AKI, poruchy metabolismu vody a iontů – jak mám postupovat?

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17th Colours of sepsis 27-30.1.2015 Ostrava

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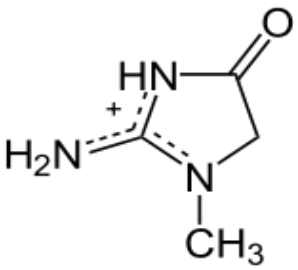
kidney INTERNATIONAL supplements

KDIGO Clinical Practice Guideline for Acute Kidney Injury

VOLUME 2 | ISSUE 1 | MARCH 2012

http://www.kidney-international.org

Stadia akutního poškození ledvin podle KDIGO



Stage	Serum creatinine	Urine output
1	1.5–1.9 times baseline OR ⩾0.3 mg/dl (⩾26.5 µmol/l) increase	<0.5 ml/kg/h for 6–12 hours
2	2.0–2.9 times baseline	<0.5 ml/kg/h for ⩾12 hours
3	3.0 times baseline OR Increase in serum creatinine to ⩾4.0 mg/dl (⩾353.6 µmol/l) OR Initiation of renal replacement therapy OR, In patients <18 years, decrease in eGFR to <35 ml/min per 1.73 m^2	<0.3 ml/kg/h for ⩾24 hours OR Anuria for ⩾12 hours

Laboratorní dif.dg. AKI

	norma	prerenální	renální
Uosmol (mmol/l)	400-600	>400	<400
spec.hmotnost	1015-1025	>1020	cca 1010
U_{Na}(mmol/l)	15-40	<20	>30
U_{kreat}/S_{kreat}	20-60	>40	<20
Index ASL $U_{Na}.S_{kreat}/U_{kreat}$	2-3	<1	>3

Diagnóza AKI

1.	2.	3.	4.
Anamnéza: •funkce ledvin, sepse, nefrotoxiny, •urea, kreatinin, K, ABR, osmolalita plazmy, GFR, CIN?	**Zhodnocení intravaskulárního objemu:** •CVP •ECHOkg	**léčba** podle klinického kontextu •volumexpanze •vysazení nefrotoxinů	• biopsie ledviny • empirická terapie • kortikoidy
Zhodnocení stavu • stav hydratace, TK	**USG** •vyloučení subrenální obstrukce		
katetrizace močového měchýře	další imunologické, mikrobiologické vyšetření krve		
biochémie krve, moči KO	USG/angio CT cévní řečiště (jen indikované stavy)		

Nephrol Dial Transplant (2014) 29: 2054–2061
doi: 10.1093/ndt/gfu292
Advance Access publication 18 September 2014

ndt
Nephrology Dialysis Transplantation

Original Articles

Eric A.J. Hoste[1], Peter A. McCullough[2,3], Kianoush Kashani[4], Lakhmir S. Chawla[5,6], Michael Joannidis[7], Andrew D. Shaw[8], Thorsten Feldkamp[9,10], Denise L. Uettwiller-Geiger[11], Paul McCarthy[12], Jing Shi[13], Michael G. Walker[13], John A. Kellum[14] on behalf of the Sapphire Investigators†

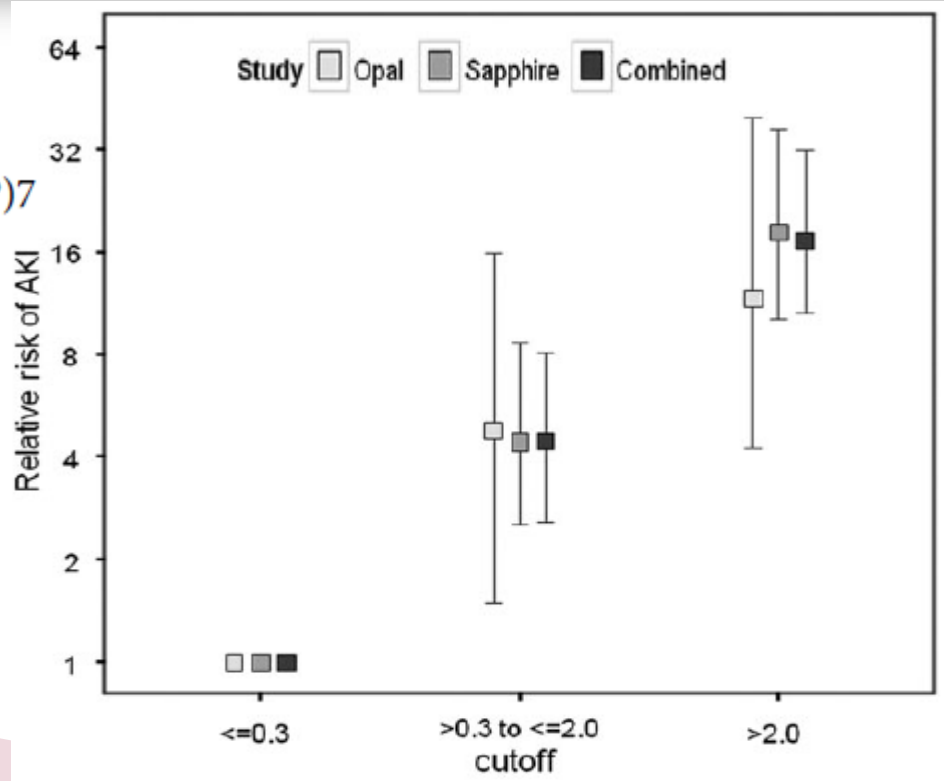
Derivation and validation of cutoffs for clinical use of cell cycle arrest biomarkers

tissue inhibitor of metalloproteinases (TIMP)-2

insulin-like growth factor binding protein (IGFBP)7

$(ng/mL)^2/1000$.

urinary biomarkers for AKI.



Rizikové faktory pro vznik AKI

Riziko	Zvýšená vnímavost
Sepse	Dehydratace
Kriticky nemocný	Věk
Oběhové selhání	Ženské pohlaví
Popáleniny	Černá rasa
Trauma	CKD
Kardiochirurgický výkon	Chronické onemocnění jater, plic..
Velký chirurgický výkon	Diabetes mellitus
Nefrotoxická léčba	Nádorové onemocnění
Kontrastní látky	Anémie
Otrava	

GMR Genetics and Molecular Research
Online Journal
ISSN:1676-5680

Etiological factors, prognostic assessment, and outcomes of patients with acute kidney injury and multiple organ dysfunction syndrome

Z. Gao[1], D.W. Mu[2], L. Guo[3], X.M. Li[1] and L.D. Lun[1]

Table 1. Causes of primary disease in 123 patients with severe AKI combined with MODS.

Cause of primary disease	N
AKI after major operation	23
Renal parenchyma disease	13
AKI caused by tumor in advanced stage	11
AKI caused by MODS	31
AKI caused by infection and pyemia	18
AKI complicating severe pancreatitis	12
AKI caused by trauma and compression syndrome	6
AKI caused by drugs (including chemotherapeutics)	9

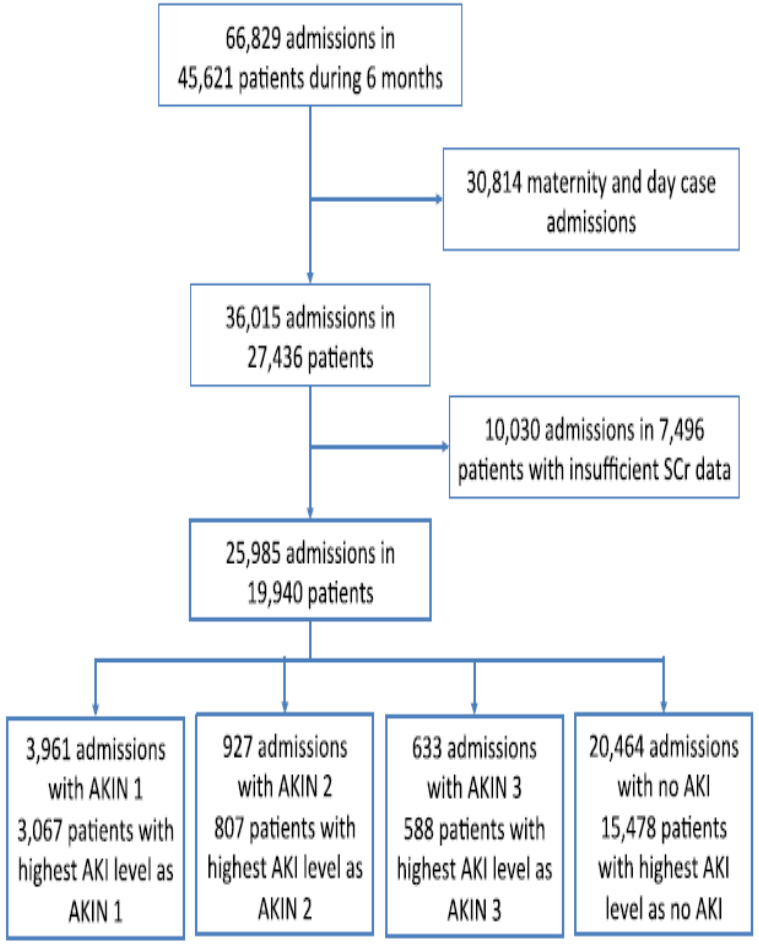
Table 4. Prognosis of 123 patients with severe AKI combined with MODS.

Number of injured organs	N	Deaths	Recovery of kidney function	Fatality rate (%)	Recovery rate of kidney function (%)
2	26	5	7	19.2	26.9
3	28	19	5	67.9	17.9
4	39	35	4	89.7	10.3
5	24	24	2	100.0	8.3
6	6	6	0	100.0	0.0

RESEARCH ARTICLE Open Access

What is the real impact of acute kidney injury?

Michael Bedford*, Paul E Stevens†, Toby WK Wheeler† and Christopher KT Farmer†



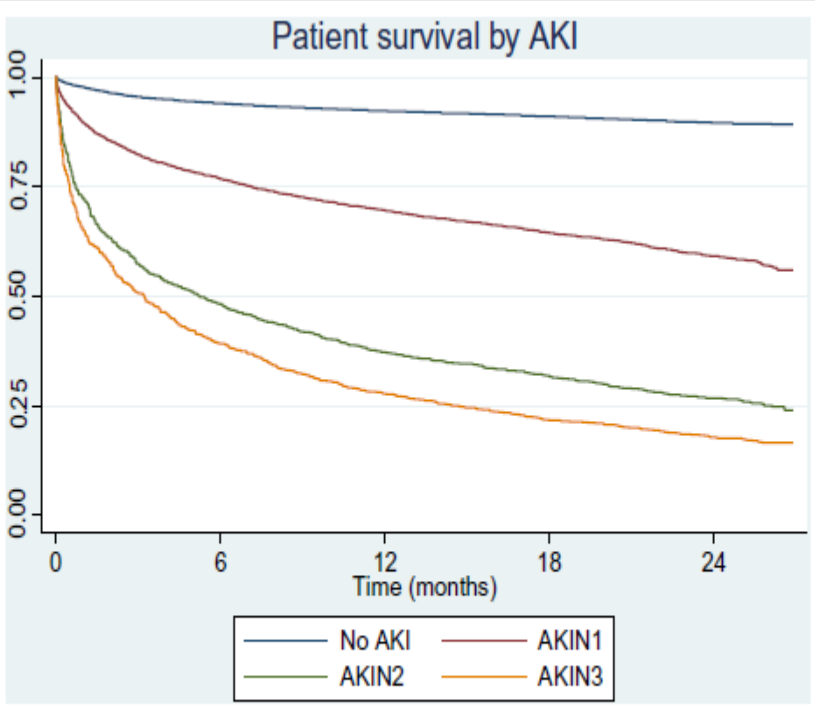
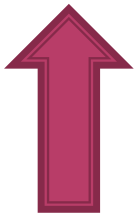


Figure 2 Kaplan-Meier survival by stage of AKI. Note that the AKI groups are based on 'upgraded' AKI risk.

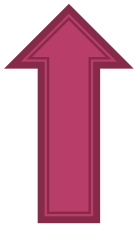
Poruchy metabolismu Na^+

Poruchy metabolismu Na^+

$[Na^+]$ = množství Na/množství H2O



RAAS



ADH

Hyponatremie
Na^+ <135 mmol/l

$[Na^+]$ = množství Na/množství H2O

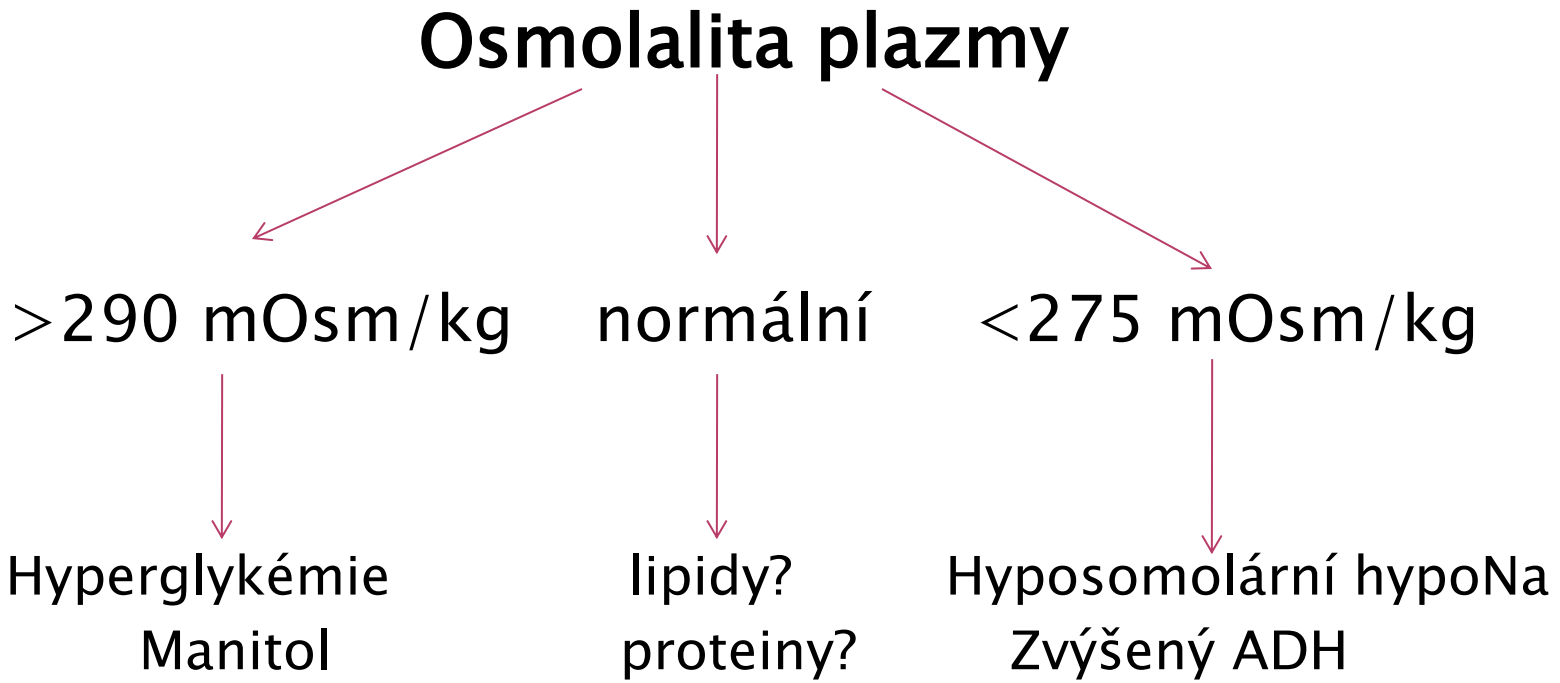
↓ Na^+/ H2O

Anebo

Na^+/ ↑ H2O

↓ Na^+/ ↑↑ H2O

Hyponatremie



Hypoosmolární hyponatremie

Objem ECT

Hypovolémie

Una>20 mmol/l ev. <20 mmol/l
Ztráty renální, extrarenální
Zvracení, průjmy
Diuretika
Addisonova choroba
Nenatriová osmotická diuréza

Euvolémie

SIADH
hypotyreosa
psychogenní polydipsie

Hypervolémie

jaterní cirhosa
selhání ledvin
nefrotický sy
selhání srdce

Nagler *et al. BMC Medicine* 2014, **12**:231
http://www.biomedcentral.com/1741-7015/12/231

BMC Medicine

RESEARCH ARTICLE Open Access

Diagnosis and treatment of hyponatremia: a systematic review of clinical practice guidelines and consensus statements

Evi V Nagler[1,2,3*], Jill Vanmassenhove[2], Sabine N van der Veer[1,4], Ionut Nistor[1,5], Wim Van Biesen[1,2], Angela C Webster[3,6,7] and Raymond Vanholder[1,2]

Table 3 Summary of recommendations for approaches to treatments for hyponatremia by included guidance documents

	Guideline Organization/Societies									
Criteria/ categories	NIV [16]	NHS [17]	GAIN [22]	AEEH [23]	EHN [25]	ERBP/ESE/ ESICM [20]	UF [18]	HEP [19]	RCHM [21]	EAH-ICD [24]
Symptoms										
Acute Onset (<48 h)	NaCl >1% Infusion speed may be guided by Adrogu-Madias	NaCl 3%	NaCl 2.7% 200 mL over 30 min		NaCl 3% 100 mL/ 10 min up to 3 or infused at 0.5 2 mL/kg/h	NaCl 3% 150 mL/ 20 min up to 4	NaCl >1%	NaCl 3% 100 mL/ 10 min up to 3 or infused at 0.5 2 mL/kg/h	NaCl 3% 4 mL/kg over 30 min	NaCl 3% 100 mL bolus
Hypovolemia								NaCl 0.9% until blood pressure restored		
Euvolemia			Fluid restriction							No hypotonic fluids
			Stop offending drugs							
			Stop hypotonic fluids							
Hypervolemia			Furosemide					Furosemide		
Chronic onset (>48 h)	NaCl >1% Infusion speed calculation may be guided by Adrogu-Madias	NaCl 3%	Only if severe symptoms NaCl 2.7% 200 mL over 30 min infusion speed by may be guided Adrogu-Madias		NaCl 3% 100 mL/ 10 min up to 3 or infused at 0.5 2 mL/kg/h	NaCl 3% 150 mL/ 20 min up to 4	NaCl >1%	NaCl 3% 100 mL/ 10 min up to 3 or infused at 0.5-2 mL/kg/h		
Hypovolemia			NaCl 0.9% 1 L over 2 4 h infusion speed may be guided by Adrogu-Madias					NaCl 0.9% until blood pressure restored		
Euvolemia			Fluid restriction							
			Stop offending medications							
			Stop hypotonic fluids							
Hypervolemia			Fluid restriction					Furosemide		
			Salt restriction							
No symptoms										
Acute onset (<48 h)	NaCl >1% Infusion speed by Adrogu-Madias		Treat underlying condition			Stop offending fluids and medications, treat underlying		Treat underlying condition		

Léčba hyponatremie

- Polydipsie – restrikce tekutin
- SIADH – restrikce tekutin, NaCl tbl p.o
- – furosemid, (vaptany??)
- Hypovolémie – fyziologický roztok NaCl i.v 0.9%
- Akutní hypoNa^+ (vznik do 48 hodin)
- bolus 100 ml 3% roztoku NaCl a v 1. 2 hodinách zvýšení o 5 mmol/l dále postupně 1-2 mmol/l/h k dosažení 130 mmol/l
- Chronická hypoNa^+ – hrazení 3% NaCl i.v s maximálním zvýšením o 6 mmol/l/24 hodin

MedCalc: Hyponatremia & Hypernatremia

Patient's Sodium : 115 mEq/L

Target Sodium : 130 mEq/L

Rate of Na Correction : 0.5 mEq/L/hr over 30 hours

Patient's Weight : 70 kg

Patient is a : man

Calculate using : Adrogue formula

Correct for:

☑ Fever? Temp: 38 °C

☑ Insensible Loss? Amount: 1000 cc/day

Calculate Fluids

Obnoviť Pôvodné Nastavenie

IVF Rate : 95.7 cc/hr for 30 hours

IV Fluids : 3% NaCl

Classic Formulas:

Hypernatremia

$$\text{Total } H_2O \text{ deficit (L)} = \text{total body water} \times \left(1 - \frac{\text{desired } Na^+}{\text{serum } Na^+}\right)$$

Hyponatremia

$$Na^+ \text{ requirement (mmol)} = \text{total body water} \times (\text{desired } Na^+ - \text{serum } Na^+)$$

$$\text{Rate of infusion (cc/hr)} = \frac{Na^+ \text{ requirement (mmol)} \times 1000}{\text{infusate } Na^+ \text{ (mmol/L)} \times \text{time (hours)}}$$

Adrogue Formula:

$$\text{Change in serum } Na^+ = \frac{(\text{infusate } Na^+ + \text{infusate } K^+) - \text{serum } Na^+}{\text{total body water} + 1}$$

Infusate	Infusate Na^+ (mmol/L)
5% NaCl	855
3% NaCl	513
0.9% NaCl (NS)	154
Lactate Ringer's	130
0.45% NaCl (½ NS)	77
0.2% NaCl (⅕ NS)	34
5% Dextrose in water (D5W)	0

Total Body Water (in liters) :	
Children	0.6 x weight
Women	0.5 x weight
Men	0.6 x weight
Elderly Women	0.45 x weight
Elderly Men	0.5 x weight

Insensible water losses = 500 - 1500 cc/day.
Fever increases insensible water losses by 10% per degree Celsius above 38°, or 100-150 cc/day increase per degree Celsius above 37°.

Adrogue, HJ; and Madias, NE. Primary Care: Hypernatremia. *New England Journal of Medicine* 2000; 342(20):1493-1499.
Adrogue, HJ; and Madias, NE. Primary Care: Hyponatremia. *New England Journal of Medicine* 2000; 342(21):1581-1589.

http://www.medcalc.com/sodium.html

Léčba hyponatremie

- 3% roztok NaCl (7 amp 10% NaCl + 250 ml F1/1)
- Pokud nelze zjistit anamnézu – hypoNa^+ považovat primárně za chronickou
- Syndrom pontinní myelinolýzy – následek nešetrné úpravy hypoNa^+

Hypernatremie
$Na^+ > 145$ mmol/l

$[Na^+]$ = množství Na/množství H2O

↑ Na^+/ H2O

Anebo

Na^+/ ↓ H2O

Hypernatremie

U_{Osm}

<800mOsm/kg

Renální ztráty vody

Diabetes insipidus

CDI

NDI (GDI)

osmotická diuréza

glu, urea, manitol

Snížený příjem vody??

>800mOsm/kg

zvýšený příjem Na

ztráta vody GIT-em

idiopatická hyper Na

nephromatic

intelligent renal calculators

fractional excretion | egfr | **water deficit** | sodium correction | potassium gradient

water deficit

Current sodium: 150 meq/L

Weight: 70 kg

Male Female

Elderly

water deficit	flow rate
2.1 liters	105 cc/hr for 20 hours

The flow rate is a calculated rate of D5W to treat the hypernatremia.

Hint: type the underlined letter to select the item without using the mouse.
Type L after entering the weight in pounds to convert to kilograms.

The free water deficit is used to assess the amount of water replacement needed to correct hypernatremia. As with many medical equations, the result is an estimate that may not be valid for a given patient. Repeated measurements of sodium may be needed to ensure safe treatment. The calculation is based on the formula:

water deficit = (total body water)*(1-(140/Na))

total body water = correction factor * weight

The correction factor is 0.6 for men, 0.5 for women and elderly men, and 0.45 for elderly women.

Also offered is a calculated flow rate and duration for IV D5W. This calculation is based on a conservative correction rate of 0.5 meq/L/hr to avoid cerebral edema. It does not take into account ongoing water losses.

Léčba hypernatremie

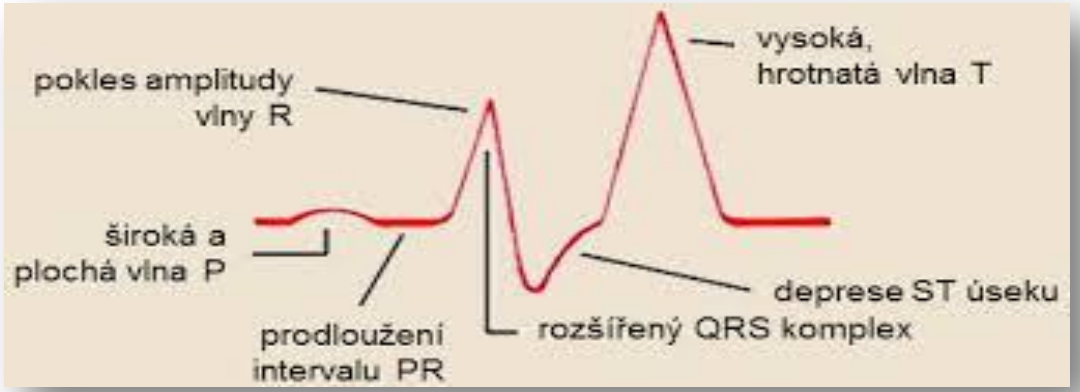
- Náhrada tekutinového deficitu – 50% v prvních 24 hodinách
- **deficit vody v l=0.6 x (TH)n x (1-140/S_{Na+})**
- **Pokles Na maximálně o 0.5 mmol/l /h a maximálně o 12 mmol/l/24 hodin**
- Podávat 5% glukosu nebo 0.45% NaCl i.v. při deficitu tekutin

- Léčba základní choroby (DDAVP)

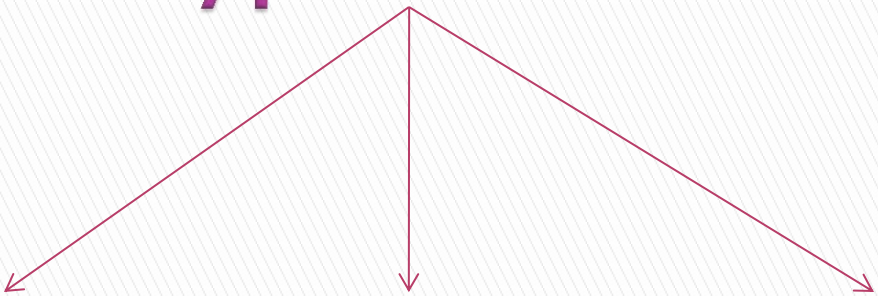
Poruchy metabolismu K^+

Hyperkalemie

- Pseudohyperkalemie
- Leukocytóza, trombocytóza
- Hemolýza
- EKG ??



Hyperkalemie



↑ příjem K^+

- Infuze s KCl
- Transfuze

↓ exkrece K^+

- GF<10 ml/min
- Beta-blokátory

uvolnění K^+ z buněk

- Digoxin
- MAC
- Katabolizmus
- Hypoxie
- rozpad buněk
- Hyperkalemická periodická paralýza

Snížená renální exkrece K^+

GFR

- **Selhání ledvin**

AKI/CKD

KSK

- **Léky**
- **adrenální insuficience**
- **Hyporeninový hypoaldosteronizmus**

- **Blokáda RAAS**
- ACEi/AT1 blokátory
- Cyklosporin
- Heparin
- NSAIDs

Léčba hyperkalemie

Vstup K^+ do buněk

- 10%Glukosa 500 ml+ 16j Humulin R i.v 60 minut
- NaHCO3 4,2% i.v. (BE x t.hm x 0,4) podat 1/3 z vypočítané dávky
- Beta-adrenergní agonisti - inhalace

Stabilizace membrány

- Calcium gluconicum i.v.

Odstranění K^+

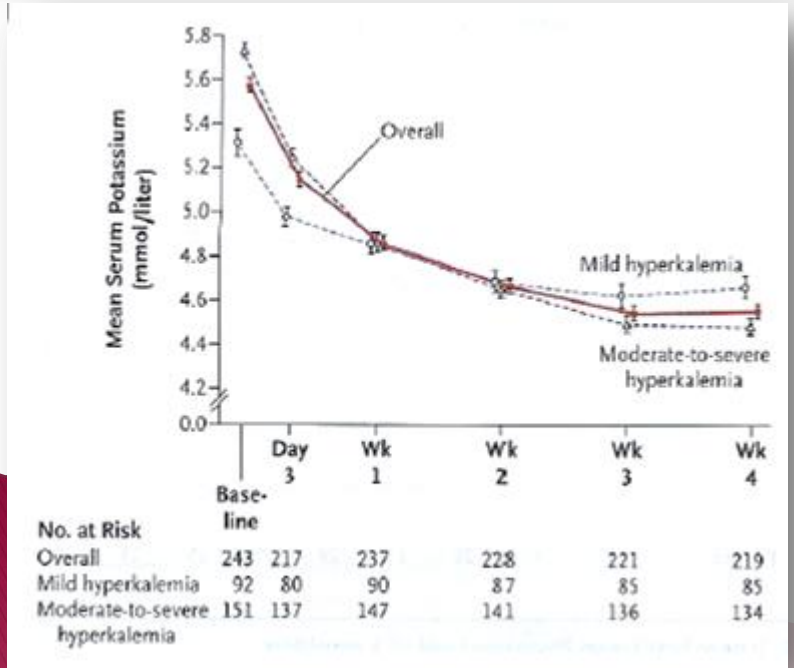
- hemodialýza
- iontoměniče (Ca resonium p.o.)
- kličková diuretika

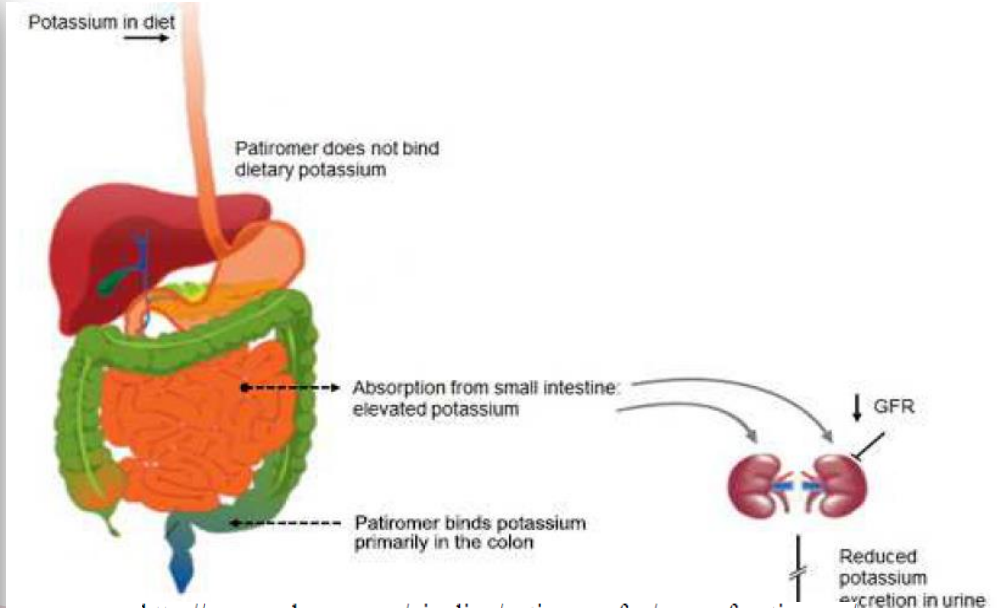
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JANUARY 15, 2015 VOL. 372 NO. 3

Patiromer in Patients with Kidney Disease and Hyperkalemia Receiving RAAS Inhibitors

Matthew R. Weir, M.D., George L. Bakris, M.D., David A. Bushinsky, M.D., Martha R. Mayo, Pharm.D., Dahlia Garza, M.D., Yuri Stasiv, Ph.D., Janet Wittes, Ph.D., Heidi Christ-Schmidt, M.S.E., Lance Berman, M.D., and Bertram Pitt, M.D., for the OPAL-HK Investigators*



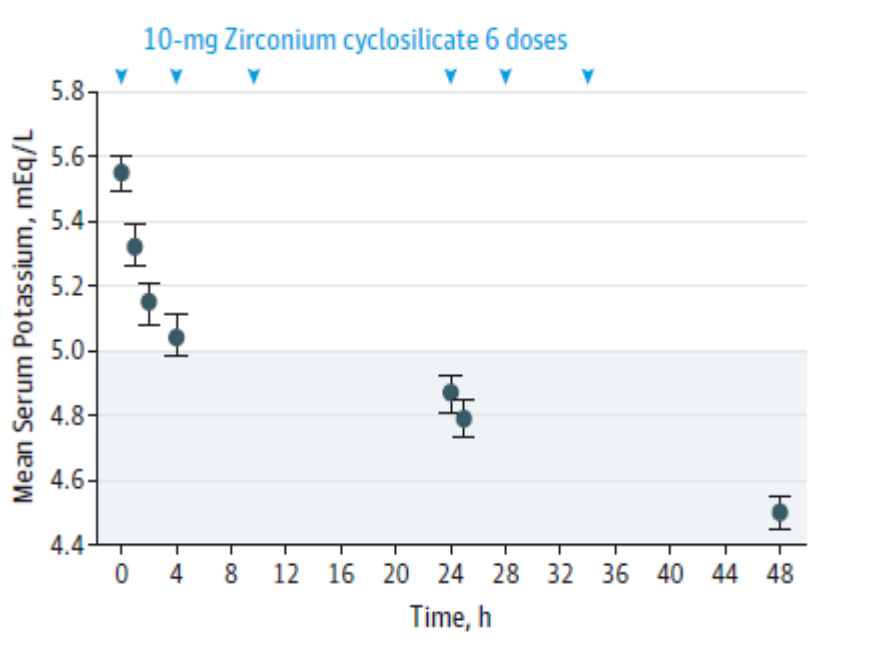


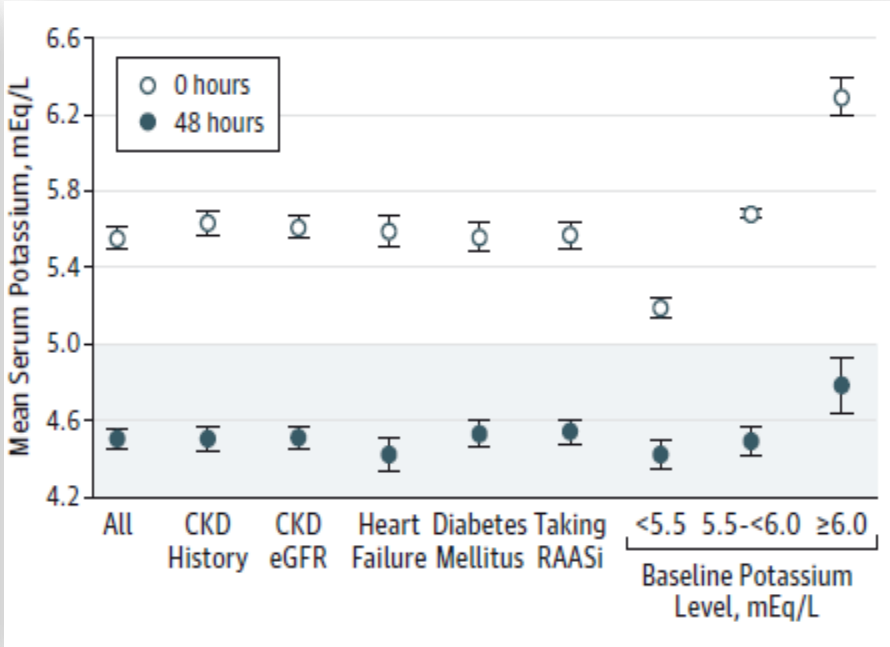
http://www.relypsa.com/pipeline/patiromer-fos/moa-of-patiromer/

Original Investigation

Effect of Sodium Zirconium Cyclosilicate on Potassium Lowering for 28 Days Among Outpatients With Hyperkalemia
The HARMONIZE Randomized Clinical Trial

Mikhail Kosiborod, MD; Henrik S. Rasmussen, MD, PhD; Philip Lavin, PhD; Wajeh Y. Qunibi, MD; Bruce Spinowitz, MD; David Packham, MD; Simon D. Roger, MD; Alex Yang, MD; Edgar Lerma, MD; Bhupinder Singh, MD





JAMA. doi:10.1001/jama.2014.15688
Published online November 17, 2014.

Hypokalemie

Vstup K^+ do buněk

- MAL
- B-agonisti
- Inzulín
- Hypokalemická periodická paralýza

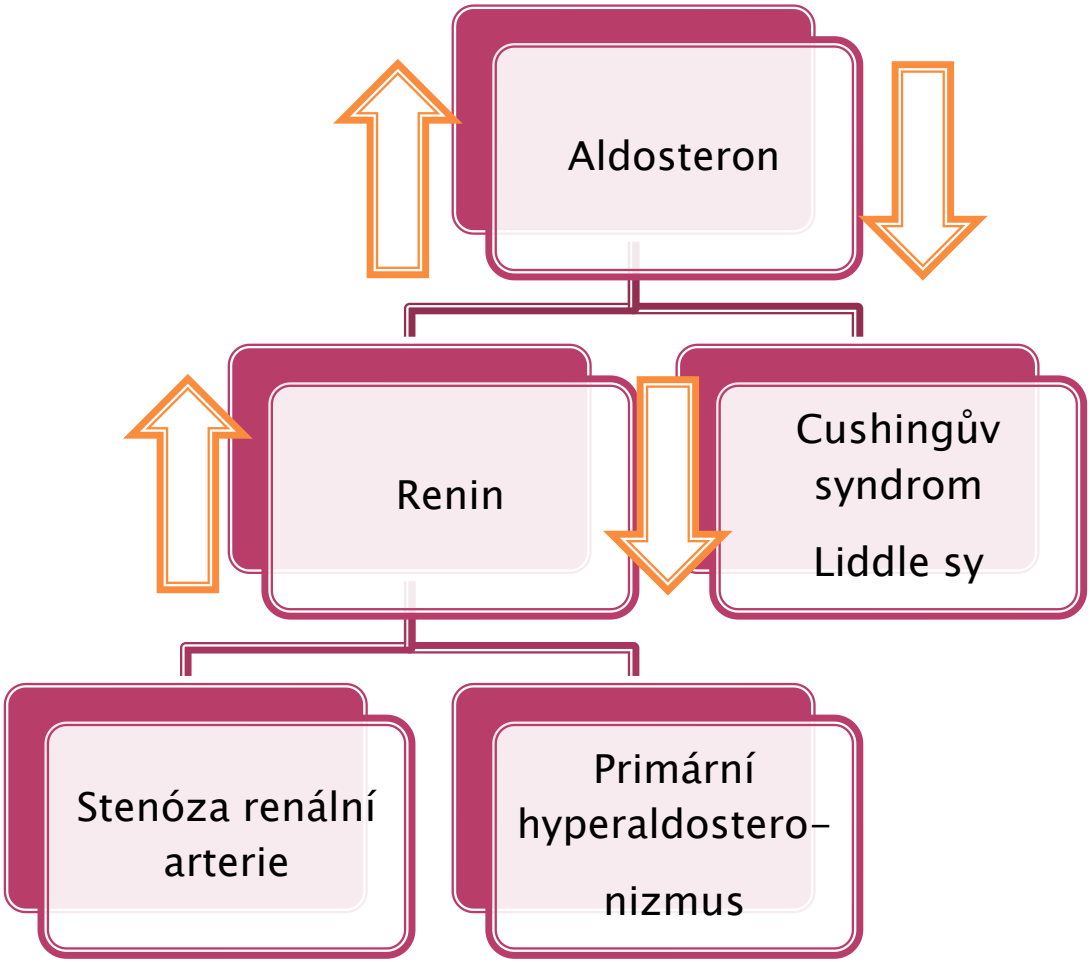
GIT ztráty

- Zvracení
- průjem

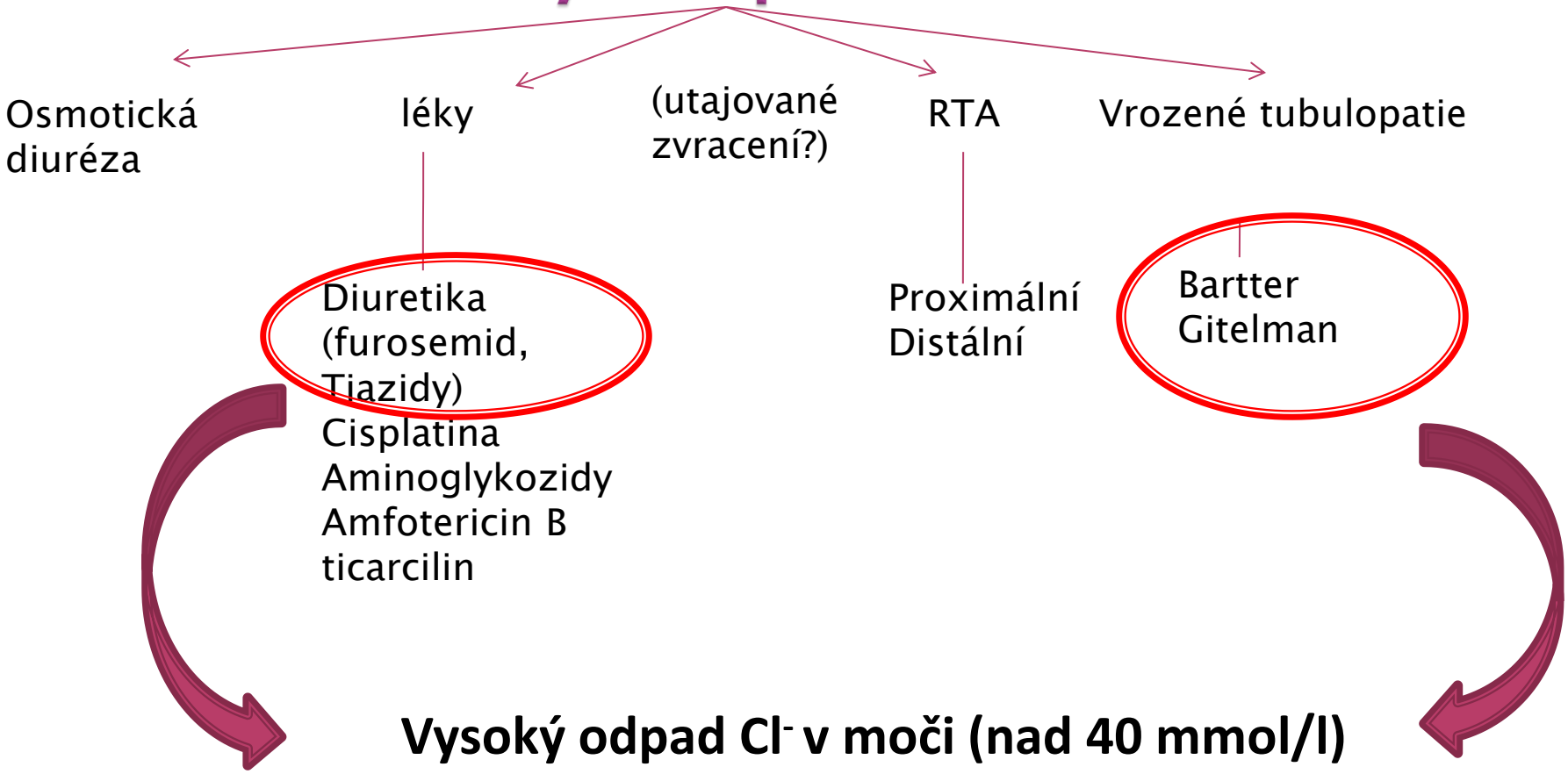
Renální ztráty

- >25 mmol/24hod

Hypokalemie a hypertenze



Renální ztráty K^+ při normotenzi



Vysoký odpad Cl^- v moči (nad 40 mmol/l)

Léčba hypokalemie

- Podle etiologie
- Hyperaldosteronizmus – spironolakton
- Kalium chloratum p.o. (1g=13,5 mmol K^+)
- – denní dávka 20–50 mmol K^+
- Kalium i.v. 10 mmol/hodinu maximálně
- Ani při těžké hypokalemii – urgentní stavy!! $K^+ < 1,5$ mmol/l **nelze podat** více než 20 mmol K^+ za 1 hodinu.
- 10 ml 7,5% roztoku kalium chloratum (750 mg) = 10 mmol K^+ a 10 mmol Cl^-

Závěr

- Při změnách v iontogramu vždy zohledni klinický stav pacienta
- Důležitá jsou anamnestická data o užívaných lécích
- Věk, pohlaví a hmotnost pacienta – zohledni vždy při úpravě vnitřního prostředí
- Rozhodni se správně kdy musíš jednat agresivně a kdy s maximální rozvahou

Petejova and Martinek *Critical Care* 2014, 18:224
http://ccforum.com/content/18/3/224

CRITICAL CARE

REVIEW

Acute kidney injury due to rhabdomyolysis and renal replacement therapy: a critical review

Nadezda Petejova* and Arnost Martinek

Děkuji za pozornost

Literatura

- DENKER BM, Electrolytes and Acid-Base 2, Boston, MA, HMS Update in Medicine, March 2014
- KDIGO – clinical pratice guidelines for acute kidney injury – www.kdigo.org
- SINGH AK, LOSCALZO J: Electrolyte disorders in The Brigham intensive review of Internal Medicine. *Oxford University Press* 2nd Edition. New York USA 2014: 578-593.
- SCHUCK O. Poruchy metabolizmu vody a elektrolytů v klinické praxi. *Grada,* Praha 2000: 43-82.
- TEPLAN V a kol. Akutní poškození a selhání ledvin v klinické medicíně. *Grada*, Praha 2010:17-83.
- VIKLICKÝ O, TESAŘ V, DUSILOVÁ-SULKOVÁ S a kol. Doporučené postupy a algoritmy v nefrologii. *Grada*, Praha 2010: 95-100.