Angiotensin II v kardiochirurgii

Komu a kdy?

Hynek Říha

Klinika anesteziologie a resuscitace

Kardiocentrum IKEM, Praha

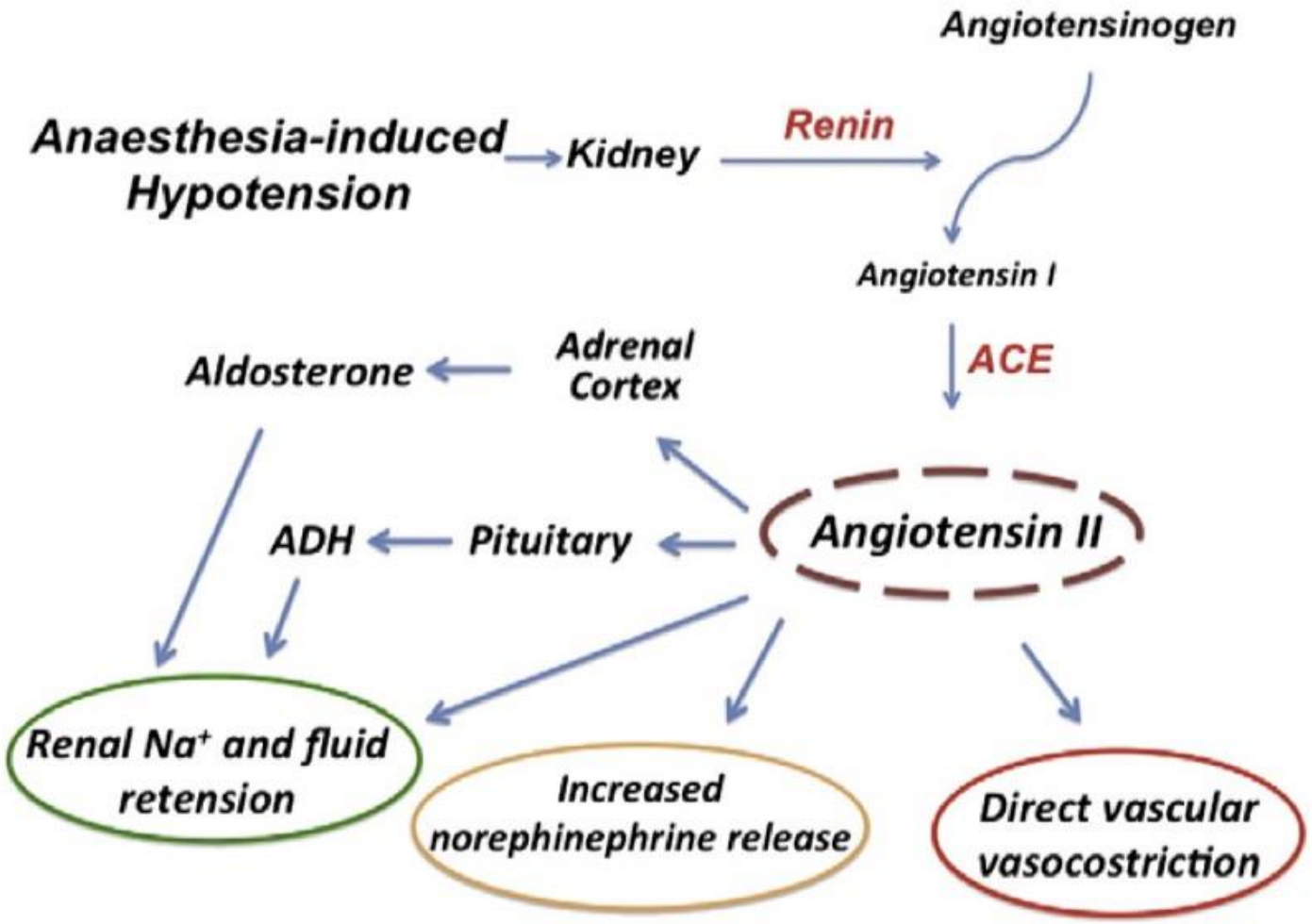
Praha 9.10.2025

Deklarace konfliktu zájmů

- Medis

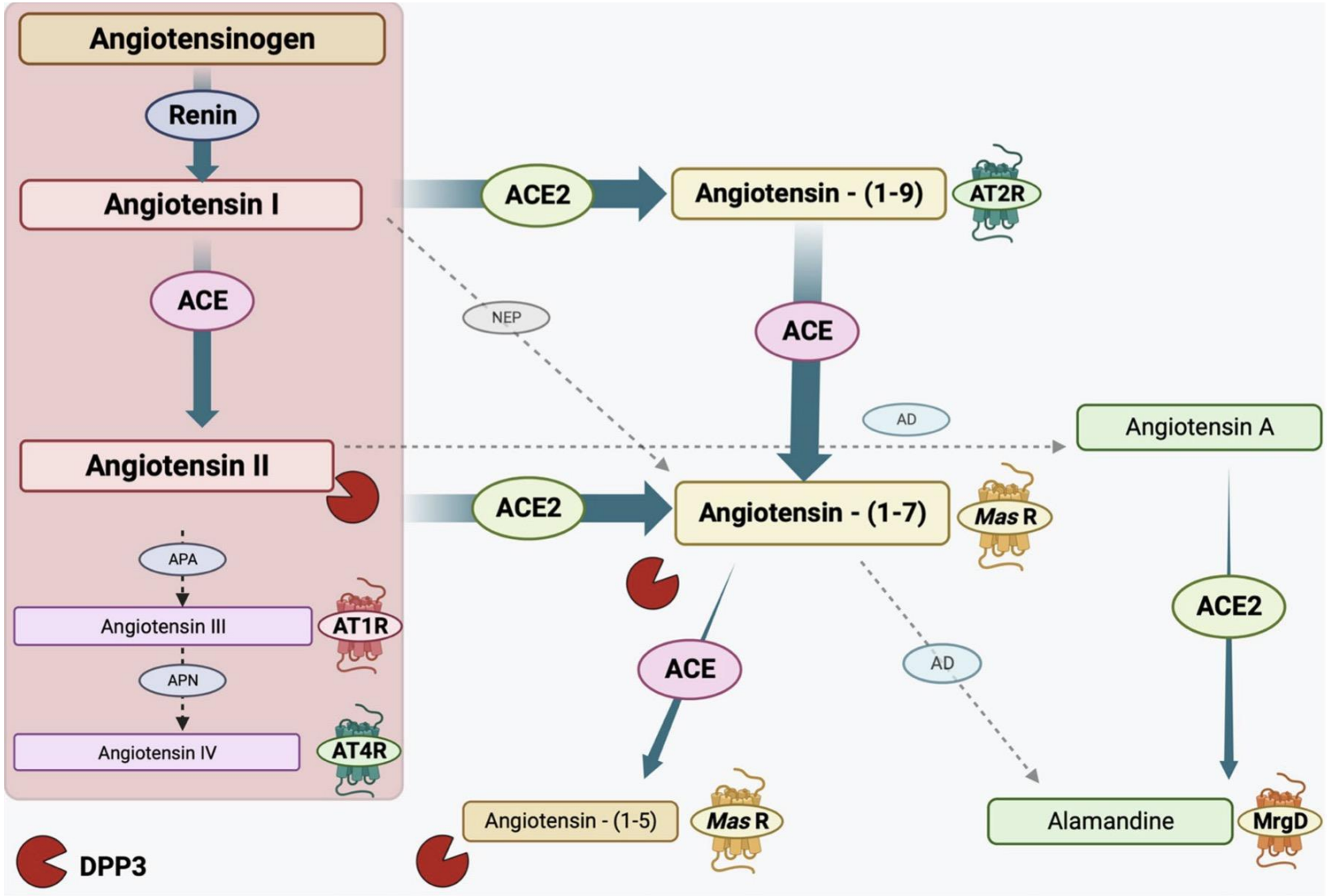
✓ 1x edukační přednáška 6/2025

Systém renin – angiotenzin – aldosteron (RAAS)



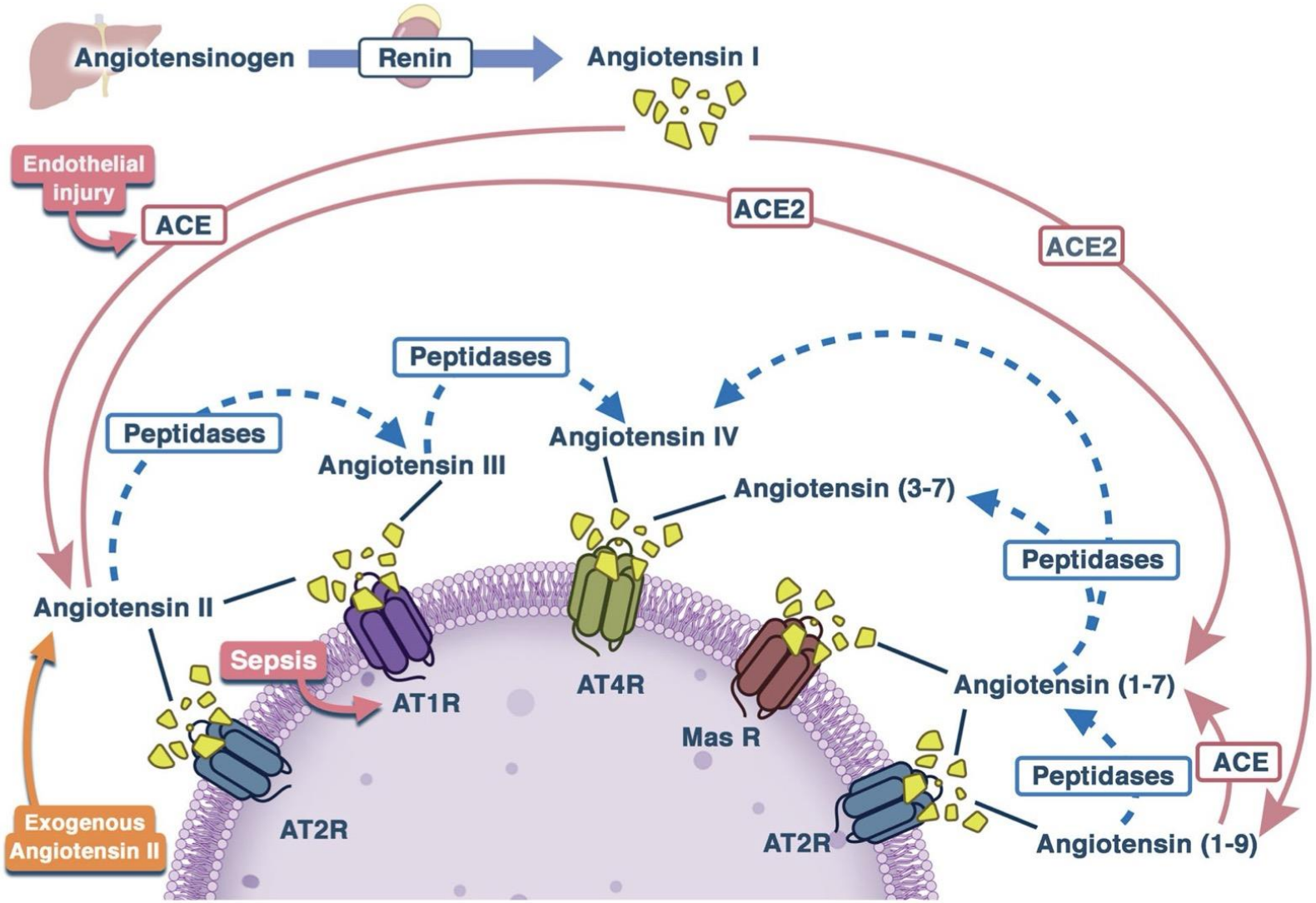
Mangieri A. J Crit Care 2015;30:613

RAAS: klasická a alternativní cesta



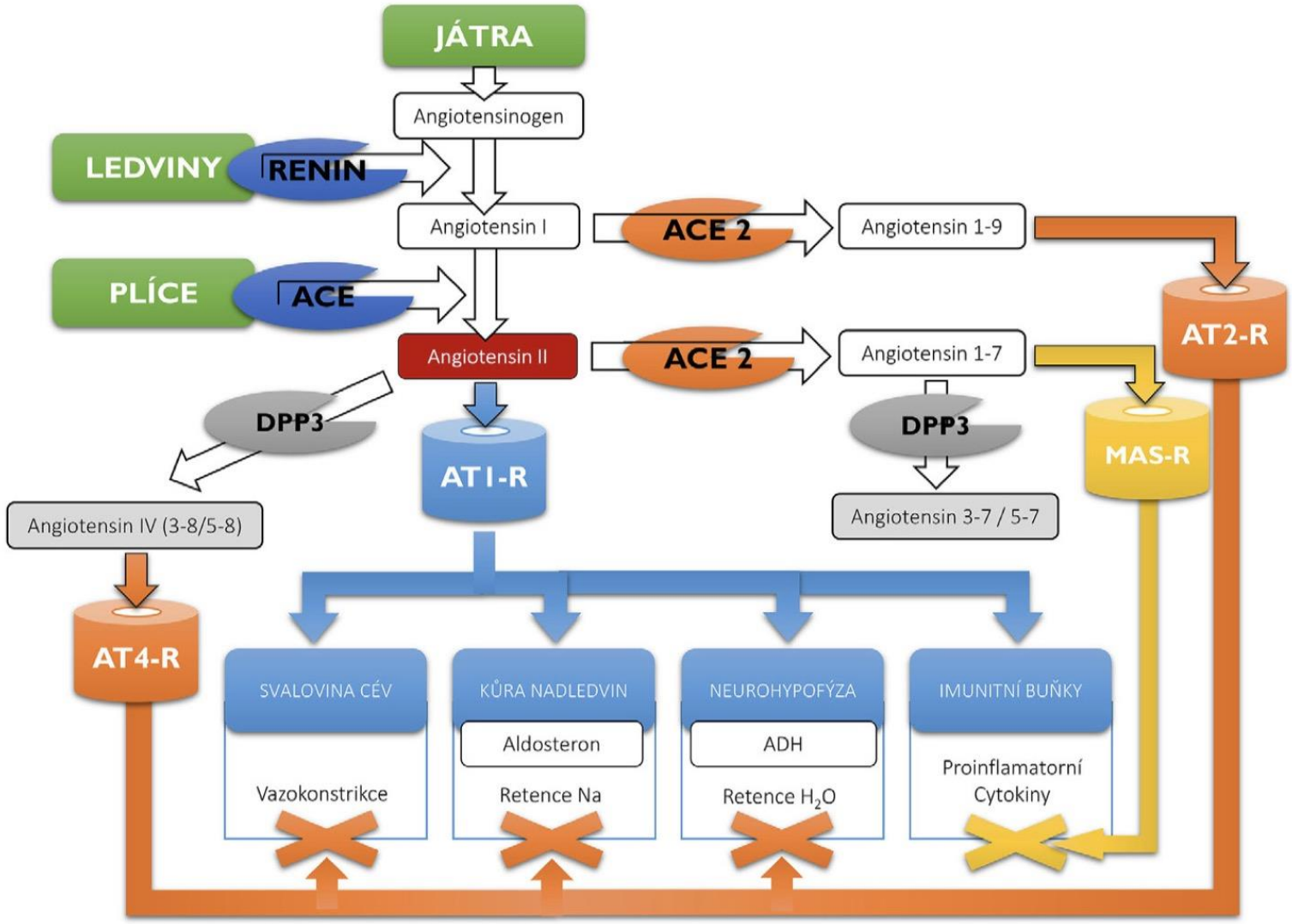
Garcia B et al. Crit Care 2023;27:453

RAAS: komplexní systém



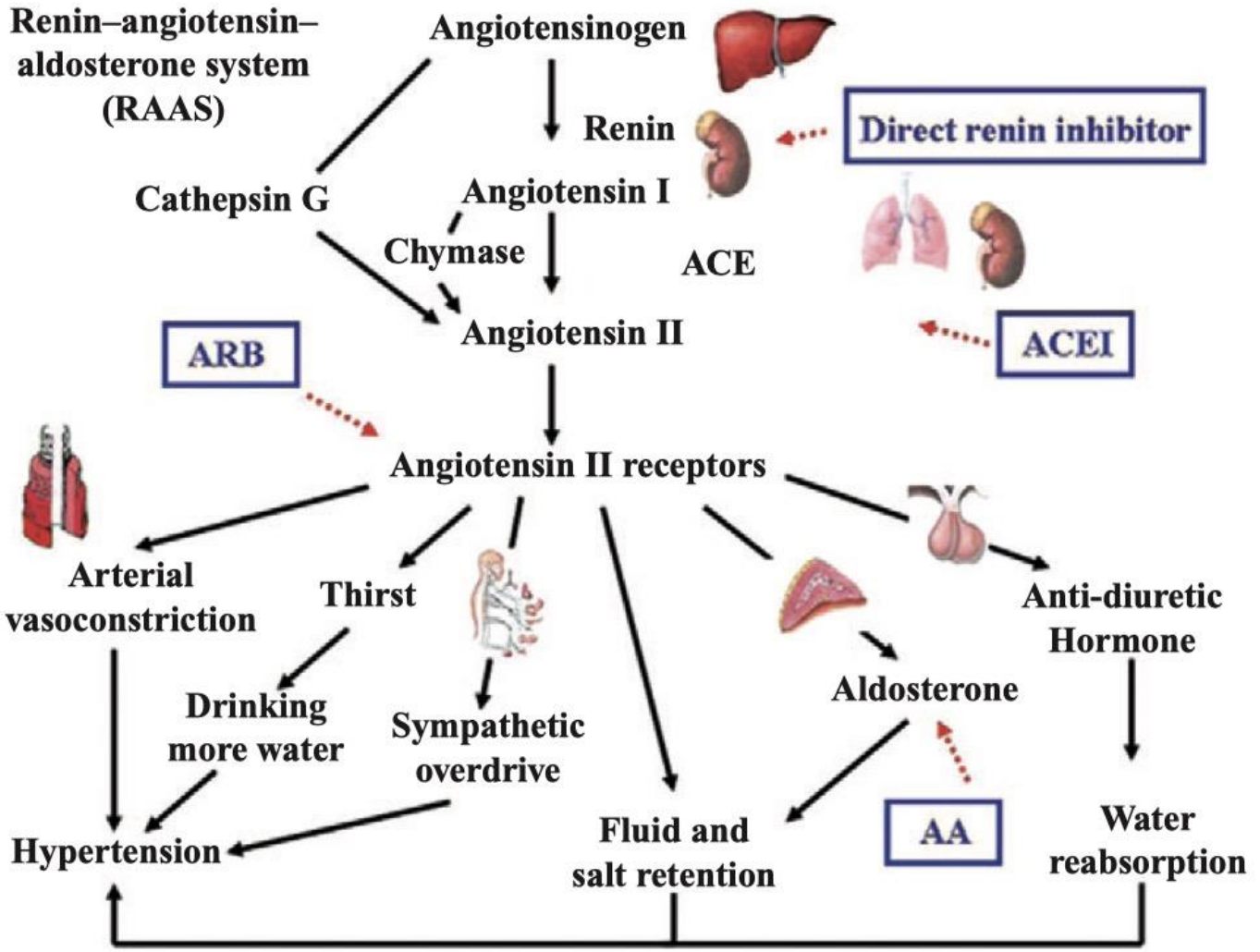
Bellomo R. Intensive Care Med 2024;50:279

RAAS: komplexní systém



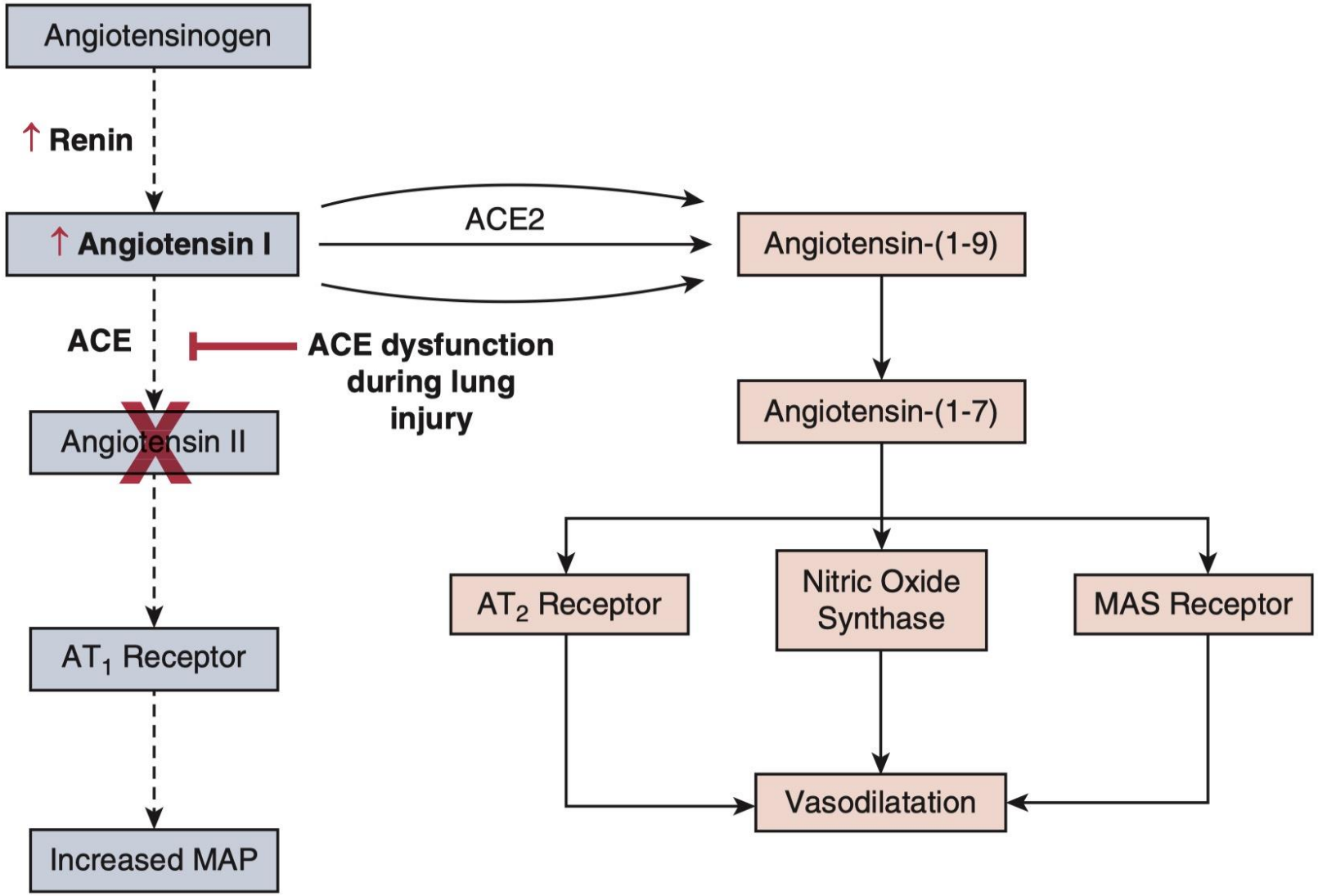
Balík M et al. Anest Intenziv Med 2025;36(1):46

RAAS: ACE inhibitory a sartany



Ma TK et al. Br J Pharmacol 2010;160:1273

RAAS: KCH výkony (mimotělní oběh) a V-A ECMO



Chow JH et al. J Thorac Cardiovasc Surg 2022;163:1407

Vazoplegie / vazoplegický syndrom / vazoplegický šok

- Stav abnormálně nízké systémové cévní rezistence (SVR), který se projevuje jako výrazná hypotenze anebo nutnost podávat farmaka k zvrácení hypotenze (nekontrolovaná vazodilatace)
- Srdeční výdej je normální anebo zvýšený

- Odpověď cév na podávané vazopresory

➢ Hypoperfuze orgánových systémů

➞ Chybí jasná a přesná, klinicky založená, definice

Lambden S et al. Crit Care 2018;22:174

Vazoplegie u kardiochirurgických pacientů

PATIENT-RELATED RISK FACTORS	Anemia, CKD, ESRD, HFrEF, recent MI (<5 days), hypothyroidism, older age, male sex, BMI>35 kg/m^2, BSA>1.9 m^2, high comorbidity/risk score (e.g. EUROSCORE, INTERMACS)
PREOPERATIVE RISK FACTORS	Anemia; diuretic, vasopressor, and/or heparin use
INTRAOPERATIVE RISK FACTORS	Anemia, transfusion of blood products, aortic cross clamp time, CPB time, total cardioplegia volume, nadir temperature

Polyak P et al. JCVA 2025;39:1815

Definice vazoplegie u kardiochirurgických pacientů

Parameters and Thresholds Used in Published Definitions

Vasodilation Criterion	Hemodynamic Criterion	Vasoactive Drugs	Timeframe	Other Criteria
MAP ≤50-80 mmHg	CI ≥2.0-3.5 $L \cdot min^{-1} m^{-2}$	Type: Norepinephrine Vasopressin Epinephrine Dobutamine Phenylephrine Methylene blue Epinephrine Vitamin B_{12} Metaraminol	Onset: <30 minutes to 4 days after CPB	HR > 80/min
SVR ≤500-900 $dynes \cdot seconds \cdot cm^{-5}$	CO >4-5 $L \cdot min^{-1}$	Dosage or NEE variations	Duration: single reading up to > 24 hours	Mixed/central venous oxygen saturation >60%-70%
SVR index ≤600-1800 $dynes \cdot seconds \cdot cm^{-5} m^{-2}$	LVEF >50%-55%	Combination of one or more agents		Oxygen extraction <35%
SBP <70-90 mmHg	CVP <5 or >8 mmHg			Bicarbonate levels < 19-20 mEq/L
	PCWP <10 mmHg			

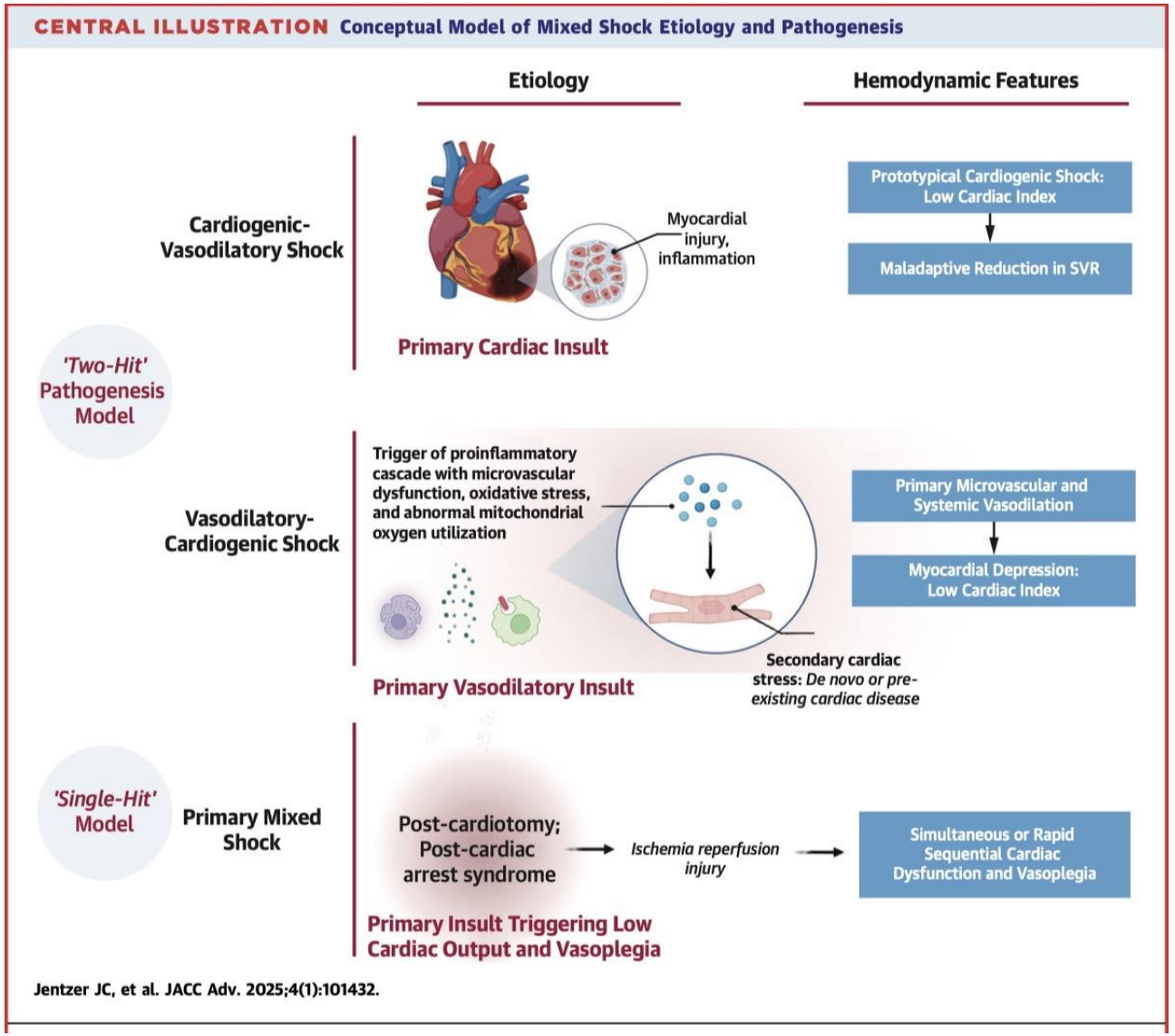
Papazisi O et al. JCVA 2025;39:1451

Vasoplegic Syndrome Consensus Definition Set by the Members of the Committee on Cardiovascular and Thoracic Anesthesia of the American Society of Anesthesiologists

Parameter	Suggestive of Vasoplegia
Mean arterial pressure	<65 mmHg
Cardiac index	≥2.2 $L/min/m^2$
Systemic vascular resistance	<800 $dynes \cdot sec \cdot cm^{-5}$
Hemodynamic support	≥0.2 μg/kg/min norepinephrine equivalents
Rule out hypovolemia, intracardiac etiology, and adrenal insufficiency	

Polyak P et al. JCVA 2025;39:1815

Kombinovaný cirkulační šok



Gentler JC et al. JACC Adv 2025;4:101432

Fyziologie a patofyziologie systémové cévní rezistence

- Cévní tonus regulován intracelulární koncentrací Ca^{2+}

➢ **Intrinsické regulátory**

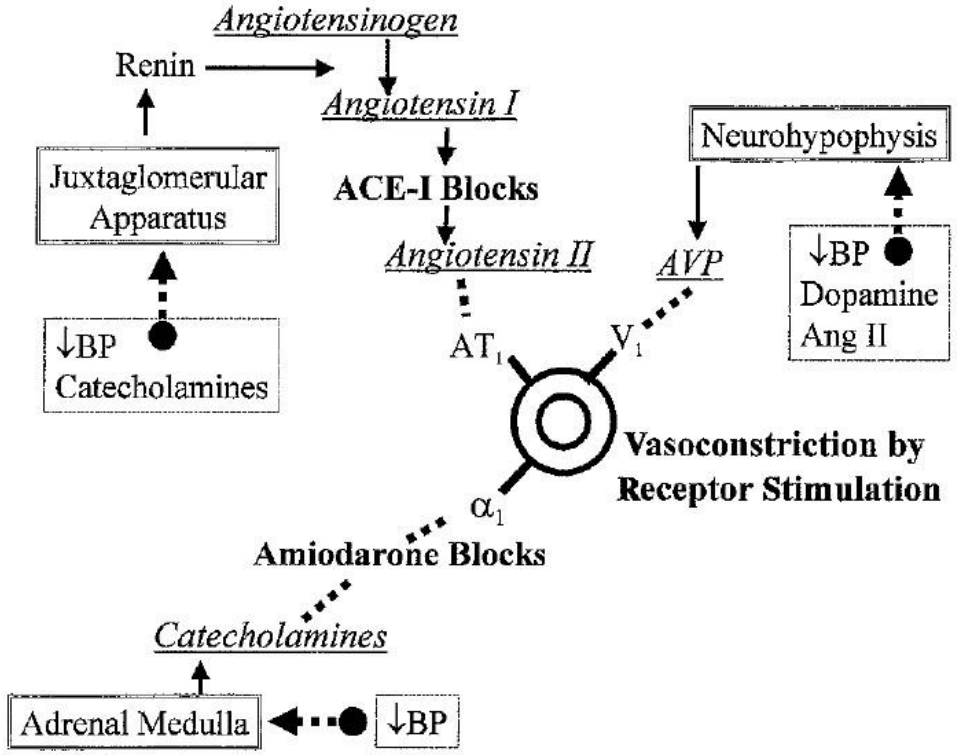
✓ NO, prostacyklin, endotelin, serotonin; acidóza, hypoxie …

➢ **Extrinsické regulátory**

✓ Receptory VNS (sympatikus)

✓ Receptory pro vazopresin

✓ Receptory pro angiotenzin II



Mets B et al. JCVA 1998;12:326

Farmakologické ovlivnění vazoplegie

Agent	MOA	Dose
Norepinephrine	Significant α1, α2 agonism Moderate β1 agonism	0.01–3 μg/kg/min
Epinephrine	Significant α1, α2 agonism Significant β1 agonism	0.01–1 μg/kg/min
Phenylephrine	Significant α1, α2 agonism No effect on β1	0.1–5 μg/kg/min
Dopamine	Dose dependent adrenergic agonism α1 agonism as dose increases	1–20 μg/kg/min
Vasopressin	Repletion of vasopressin in ADH depleted state V1 agonism	0.01–0.1 U/min
Vitamin C Thiamine Hydrocortisone	Cofactor for catecholamine synthesis Cofactor of lactate dehydrogenase (increase in lactate clearance) Aids in vitamin C metabolism Repletion of glucocorticoid and mineralocorticoid activity in cortisol depleted state Inhibition of pro-inflammatory cytokines	1.5 g every 6 h 100 mg every 6 h 50 mg every 6 h
Methylene blue	Inhibition of guanylyl cyclase and inducible endothelial NO synthase	1–2 mg/kg
Hydroxocobalamin	Inhibition of NO directly and inducible endothelial NO synthase Inhibition of hydrogen sulfide	5 g
Angiotensin II	AT1 agonism Stimulation of aldosterone release Increase in ADH synthesis	10–40 ng/kg/min

Busse et al. Crit Care 2020;24:36

Studie ATHOS-3

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 AUGUST 3, 2017 VOL. 377 NO. 5

Angiotensin II for the Treatment of Vasodilatory Shock

Ashish Khanna, M.D., Shane W. English, M.D., Xueyuan S. Wang, M.D., Kealy Ham, M.D., James Tumlin, M.D., Harold Szerlip, M.D., Laurence W. Busse, M.D., Laith Altaweel, M.D., Timothy E. Albertson, M.D., M.P.H., Ph.D., Caleb Mackey, M.D., Michael T. McCurdy, M.D., David W. Boldt, M.D., Stefan Chock, M.D., Paul J. Young, M.B., Ch.B., Ph.D., Kenneth Krell, M.D., Richard G. Wunderink, M.D., Marlies Ostermann, M.D., Ph.D., Raghavan Murugan, M.D., Michelle N. Gong, M.D., Rakshit Panwar, M.D., Johanna Hästbacka, M.D., Ph.D., Raphael Favory, M.D., Ph.D., Balasubramanian Venkatesh, M.D., B. Taylor Thompson, M.D., Rinaldo Bellomo, M.D., Jeffrey Jensen, B.S., Stew Kroll, M.A., Lakhmir S. Chawla, M.D., George F. Tidmarsh, M.D., Ph.D., and Adam M. Deane, M.D., for the ATHOS-3 Investigators*

Studie ATHOS-3: uspořádání

- RCT: AT II vs. placebo (163 vs. 158 pacientů)

✓ Vazodilatační šok s dávkou noradrenalinu >0,2 ug/kg/min

✓ Sepse, pankreatitida, pooperační vazoplegie, multifaktoriální stav

- Primární výsledný ukazatel

✓ MAP po 3 h od zahájení infuze

✓ Vzestup MAP o ≥10 mmHg anebo MAP ≥75 mmHg

✓ Bez zvýšení dávky ostatních vazopresorů

- Sekundární výsledné ukazatele

✓ SOFA (kardiovaskulární, celkové)

- Další výsledné ukazatele (mortalita 7/28 dní)

Khanna A et al. NEJM 2017;377(5):419

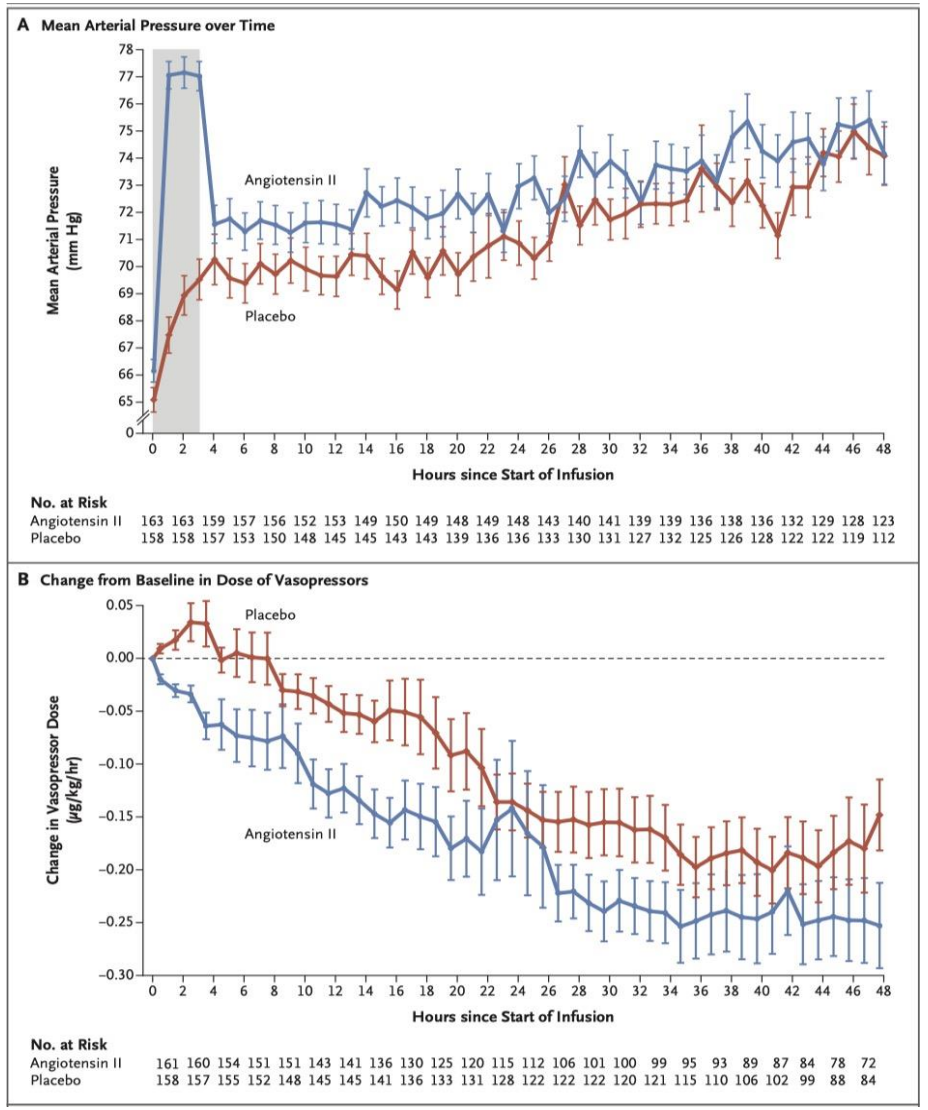
Studie ATHOS-3: výchozí charakteristika

Mean arterial pressure			
Median (IQR) — mm Hg	66.3 (63.7–69.0)	66.3 (63.0–68.3)	66.3 (63.7–68.7)
<65 mm Hg — no. (%)	52 (31.9)	50 (31.6)	102 (31.8)
APACHE II score‡			
Median (IQR)	27 (22–33)	29 (22–34)	28 (22–33)
Distribution — no. (%)			
≤30	105 (64.4)	93 (58.9)	198 (61.7)
31–40	50 (30.7)	54 (34.2)	104 (32.4)
≥41	8 (4.9)	11 (7.0)	19 (5.9)
Albumin			
Median (IQR) — g/dl	2.2 (1.8–2.7)	2.4 (1.9–2.8)	2.3 (1.8–2.7)
<2.5 g/dl — no./total no. (%)	103/154 (66.9)	89/156 (57.1)	192/310 (61.9)
$Scvo_2$			
Median (IQR) — %	76.9 (73.0–82.8)	77.0 (72.5–82.0)	77.0 (72.9–82.2)
Data missing — no.	43	41	84
Central venous pressure			
Median (IQR) — mm Hg	13 (10–15)	12 (10–16)	12 (10–15)
Data missing — no.	37	35	72
Cardiac index			
Median (IQR) — liters/min/m^2	3.0 (2.6–3.8)	3.2 (2.7–3.9)	3.1 (2.6–3.8)
Data missing — no.	94	85	179
Median MELD score (IQR)§	21 (15–25)	23 (17–26)	22 (16–26)
Cause of shock — no. (%)			
Sepsis	127 (77.9)	132 (83.5)	259 (80.7)
Other, potentially sepsis	20 (12.3)	11 (7.0)	31 (9.7)
Pancreatitis	0	2 (1.3)	2 (0.6)
Postoperative vasoplegia	10 (6.1)	9 (5.7)	19 (5.9)
Multifactorial	6 (3.7)	4 (2.5)	10 (3.1)
Exposure to ACE inhibitors — no. (%)	15 (9.2)	15 (9.5)	30 (9.3)
Exposure to ARBs — no. (%)	11 (6.7)	11 (7.0)	22 (6.9)
Vasopressin use during 6 hr before randomization — no. (%)	113 (69.3)	111 (70.3)	224 (69.8)
Vasopressor dose — μg/kg/min¶			
Median (IQR)	0.33 (0.23–0.56)	0.34 (0.23–0.56)	0.34 (0.23–0.56)
Distribution — no. (%)			
<0.35	83 (50.9)	83 (52.5)	166 (51.7)
≥0.35 to <0.50	34 (20.9)	27 (17.1)	61 (19.0)
≥0.50	46 (28.2)	48 (30.4)	94 (29.3)

Khanna A et al. NEJM 2017;377(5):419

Studie ATHOS-3: výsledky

End Point	Angiotensin II (N=163)	Placebo (N=158)	Odds or Hazard Ratio (95% CI)	P Value
Primary efficacy end point: MAP response at hour 3 — no. (%)†	114 (69.9)	37 (23.4)	Odds ratio, 7.95 (4.76–13.3)	<0.001
Secondary efficacy end points				
Mean change in cardiovascular SOFA score at hour 48‡	−1.75±1.77	−1.28±1.65		0.01
Mean change in total SOFA score at hour 48§	1.05±5.50	1.04±5.34		0.49
Additional end points				
Mean change in norepinephrine-equivalent dose from baseline to hour 3¶	−0.03±0.10	0.03±0.23		<0.001
All-cause mortality at day 7 — no. (%)	47 (29)	55 (35)	Hazard ratio, 0.78 (0.53–1.16)	0.22
All-cause mortality at day 28 — no. (%)	75 (46)	85 (54)	Hazard ratio, 0.78 (0.57–1.07)	0.12



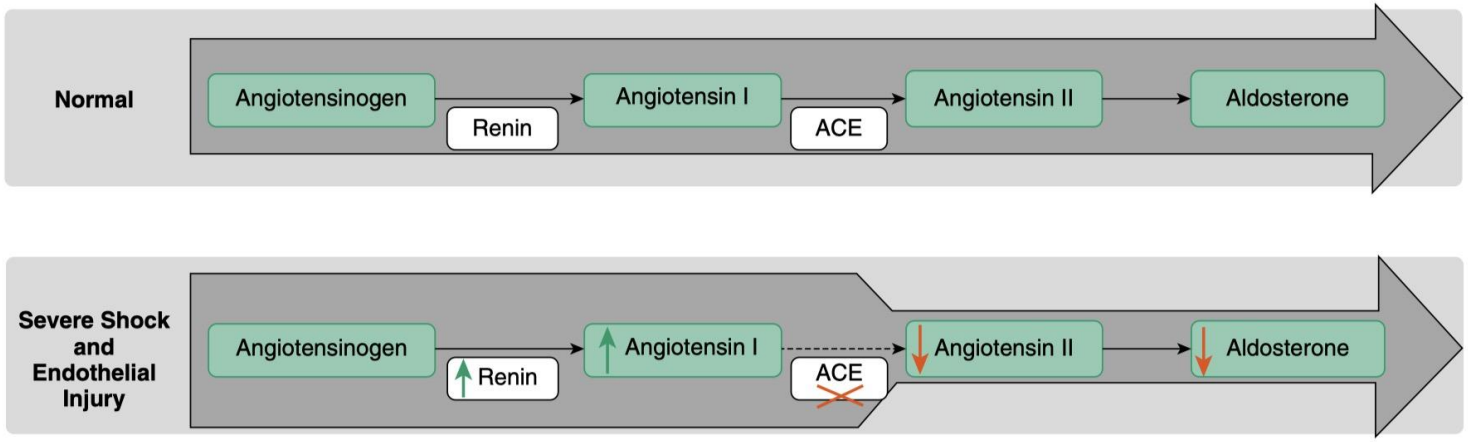
Khanna A et al. NEJM 2017;377(5):419

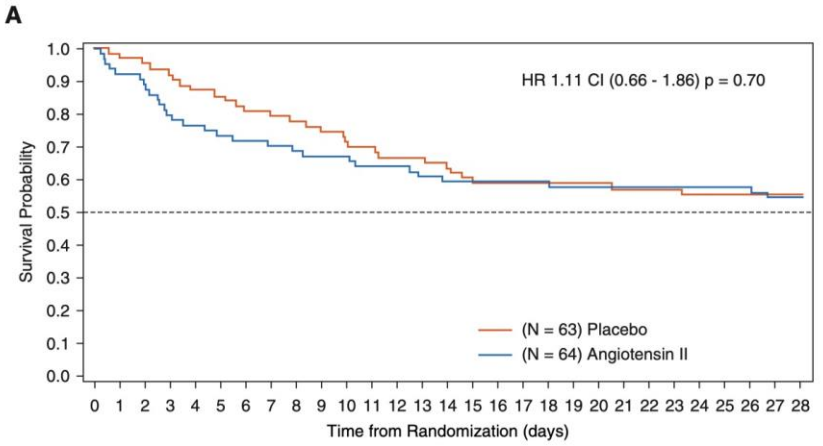
Studie ATHOS-3: post-hoc analýzy

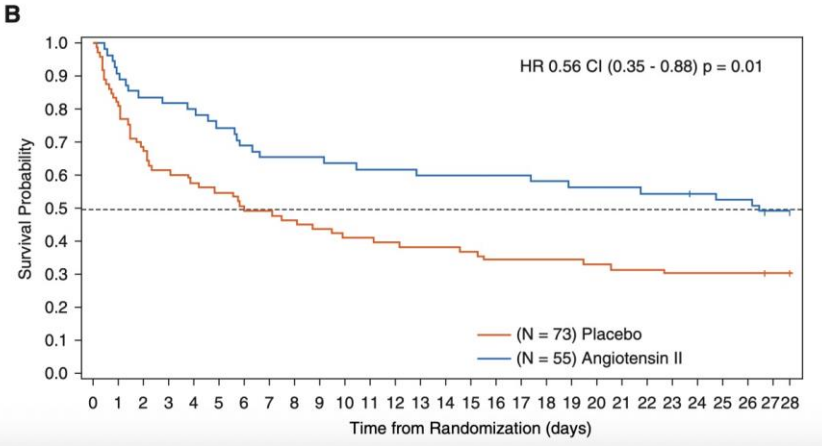
Renin and Survival in Patients Given Angiotensin II for Catecholamine-Resistant Vasodilatory Shock

A Clinical Trial

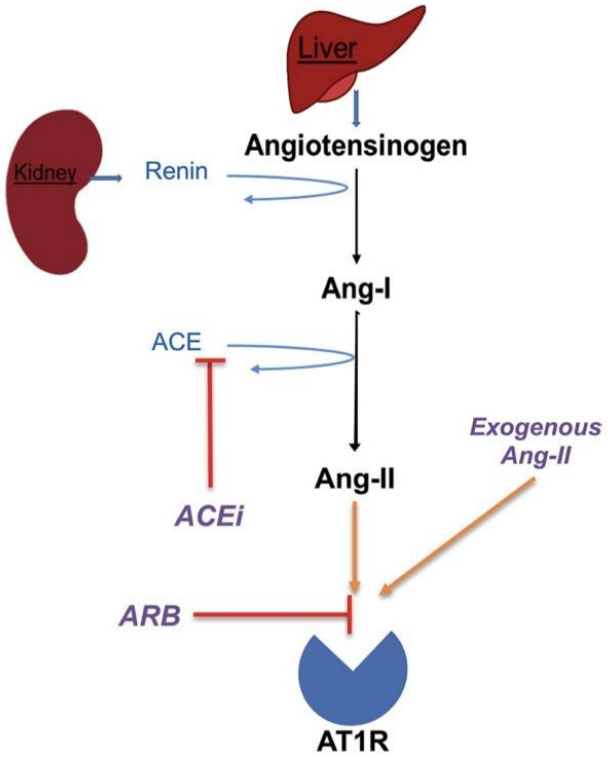
Rinaldo Bellomo[1,2], Lui G. Forni[3,4], Laurence W. Busse[5], Michael T. McCurdy[6], Kealy R. Ham[7], David W. Boldt[8], Johanna Hästbacka[9], Ashish K. Khanna[10,11], Timothy E. Albertson[12], James Tumlin[13], Kristine Storey[14], Damian Handisides[14], George F. Tidmarsh[14,15], Lakhmir S. Chawla[14,16], and Marlies Ostermann[17]; on behalf of the ATHOS-3 Investigators

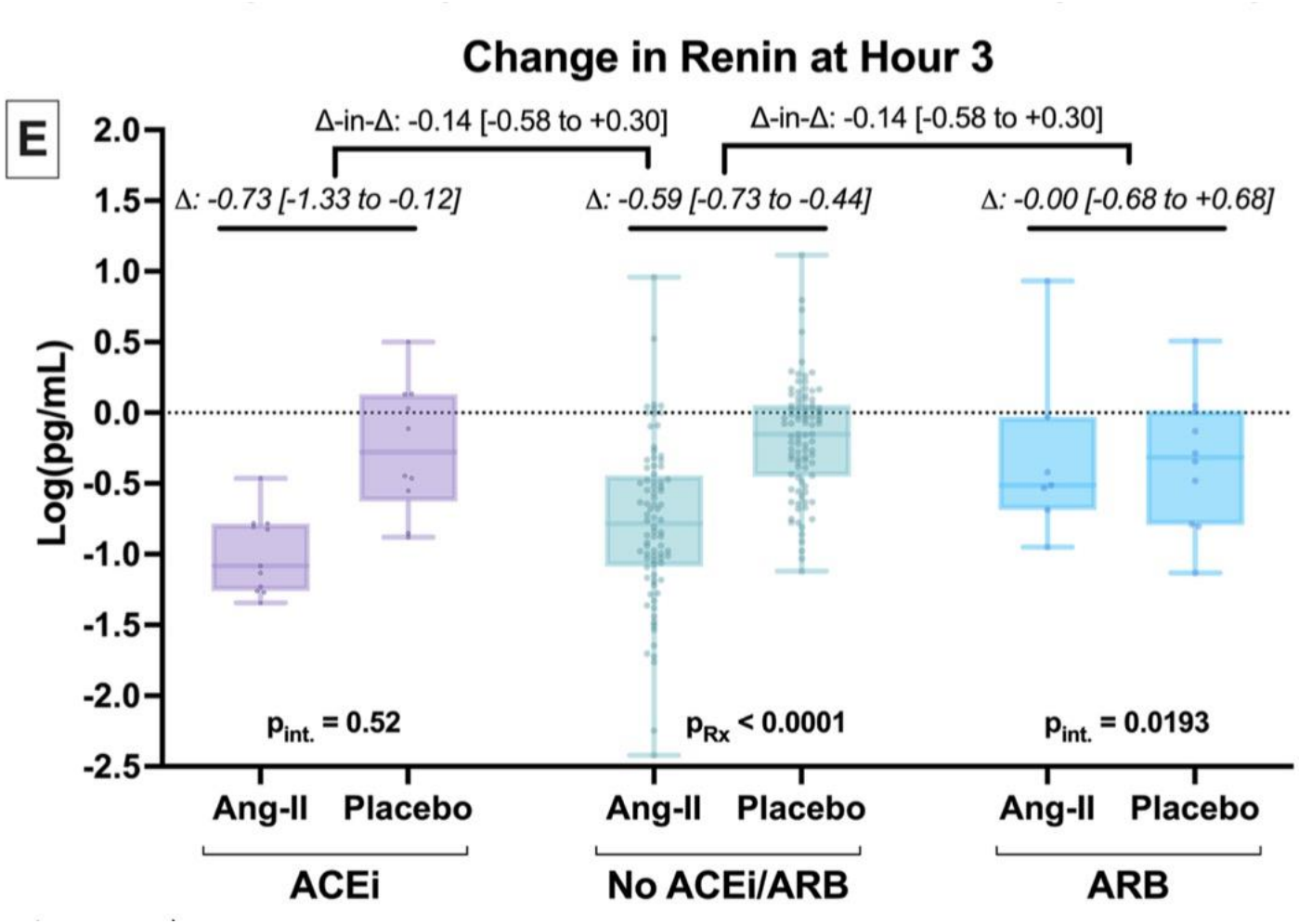






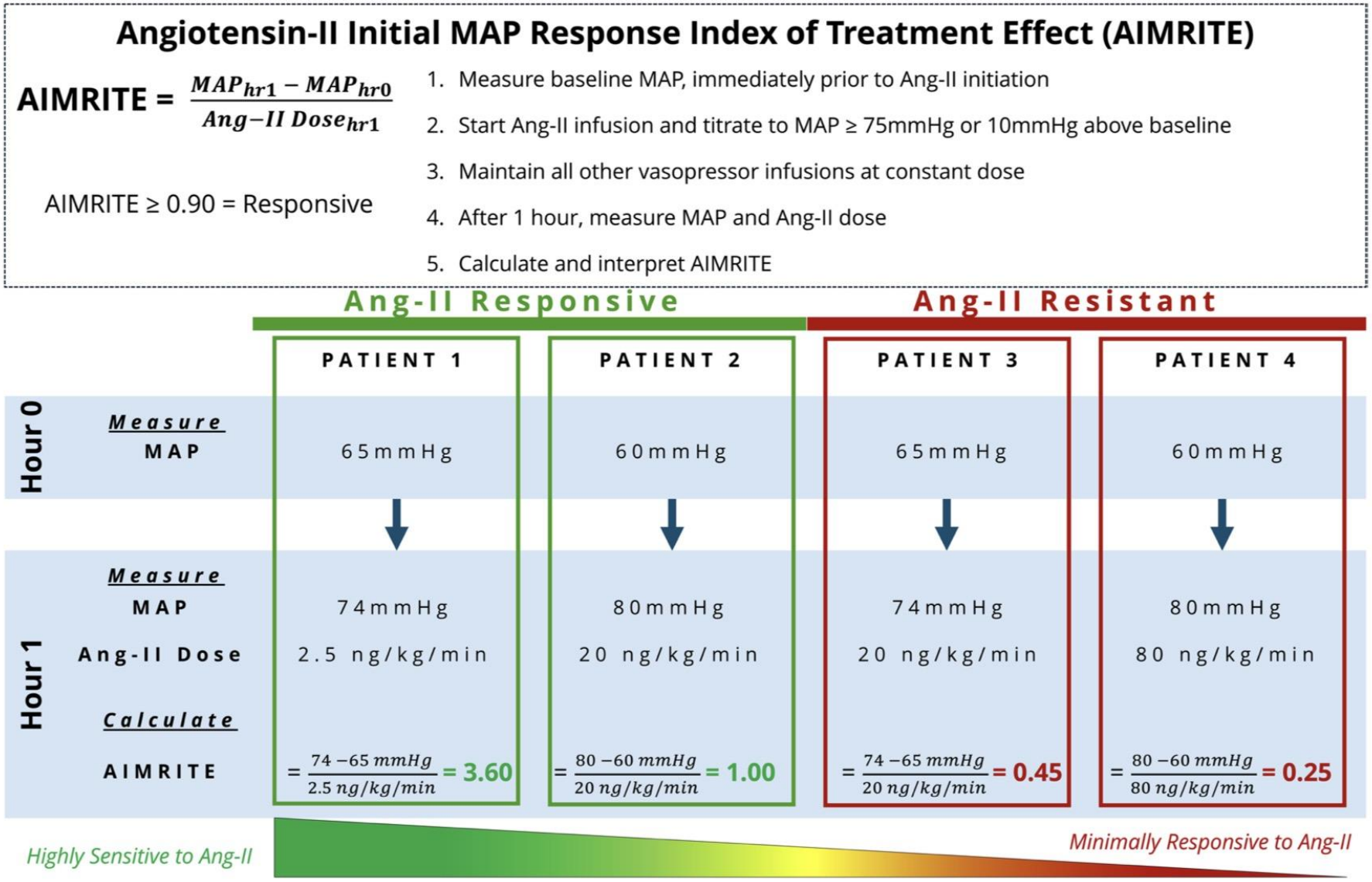
Studie ATHOS-3: post-hoc analýzy





Leisman DE et al. Crit Care 2024;28:130

Studie ATHOS-3: post-hoc analýzy

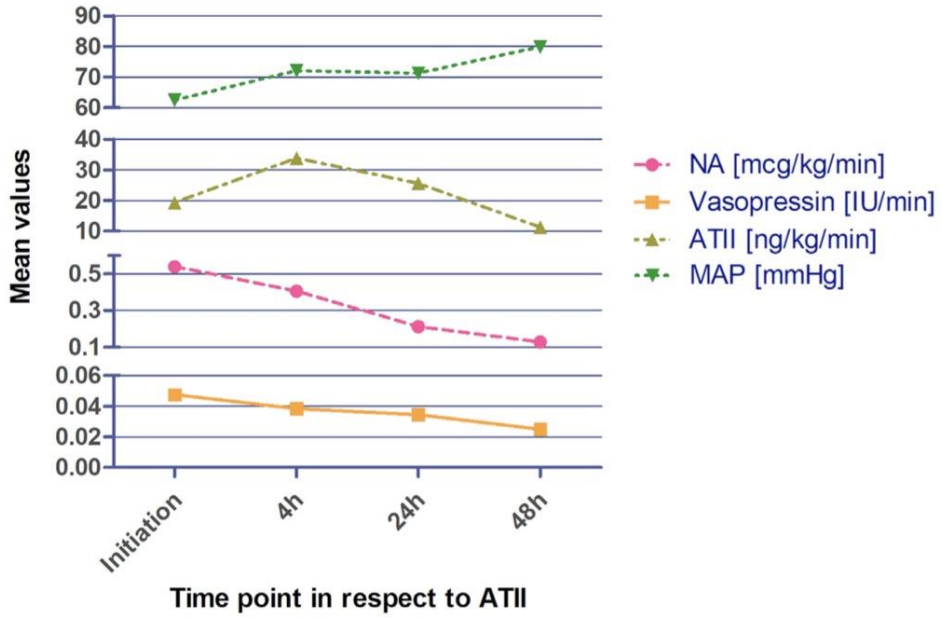


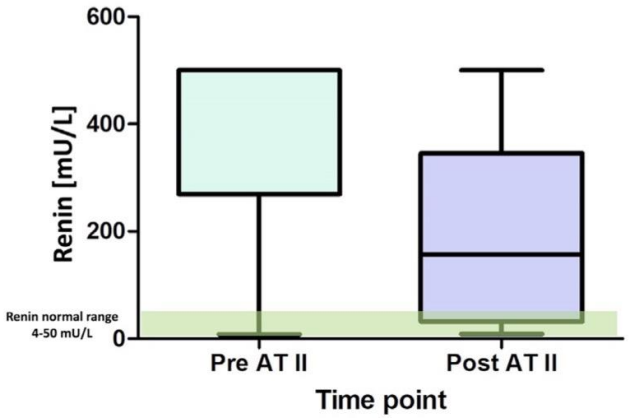
Leisman DE et al. Crit Care 2025;29:81

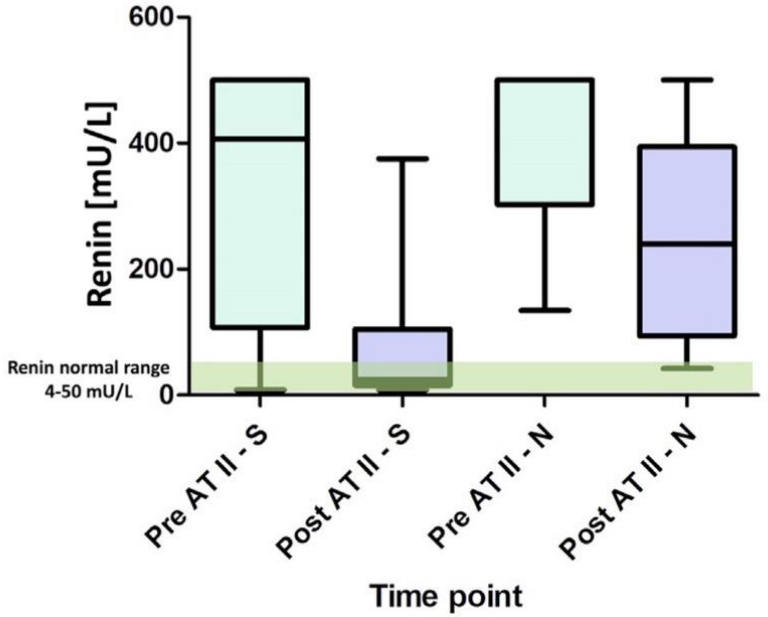
Intenzivní medicína: reálné zkušenosti s AT II

- 42 pacientů na ICU

✓ Distributivní šok + vazopresorická podpora NAD ≥0.3 ug/kg/min + VAS





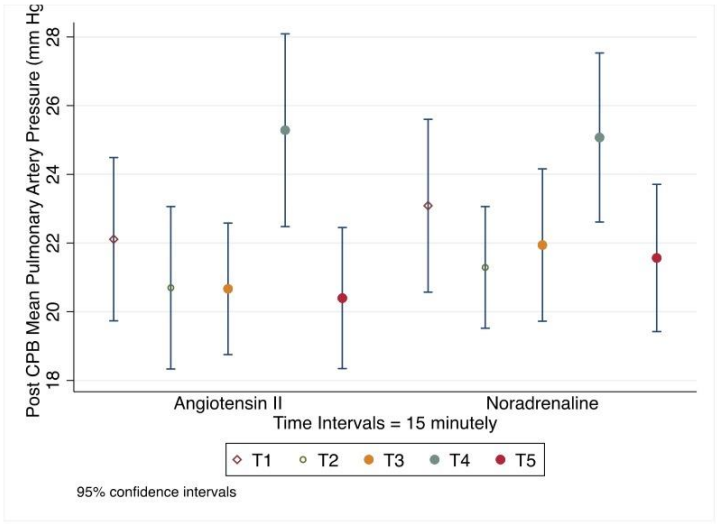


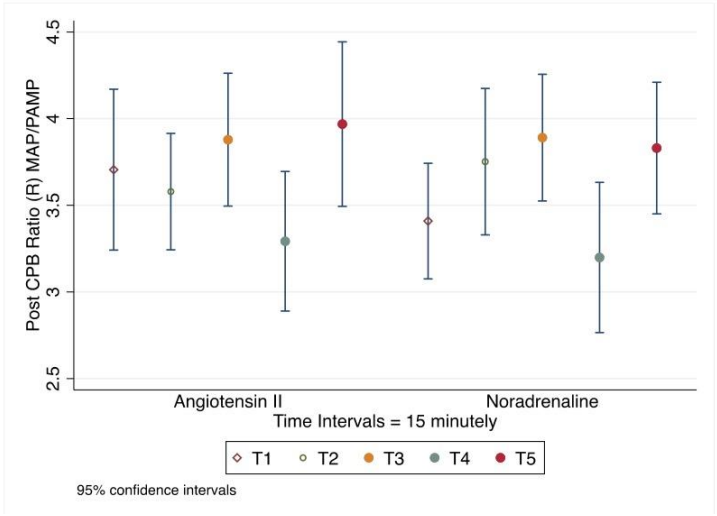
Moller Petrun A et al. JCVA 2025;in press

Vliv AT II na plicní cévní rezistenci

- Post-hoc analýza

✓ 58 pacientů
✓ KCH výkon s CPB
✓ Vyšší riziko rozvoje AKI





Original Article

The Effects of Angiotensin II versus Norepinephrine on Pulmonary Vascular Resistance in Cardiac Surgery: Post Hoc Analysis of a Randomized Controlled Trial

Jolene Lim, MBBS, MSc, FANZCA[*,†], Kathy Zhang, MD[‡], Lachlan Miles, PhD, FANZCA[‡,§], Rinaldo Bellomo, MD, PhD[§,‖,¶,**], Tim G. Coulson, PhD, FANZCA[*,§,1]

Lim J et al. JCVA 2024;38:2950

Metaanalýza: 2918 pacientů

Kotani Y et al. JCVA 2025;39:653

Author, year	No. of patients	Population	Follow-up
Randomized controlled trials			
Bennett SR, 2001[74]	20	Cardiac surgery	48 hours
Chawla LS, 2014[66]	20	Septic shock	30 days
Khanna A, 2017[4]	321	Mixed vasodilatory shock	28 days
Coulson TG, 2022[5]	60	Cardiac surgery	Hospital discharge
Sadjadi M, 2024[6]	63	Cardiac surgery	90 days
Observational studies			
Singh S, 1966[72]	50	Septic shock	Hospital discharge
Leisman DE, 2020[22]	29	COVID-19	7 days
Wong A, 2020[23] [a]	16	Mixed vasodilatory shock	30 days
Wieruszewski PM, 2021[24] [ab]	270	Mixed vasodilatory shock	30 days
Andrews L, 2022[7]	20	Kidney transplant	30 days
Meersch M, 2022[25]	40	Cardiac surgery	28 days
Quan M, 2022[26]	147	Septic shock	Hospital discharge
Serpa Neto A, 2022[8]	132	COVID-19	Hospital discharge
Smith SE, 2022[27] [ab]	162	Mixed vasodilatory shock	28 days
Ten Lohuis CC, 2022[28] [ab]	78	Cardiac surgery	30 days
Wieruszewski PM, 2023[29] [ab]	50	Mixed vasodilatory shock	28 days
Wieruszewski PM, 2023[30] [ab]	254	Mixed vasodilatory shock	Hospital discharge
Smith LM, 2023[31] [ab]	813	Mixed vasodilatory shock	90 days
See EJ , 2023[32]	120	Mixed vasodilatory shock	90 days
Blankenship CR, 2024[33]	69	Septic shock	28 days
Case reports and case series			
Cohn JN, 1965[67]	28	Septic shock	1 hour after vasopressor discontinuation
Belle MS, 1965[68]	1	Cardiogenic shock	11 days
Jackson T, 1993[69]	1	Drug overdose	20 hours
Trilli LE, 1994[70]	1	Drug overdose	10 days
Newby DE, 1995[71]	1	Drug overdose	Hospital discharge
Yunge M, 2000[73]	2	Septic shock	24 days
Ahmed M, 2018[34]	1	Multiple trauma	Hospital discharge
Chow JH, 2018[35] [ab]	1	Septic shock	41 days
Bailey DM, 2019[36]	2	Septic shock	10 days
Evans A, 2019[37] [a]	1	Cardiac surgery	12 days
Wieruszewski PM, 2019[38] [ab]	4	Cardiac surgery	29 days
Wieruszewski PM, 2019[39]	1	Heart and liver transplant	Surgery completion
Bobeck KA, 2020[40]	1	COVID-19	15 days
Bui AD, 2020[41]	1	Septic shock	7 days
Chatterjee S, 2020[42]	1	Thoracoabdominal aortic surgery	18 days
Coleman PJ, 2020[43]	1	Septic shock	9 days
Cutler NS, 2020[44] [a]	1	Cardiac surgery	18 days
Ferdowsali J, 2020[45]	1	Drug overdose	9 days
Heinicke U, 2020[46]	6	COVID-19	16 days
Hylton DJ, 2020[47]	1	Pheochromocytoma resection	8 days
Morselli F, 2020[48]	7	COVID-19	28 days
Trethowan B, 2020[49] [ab]	1	Cardiac surgery	11 days
Wang H, 2020[50]	1	COVID-19	9 days
Wieruszewski PM, 2020[51]	1	Mixed vasodilatory shock	5 days
Chandra R, 2021[52]	1	Septic shock	Hospital discharge
Chow JH, 2021[53] [ab]	2	Septic shock	37 days
Cutler NS, 2021[54] [b]	4	Heart transplant	29 days
Ofosu-Barko K, 2021[55]	10	COVID-19	Hospital discharge
Running K, 2021[56] [b]	1	Liver transplantation	14 days
Smith SE, 2021[57]	2	Drowning	7 days
Sovic W, 2021[58] [a]	2	Cardiac surgery	30 days
Gutierrez GC, 2022[64]	1	Drug overdose	9 days
Konkol SB, 2022[59]	6	Cardiac surgery	Hospital discharge
Mohamed A, 2022[60] [a]	14	Cardiogenic shock	Hospital discharge
Bird S, 2023[61] [a]	19	Cardiac surgery	30 days
Johnson AJ, 2023[75]	30	Cardiac surgery	28 days
Šribar A, 2023[62]	1	Cardiac surgery	46 days
Tezel O, 2023[63]	23	Mixed vasodilatory shock	7 days
Razdan S, 2024[65]	1	Bilateral renal agenesis	6 months

Author, year	Maximal dose	Duration
Randomized controlled trials		
Bennett SR, 2000[74]	Not reported	24 hours
Chawla LS, 2014[66]	40 ng/kg/min	7 days
Khanna A, 2017[4]	40 ng/kg/min	48 hours
Coulson TG, 2022[5]	27.2 g/min	217.5 minutes (surgery), 5 hours (ICU)
Sadjadi M, 2024[6]	80 ng/kg/min	12 hours
Observational studies		
Singh S, 1966[72]	12 g/min	105 hours
Wong A, 2020[23]	80 ng/kg/min	15.2 hours
Wieruszewski PM, 2021[24]	52 ng/kg/min	23 hours
Meersch M, 2022[25]	80 ng/kg/min	8 hours
Quan M, 2022[26]	80 ng/kg/min	Not reported
Serpa Neto A, 2022[8]	32 ng/kg/min	5 days
Smith SE, 2022[27]	40 ng/kg/min	25 hours
Ten Lohuis CC, 2022[28]	40 ng/kg/min	Not reported
Wieruszewski PM, 2023[29]	Not reported	12 hours
Wieruszewski PM, 2023[30]	40 ng/kg/min	47 hours
Smith LM, 2023[31]	Not reported	17 hours
See EJ , 2023[32]	40 ng/kg/min	43 hours
Case reports or case series		
Belle MS, 1965[68]	250 mg/day	7 days
Cohn JN, 1965[67]	60 g/min	Not reported
Jackson T, 1993[69]	18 g/min	4 hours and 50 minutes
Trilli LE, 1994[70]	9.0 g/min	120 hours
Newby DE, 1995[71]	100 g/h	30 hours
Yunge M, 2000[73]	800 ng/kg/min	7 days
Ahmed M, 2018[34]	15 ng/kg/min	51 hours
Chow JH, 2018[35]	80 ng/kg/min	36.5 hours
Bailey DM, 2019[36]	39.1 ng/kg/min	80 hours
Evans A, 2019[37]	40 ng/kg/min	13 hours
Wieruszewski PM, 2019[39]	50 ng/kg/min	20 hours
Bobeck KA, 2020[40]	Not reported	8 days
Bui AD, 2020[41]	20 ng/kg/min	6 days
Chatterjee S, 2020[42]	80 ng/kg/min	40 hours
Coleman PJ, 2020[43]	40 ng/kg/min	4 days
Cutler NS, 2020[44]	15 ng/kg/min	24 hours
Ferdowsali J, 2020[45]	10 ng/kg/min	72 hours
Hylton DJ, 2020[47]	38 ng/kg/min	42 hours
Trethowan B, 2020[49]	40 ng/kg/min	17.5 hours
Wang H, 2020[50]	10 ng/kg/min	1 day
Wieruszewski PM, 2020[51]	30 ng/kg/min	16 hours
Chandra R, 2021[52]	40 ng/kg/min	Not reported
Chow JH, 2021[53]	80 ng/kg/min	65 hours
Cutler NS, 2021[54]	80 ng/kg/min	34 hours
Running K, 2021[56]	Not reported	16 hours
Smith SE, 2021[57]	50 ng/kg/min	14.5 hours
Sovic W, 2021[58]	25 ng/kg/min	42 hours
Gutierrez GC, 2022[64]	80 ng/kg/min	48 hours
Konkol SB, 2022[59]	80 ng/kg/min	20 hours
Bird S, 2023[61]	80 ng/kg/min	58.5 hours
Johnson AJ, 2023[75]	80 ng/kg/min	9.4 hours
Šribar A, 2023[62]	Not reported	24 hours
Tezel O, 2023[63]	80 ng/kg/min	27 hours
Razdan S, 2024[65]	40 ng/kg/min	10 days

Metaanalýza: 2918 pacientů

Original Article

The Efficacy and Safety of Angiotensin II for Treatment of Vasoplegia in Critically Ill Patients: A Systematic Review

Yuki Kotani, MD*, Martina Lezzi, MD†, Carlotta Pia Murru, MD†,
Ashish K Khanna, MD, FCCP, FCCM‡,§,‖,
Alexander Zarbock, MD, PhD¶,
Rinaldo Bellomo, MD, PhD, FRACP, FCICM**,††,‡‡,
Giovanni Landoni, MD†,§§,1

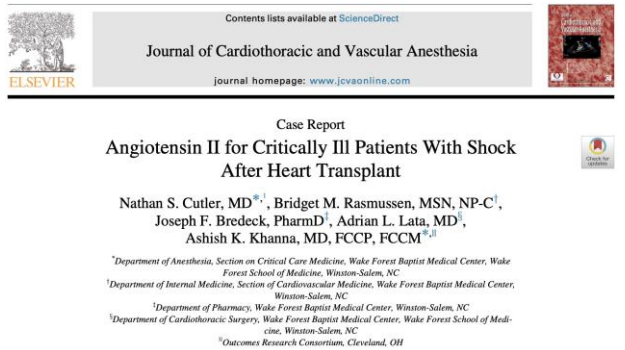
Conclusions: Intravenous angiotensin II has been reported in almost 3000 critically ill patients with diverse types of shock. Despite unclear mortality impacts, angiotensin II seems to confer beneficial effects on several organ systems and RAS derangements, without increasing adverse events.

Kotani Y et al. JCVA 2025;39:653

Transplantace srdce

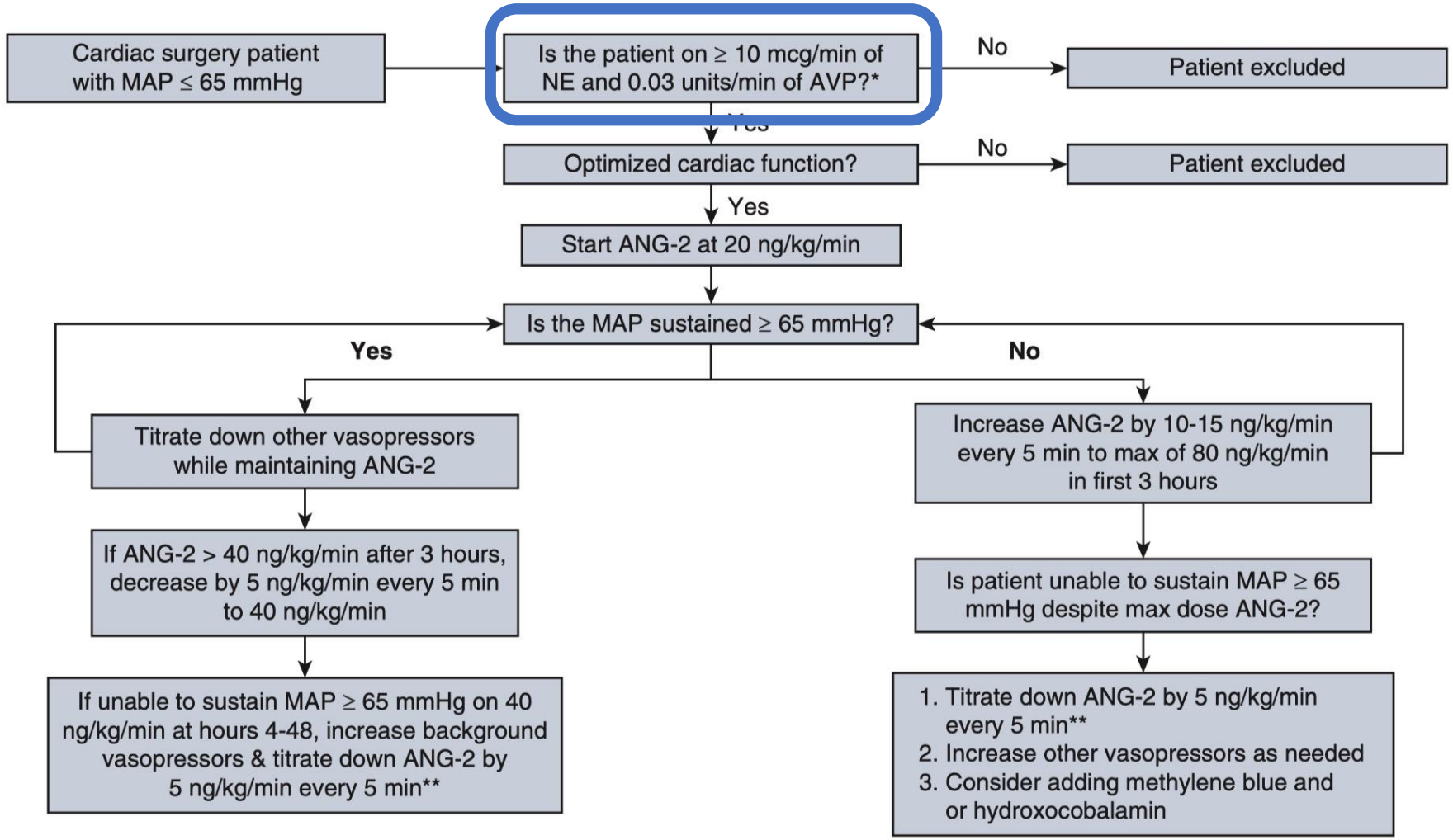
Case Summary

	Case 1	Case 2	Case 3	Case 4
Age (y), sex	62, male	61, male	69, male	60, male
Primary diagnosis	NICM	ICM	ICM	NICM
Prior treatment	HM3 LVAD BTT	CABG, HM3 LVAD BTT	CABG twice, long-term milrinone	HM3 LVAD BTT
Sternotomy #	2	3	3	3
Ischemia time	259 min	181 min	194 min	226 min
Just prior to starting ANG-2:				
Vasopressor support	NE 0.29 μg/kg/min AVP 0.06 units/min	NE 0.11 μg/kg/min AVP 0.04 units/min EPI 0.03 μg/kg/min	NE 0.29 μg/kg/min AVP 0.03 units/min EPI 0.06 μg/kg/min	NE 0.06 μg/kg/min AVP 0.04 units/min EPI 0.04 μg/kg/min
MAP (mean of last 3)	59 mmHg	59 mmHg	70 mmHg	71 mmHg
ANG-2:				
Time initiated	1 h after wean from CPB	1.5 h before wean from CPB	10 hours after ICU arrival, 13 h after CPB	45 min after wean from CPB
Dose range	10-60 ng/kg/min	2.5-60 ng/kg/min	5-30 ng/kg/min	5-80 ng/kg/min
Duration	12 h	34 h	20 h	29 h
Adjunctive therapies for vasoplegia:				
Prior to ANG-2	-	-	Hydroxocobalamin 5 g	-
After ANG-2	Methylene blue, 2 mg/kg	Methylene blue, 1.5 mg/kg Hydroxocobalamin, 5 g	-	-
Other hemodynamic support required during ICU stay	IABP Milrinone Dobutamine Epinephrine Inhaled epoprostenol	IABP Milrinone Inhaled epoprostenol	IABP Milrinone Inhaled epoprostenol	Milrinone Inhaled epoprostenol
Major complications	Open chest owing to poor hemodynamics Ischemic optic neuropathy Subdural hematoma IABP insertion site pseudoaneurysm	Re-exploration (bleeding) Open chest owing to poor hemodynamics Renal failure Respiratory failure, reintubation VAP Femoral cannulation site dehiscence	Liver injury	Agitated delirium
Discharge date	POD 28	POD 49	POD 15	POD 22



JCVA 2021;35:2756

Protokoly pro kardiochirurgické pacienty



Chow JH et al. J Thorac Cardiovasc Surg 2022;163:1407

Protokoly pro kardiochirurgické pacienty

Proposal for the use of angiotensin II in distributive shock after extracorporeal circulation – position paper of the Section of Intensive Care Medicine and the Section of Cardiothoracic Anaesthesiology of the Polish Society of Anaesthesiology and Intensive Therapy

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[5]Section of Cardiothoracic Anaesthesiology, Polish Society of Anaesthesiology and Intensive Therapy

Kardiochirurgia i Torakochirurgia Polska 2024; 21 (2): 96-98

Haemodynamic criteria of inclusion:
MAP < 65 mm Hg + SVR < 500 dyn + NED ≥ 0.2 (0.3) µg/kg/min
Haemodynamic criteria of exclusion: CI < 2.2 l/min/m^2
or mPAP > 45 mm Hg

↓

Solution preparation: 2.5 mg AT in 500 ml 0.9% NaCl (5,000 ng/ml)

↓

Starting AT dose: (10) 20 ng/kg/min + escalation to reach MAP 75 mm Hg
Maximum AT dose: 80 ng/kg/min in 3 h

↓

Maintenance AT dose: ≤ 40 ng/kg/min up to 48 h to reach MAP +75 mm Hg + reduction of vasoactive drugs until NED 0.1 µg/kg/min

↓

AT de-escalation: 5 ng/kg/min every 5 min if MAP > 65 mm Hg

Krzych JL et al. Kardiochir Torakochirurgia Pol 2024;21(2):96

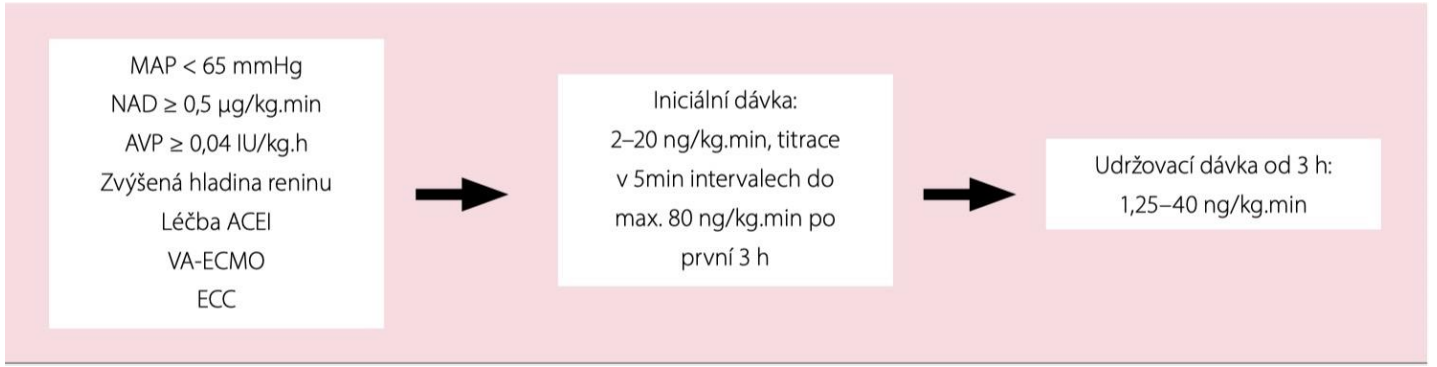
Doporučené postupy

V. **Indikace a podávání angiotensinu II**

6. Nitrožilní podání ang-II průkazně snižuje potřebu katecholaminů u pacientů s vazoplegickým šokem nereagujících na standardní léčebné postupy (zahrnuje obvykle podávání noradrenalinu v kombinaci s vazopresinem).
7. Nitrožilní podání ang-II by mělo být zváženo u pacientů
   a) s klinickým fenotypem vazoplegie (hypotenze, nízká systémová vaskulární rezistence, normální nebo zvýšený srdeční výdej),
   b) nereagujících na standardní vazopresory a
   c) kde jsou vyloučeny všechny ostatní odstranitelné příčiny s možným podílem na rozvoji vazoplegie.
8. Současný stav odborného poznání neumožňuje formulovat jednoznačné stanovisko k měření hladin reninu v procesu stanovení indikace podávání ang-II.
9. Před zahájením podávání ang-II by mělo být vždy vyhodnoceno aktuální individuální riziko hluboké žilní trombozy a zvážen poměr přínosu a rizika zahájení profylaxe tromboembolické choroby.

Angiotensin II – mechanismus účinku, současná evidence a stanovisko mezioborové pracovní skupiny k jeho použití na pracovištích intenzivní péče

Balík M.[1], Beneš J.[2], Černý V.[3–8], Kula R.[9], Matějovič M.[10], Říha H.[11], Tencer T.[12]



Balík M et al. Anest Intenziv Med 2025;36(1):46

Naše zkušenosti

- 24 pacientů (10/2023 - 09/2025)

- Všechny typy KCH výkonů

✓ V-A ECMO 8x

✓ HM3 LVAD 4x

✓ OTS 5x

➞ RES (vs. operační sál [během CPB])

➞ Zahájení infuze: dávka ostatních vazopresorů (NAD + VAS)

➞ Délka trvání infuze: 12-48 h (72-96 h)

➞ Dávka po iniciální stabilizaci hemodynamiky: 10-30 ng/kg/min

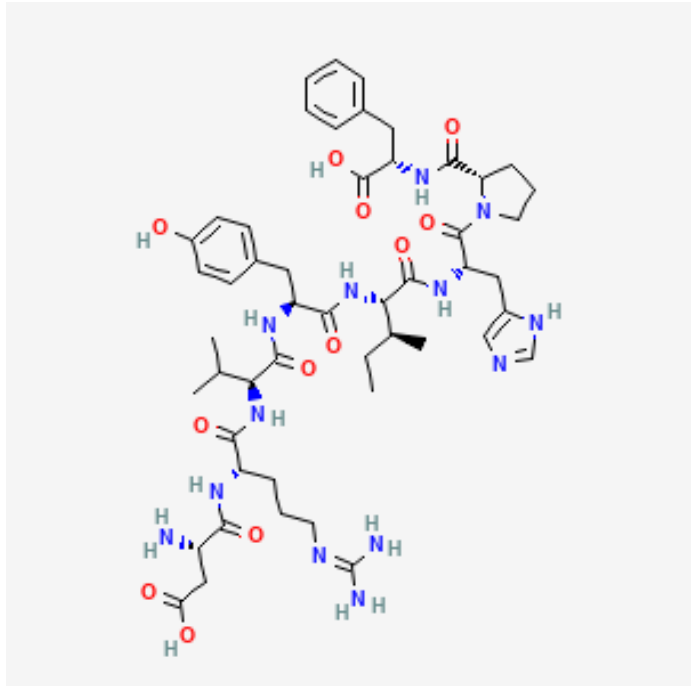
➞ Účinek

Předběžné, neauditované údaje

Angiotensin II

✓ Poločas AT II 15 s

✓ Poločas Giapreza® <1 min



H—Asp — Arg — Val — Tyr — Ile — His — Pro — Phe—OH

➞ Komu v kardiochirurgii podávat AT II?

➞ Kdy zahájit aplikaci AT II (dávka noradrenalinu/vazopresinu)?

➞ Vazopresor 1./2./3. linie (multimodální strategie)?

➞ Dostupnost rychlého stanovení plazmatické koncentrace reninu?