactic acidosis
- If cardiac output measured, ≥ 3.0