



1. LÉKAŘSKÁ FAKULTA
UNIVERZITY KARLOVY V PRAZE



ECMO v léčbě septického šoku u dětí

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Adaptační možnosti kardiovaskulárního systému u dětí

- ♥ Nižší počet kardiomyocytů (proliferace kardiomyocytů trvá až do 18. měs. věku života)
- ♥ Relativně vyšší zastoupení nekontraktilních proteinů
- ♥ Nižší poddajnost myokardu
- ♥ „chaotické“ rozložení mitochondrií do subsarkolemální a intermyofibrilární lokality
- ♥ NCX jako hlavní transportní systém Ca^{++} (Ca^{++} určené pro vazbu na troponin C pochází z EC prostoru nikoliv ze SR)
- ♥ Velká betaadrenergní stimulace – vyšší tepová frekvence



Hemodynamické profily v dětské sepsi

Hemodynamic Support in Fluid-refractory Pediatric Septic Shock

Gary Ceneviva, MD*†; J. Alan Paschall, MDi†; Frank Maffei, MD‡; and Joseph A. Carcillo, MD, FAAP*†§i

PEDIATRICS Vol. 102 No. 2 August 1998

$$\begin{array}{l} \downarrow CO \nearrow \frac{n(MABP - CVP)}{\uparrow SVR} \\ \searrow \frac{\downarrow(MABP - CVP)}{\downarrow SVR} \\ \uparrow CO \rightarrow \frac{n(MABP - CVP)}{\downarrow SVR} \end{array}$$



Pediatrics. 1994 May;93(5):726-9.

Extracorporeal membrane oxygenation for refractory septic shock in children.

Beca J, Butt W

Extracorporeal support for intractable cardiorespiratory failure due to meningococcal disease

Allan P Goldman, Steven J Kerr, Warwick Butt, Michael J Marsh, Ian A Murdoch, Thankam Paul, Richard K Firmin, Robert C Tasker, Duncan J Macrae

	Patient											
	1	2	3	4	5	6	7	8	9	10	11	12
Age	2.7 yr	20 mo	8 mo	4 yr	5 mo	2.5 yr	15 mo	4 mo	5.2 yr	14 mo	18 yr	13 yr
Indication for ECMO	Shock	Shock	Shock	Shock	Shock	Shock	Shock	ARDS	ARDS	ARDS	ARDS	ARDS
PRISM pre ECMO	29	33	31	34	40	28	29	14	26	15	13	16
GMSPS pre ECMO	10	12	15	12	15	13	15	7	10	8	10	10
CPR pre ECMO	Yes	Yes	No	Yes	No	No	Yes	No	No	No	Yes	No
OI pre ECMO	30	4	69	49	29	5	37	53	46	75	60	58
A-aDO ₂ pre ECMO	473	189	610	619	614	197	523	510	576	688	714	599
PIP pre ECMO (cm H ₂ O)	30	22	40	34	45	22	35	43	40	37	50	40
PEEP pre ECMO (cm H ₂ O)	8	5	14	16	12	6	10	12	10	11	8	10
FiO ₂ pre ECMO	0.8	0.45	1.0	1.0	1.0	1.0	0.9	0.9	1.0	1.0	1.0	1.0
Organ failure pre ECMO	C, R, DIC	C, R,	C, R, K, L, Sz, PF, DIC	C, R, K, L, DIC	C, R, K, PF, DIC	C, R, K	C, R, K, PF, DIC	C, R, Sz, DIC	R, C, K, PF, DIC	R, Sz, DIC	R, DIC	R, DIC
Vasoactive drugs pre ECMO*	A1.2, Ab, D5, NA1.2	A1.8, D5NA0.3, Db20	A1.0, D35	A10, NA0.4, D10	A1.0, D10	A2.0, Ab, D15, Db15	A3.0, D20, Db3.0	NA0.1, D12	A0.7, Db12, D10	Db15	D, Db	D20, NA0.15
CH during ECMO	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No
Outcome	Survived	Died	Died	Survived	Died	Survived	Survived	Survived	Died	Survived	Survived	Survived

A-aDO₂=alveolar arterial oxygen gradient, A=adrenaline, Ab=bolus doses of adrenaline, ARDS=acute respiratory distress syndrome, C=cardiac, CH=continuous haemofiltration, CPR=cardiopulmonary resuscitation, D=dopamine, Db=dobutamine, DIC=disseminated intravascular coagulopathy, GMSPS=Glasgow meningococcal septicæmic prognostic score, K=kidney, L=liver, NA=noradrenaline, OI=oxygen index, PEEP=positive end expiratory pressure, PF=purpura fulminans, PIP=peak inspiratory pressure, PRISM=paediatric risk of mortality score, R=respiratory, Sz=seizures.



Extracorporeal membrane oxygenation for pediatric respiratory failure: Survival and Predictors of Mortality

Zabrocki LA et al.: Crit Care Med 2011;39:364-370

Table 2. Primary diagnosis and comorbidities of patients treated with extracorporeal membrane oxygenation for acute respiratory failure

Primary Diagnosis/Comorbidity	n (%)	Survival
All Patients	3213	57%
Primary Diagnosis		
Acute respiratory failure, non-ARDS	607 (19)	49%
Respiratory syncytial virus pneumonia	496 (15)	70%
Bacterial pneumonia	476 (15)	57%
Other viral pneumonia	378 (12)	56%
Other	285 (9)	51%
ARDS, sepsis	235 (7)	40%
Aspiration pneumonia	225 (7)	71%
ARDS, trauma/postoperative	159 (5)	59%
Pertussis	85 (3)	39%
Status asthmaticus	71 (2)	83%
Pulmonary hemorrhage	51 (2)	69%
Influenza	47 (2)	57%
Submersion injury	43 (1)	65%
Pneumocystis pneumonia	25 (1)	48%
ARDS, other causes	17 (.5)	47%
Fungal pneumonia	13 (.4)	23%
Comorbidity		
Renal failure	329 (10)	33%
Chronic lung disease	296 (9)	59%
Congenital heart disease (CHD): two ventricle	195 (6)	52%
Cardiac arrest	88 (3)	38%
Cancer	84 (3)	30%
CHD: single ventricle	75 (2)	60%
Solid organ transplant	70 (2)	39%
Cardiomyopathy/myocarditis	61 (2)	43%
Primary immunodeficiency	59 (2)	34%
Liver failure	51 (2)	16%
Hematopoietic stem cell transplantation	22 (1)	5%
Any comorbidity	1104 (34)	46%
No comorbidity	2109 (66)	63%

ARDS, acute respiratory distress syndrome.



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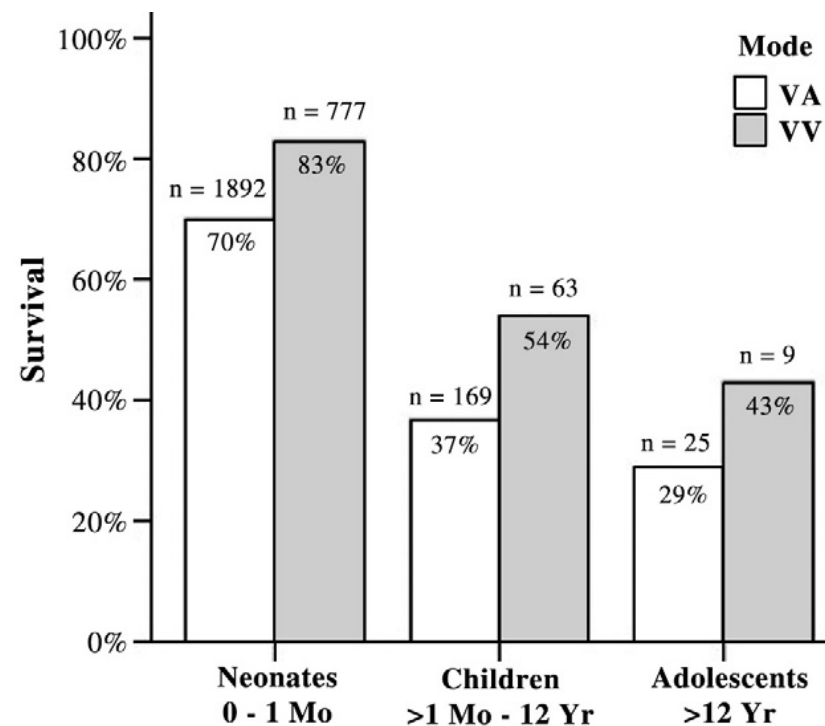
ARDS, acute respiratory distress syndrome.



Improved survival in venovenous vs venoarterial extracorporeal membrane oxygenation for pediatric noncardiac sepsis patients: a study of the Extracorporeal Life Support Organization registry.

Sean C. Skinnera, Joseph A. Iacono, Hubert O. Ballard, Marion D. Turner, Austin N. Ward, Daniel L. Davenport, Matthew L. Paden, Joseph B. Zwischenberger. Journal of Pediatric Surgery (2012) 47, 63–67

Neonatální i pediatrické ECMO, ELSO registr ;
4332 pacientů





[MacLaren G](#), [Butt W](#), [Best D](#), [Donath S](#), [Taylor A](#)

Extracorporeal membrane oxygenation for refractory septic shock in children: one institution's experience.

[Pediatr Crit Care Med.](#) 2007 Sep;8(5):447-51.

- July 1988 - October 2006, 441 children received extracorporeal life support
- 45 pat. (10%) with septic shock received V-A ECMO
- 18 pat. (40%) of these had suffered cardiac arrest and were receiving chest compressions immediately before cannulation
- 21 pat. (47%) patients survived to hospital discharge
- 73% of those with central cannulation survived vs. 44% without, ($p = .05$)
- No survivors had severe disability at long-term follow-up
- This study adds support to existing guidelines.



Mac Laren G, Butt W, Best D, Donath S. Central extracorporeal membrane oxygenation for refractory pediatric septic shock.

[Pediatr Crit Care Med.](#) 2011 Mar;12(2):133-6

Patients: Twenty-three children with refractory septic shock who received central ECMO primarily as circulatory support.

- All patients had microbiological evidence of infection, and meningococemia was the most common diagnosis.
- Twenty-two (96%) patients had failure of at least three organ system
- Eight (35%) patients suffered cardiac arrest and required external cardiac massage before ECMO
- Eighteen (78%) patients survived to be decannulated off ECMO, and 17 (74%) children survived to hospital discharge

CONCLUSIONS:

- Central ECMO seems to be associated with better survival than conventional ECMO and should be considered by clinicians as a viable strategy in children with refractory septic shock.



Způsob provedení

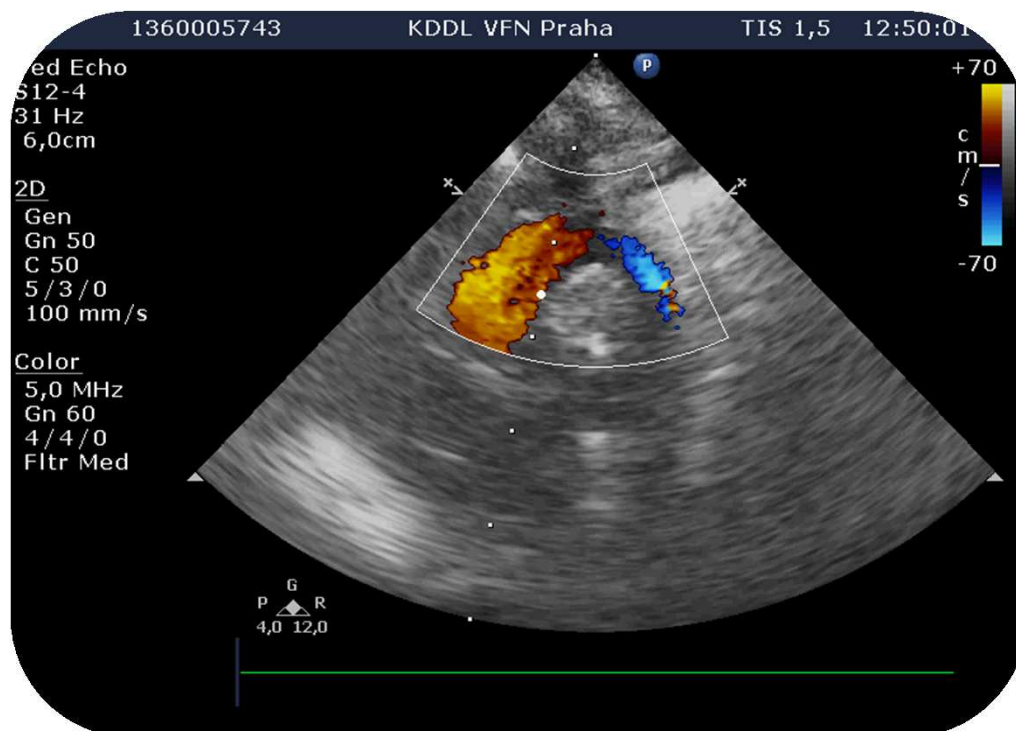


- V-A způsob
- Chirurgická preparace
- Jugulo-karotický přístup
- Femoro-femorální přístup?
- Průtok krve 150 ml/kg/min (<10 kg)
- Průtok krve 2,4 l/min/m² (>10 kg)
- APTT 70 – 80s
- Trombocyty >100 tis
- Centrální přístup ?



Indikační kritéria ????

- Perzistující hladina laktátu > 5 mmol/l,
- $SvO_2 < 55\%$ při současném CI min $2,1$ l/min/m²
- Hemodynamicky významná arytmie
- $IS > 50$



- Echokardiografická kontrola
- „Resting mode“ ventilátoru
- Restrikce medikamentózní podpory
- Problematika nepulzatilního flow



Septický šok - vlastní soubor

Přehled novorozenců léčených ECMO 2010 - 2013					
Pac.	Laktát (mmol/l)	IS	Septický šok	Přežití	Dimise
1. ♀				ANO	ANO
2. ♂				ANO	EXITUS
3. ♀				NE	EXITUS
4. ♀	14	105	ANO	ANO	ANO
5. ♂				ANO	ANO
6. ♀	26	100	ANO	NE	EXITUS
7. ♂	13	120	ANO	ANO	ANO
8. ♀	8,5			ANO	EXITUS

Přehled dětí léčených ECMO 2010 - 2013					
Pac.	Laktát (mmol/l)	IS	Septický šok	Přežití	Dimise
1. ♀				ANO	ANO
2. ♀	8,1	40	ANO	ANO	ANO
3. ♂				NE	EXITUS
4. ♀	9,2	90	ANO	ANO	ANO
5. ♀				ANO	ANO
6. ♂				ANO	ANO
7. ♂	20	130	ANO	NE	EXITUS
8. ♀				ANO	ANO
9. ♂				ANO	ANO

Cheung 2002 laktát = prediktivní faktor mortality
 25 mmol/l zemřelí
 15 mmol/l přeživší $p=0,001$

McLaren 2011: laktát = prediktivní faktor mortality
 11,7mmol/l zemřelí
 6,7mmol/l přeživší $p=0,007$



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Děkuji za pozornost