DYSKALIEMIE
EN
REANIMATION

lila.bouadma@bch.aphp.fr

K^+ = ppal cation intracellulaire

$[K^+]$ intracellulaire élevée
(98% du potassium de l'organisme)

[K+] extracellulaire faible
(2% du potassium de l'organisme

La kaliémie ne reflète donc pas l'état du capital potassique total.

K^+ = ppal cation intracellulaire

[K^+] intracellulaire élevée
(98% du potassium de l'organisme)

[K+] extracellulaire faible
(2% du potassium de l'organisme

K^+ = ppal cation intracellulaire

[K^+] intracellulaire élevée
(98% du potassium de l'organisme)
3500 mmol
100 à 150 mmol/L

[K+] extracellulaire faible
(2% du potassium de l'organisme
80 mmol
4 mmol/L

Rôles du potassium intracellulaire

-maintien du volume cellulaire

-régulation du pH intracellulaire

-fonctionnement enzymatique cellulaire

-synthèse protéique/ADN

-croissance cellulaire

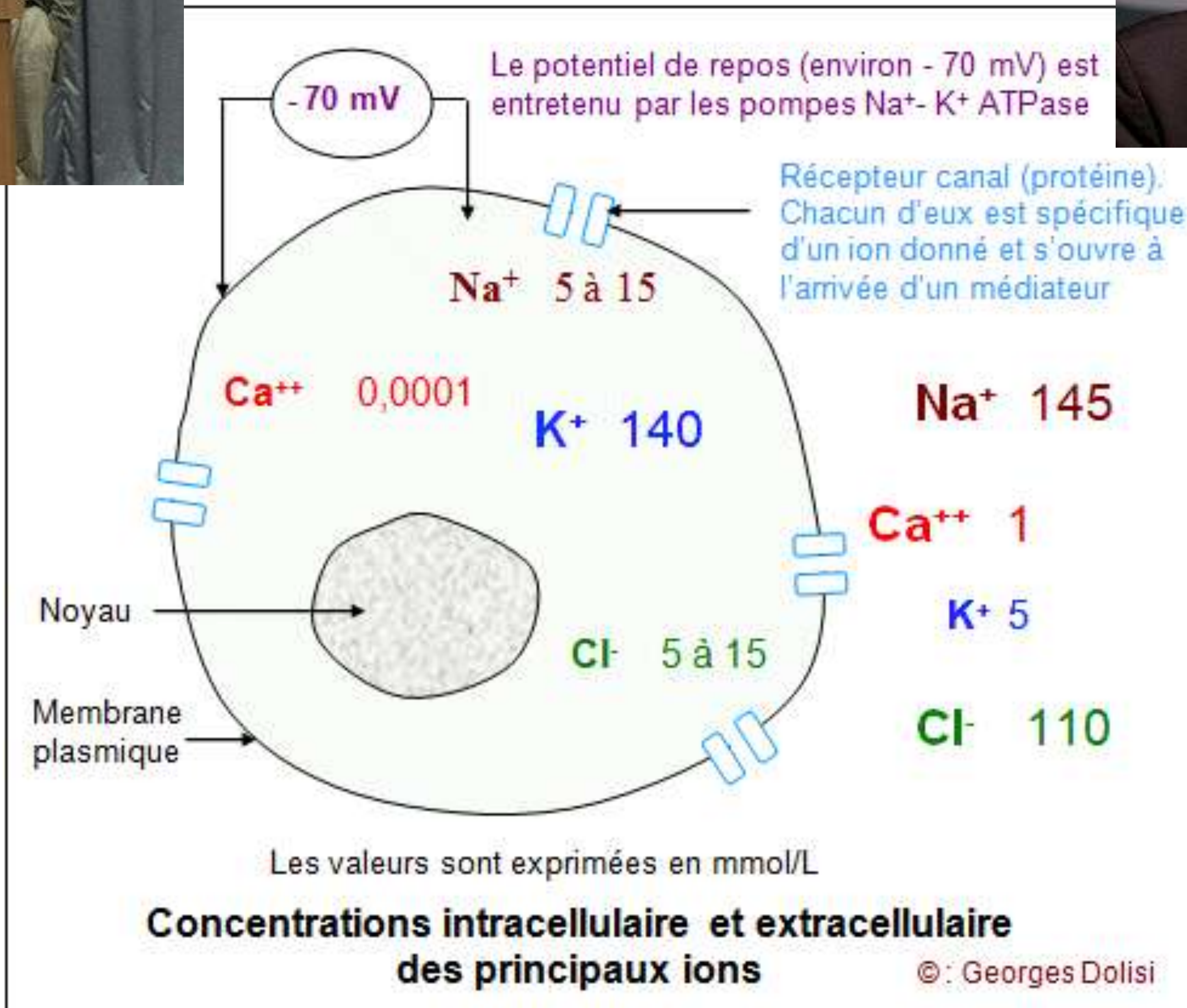
Rôles du gradient transcellulaire du K+: propriétés électriques des mbç

tissus excitables (nerfs. muscles). tissus non excitables (épithélium)

-potentiel de repos mb

-excitabilité neuromusculaire

Bert Sakmann et Erwin Neher
Prix Nobel de physiologie et médecine en 1991.



K^+ = ppal cation intracellulaire

[K^+] intracellulaire élevée
(98% du potassium de l'organisme)
3500 mmol
100 à 150 mmol/L

[K+] extracellulaire faible
(2% du potassium de l'organisme
80 mmol
4 mmol/L

[K^+] intacellulaire et extracellulaire très régulées

Rôles du potassium intracellulaire

- -maintien du volume cellulaire
- -régulation du pH intracellulaire
- -fonctionnement enzymatique cellulaire
- -synthèse protéique/ADN
- -croissance cellulaire

Rôles du gradient transcellulaire du K+: propriétés électriques des mbç

tissus excitables (nerfs. muscles). tissus non excitables (épithélium)

- -potentiel de repos mb
- -excitabilité neuromusculaire

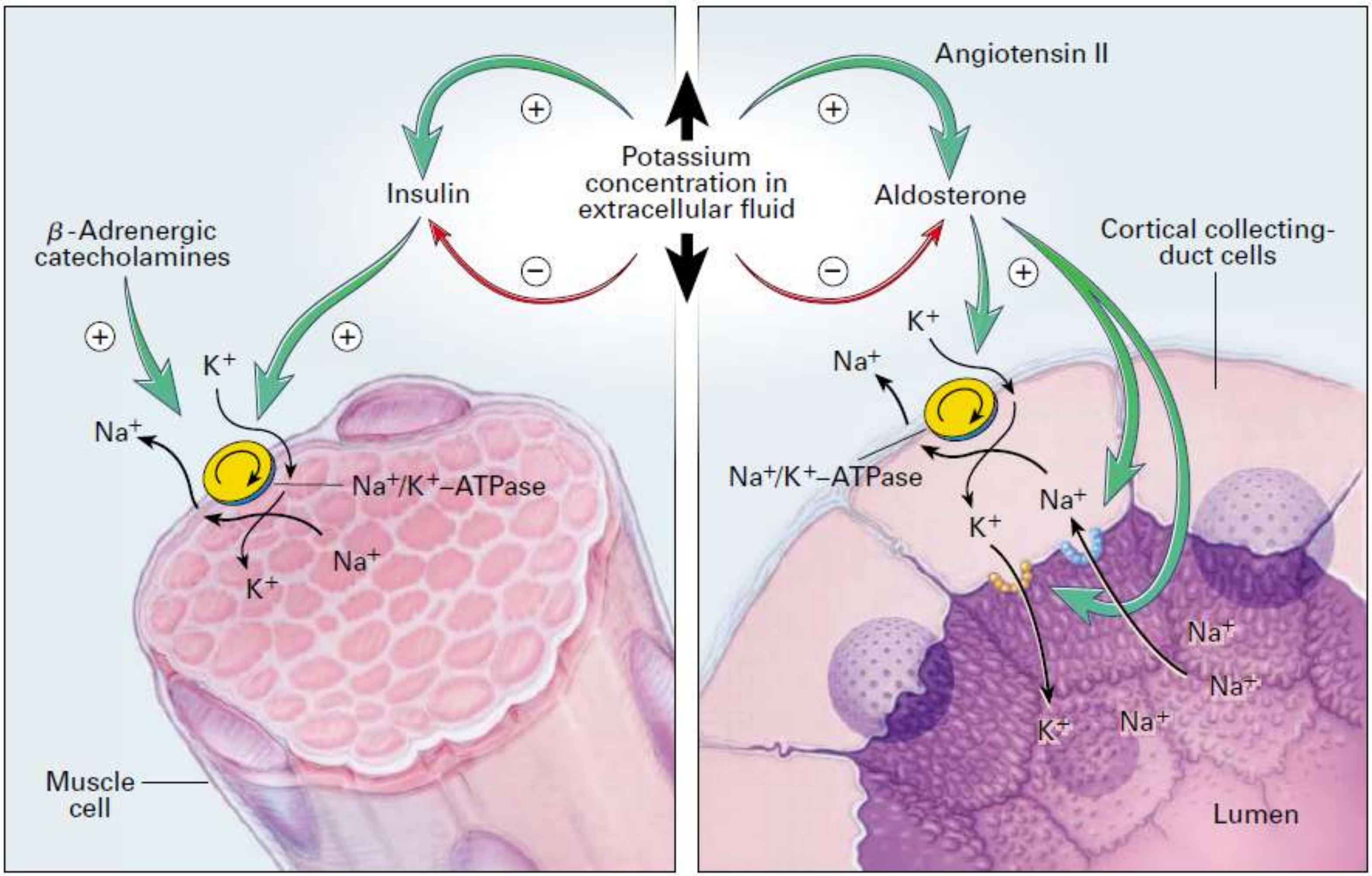
CURRENT CONCEPT

REVIEW ARTICLE

The NEW ENGLAND JOURNAL of MEDICINE

BILAN INTERNE
CELLULE

BILAN EXTERNE
CANAL COLLECTEUR



Quelle est la [K^+] optimale en réanimation ?

INCONNUE ++++

Recommandations pour les patients de cardiologie en post-infarctus du myocarde

Cohn JN. Kowey PR. Whelton PK. Prisant LM. New guidelines for potassium replacement in clinical practice: a contemporary review by the National Council on Potassium in Clinical Practice. *Arch Intern Med.* 2000;160(16):2429-2436

Macdonald JE. Struthers AD. What is the optimal serum potassium level in cardiovascular patients? *J Am Coll Cardiol.* 2004;43(2):155-161

Rogers WJ. Frederick PD. Stoehr E. et al. Trends in presenting characteristics and hospital mortality among patients with ST elevation and non-ST elevation myocardial infarction in the National Registry of Myocardial Infarction from 1990 to 2006. *Am Heart J.* 2008;156(6):1026-1034

Clinical practice guidelines recommend maintaining serum potassium levels between 4.0 and 5.0 mEq/L in patients with acute myocardial infarction (AMI).

TRAITEMENT HYPOKALIEMIE

REVIEW ARTICLE

New guidelines for potassium replacement in clinical practice: a contemporary review by the National Council on Potassium in Clinical Practice.

Cohn JN. Kowey PR. Whelton PK. Prisant LM.

Table 4. Potassium Supplements

Supplement	Attributes
Controlled-release microencapsulated tablets	Disintegrate better in stomach than encapsulated microparticles; less adherent and less cohesive[38]
Encapsulated controlled-release microencapsulated particles	Fewer erosions than wax-matrix tablets[38-42]
Potassium chloride elixir	Inexpensive, tastes bad, poor compliance; few erosions; immediate effect[43,44]
Potassium chloride (effervescent tablets) for solution	Convenient, but more expensive than elixir; immediate effect
Wax-matrix extended-release tablets	Easier to swallow; more gastrointestinal tract erosions compared with microencapsulated formulations[39-42]

ORIGINAL CONTRIBUTION

Serum potassium levels and mortality in acute myocardial infarction.

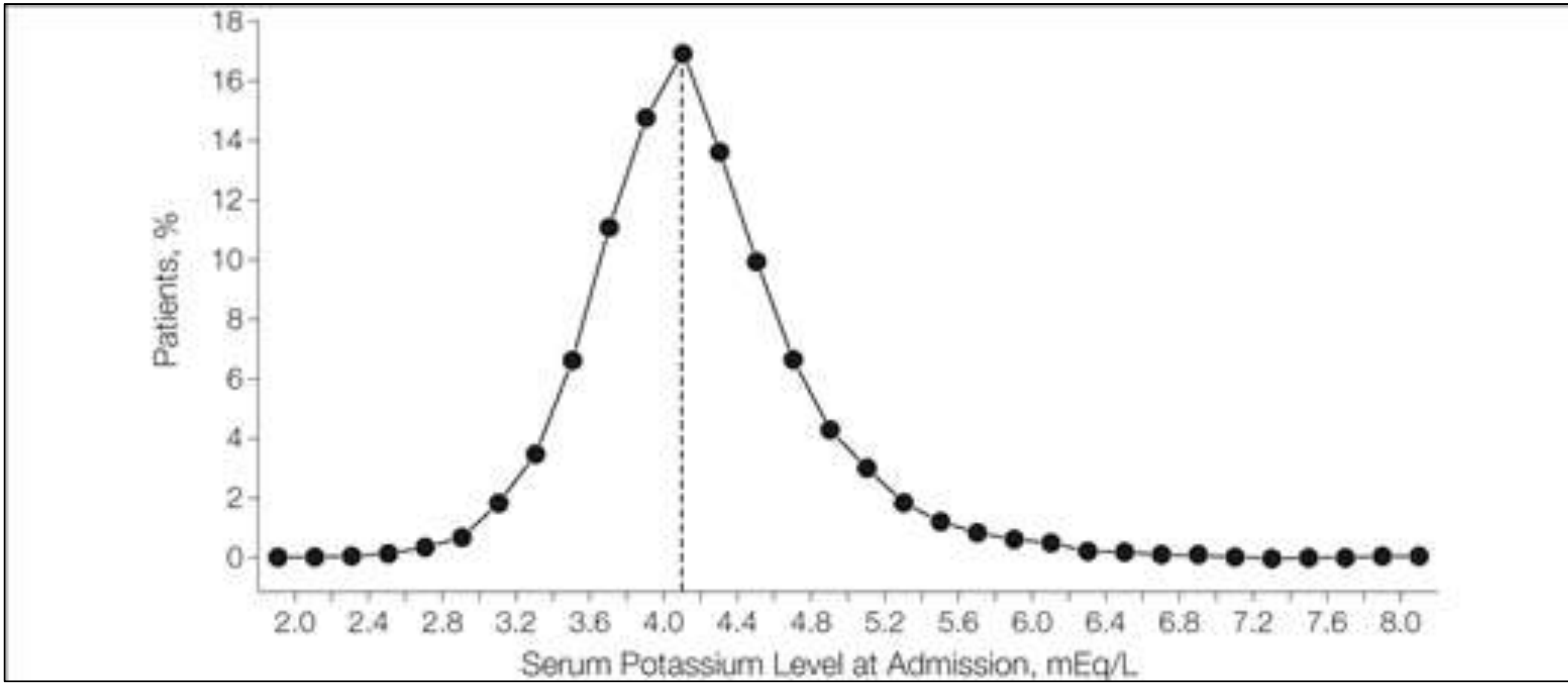
Goyal A. Spertus JA. Gosch K. Venkitachalam L. Jones PG. Van den Berghe G. Kosiborod M.

- Retrospective cohort study using the Cerner Health Facts database
- 38 689 patients with biomarker-confirmed AMI admitted to 67 US hospitals between January 2000 and December 2008
- All patients had in-hospital serum potassium measurements and were categorized by mean postadmission serum potassium level (<3.0. 3.0-<3.5. 3.5-<4.0. 4.0-<4.5. 4.5-<5.0. 5.0-<5.5. and ≥5.5 mEq/L)
- Hierarchical logistic regression was used to determine the association between potassium levels and outcomes after adjusting for patient- and hospital-level factors

ORIGINAL CONTRIBUTION

Serum potassium levels and mortality in acute myocardial infarction.

Goyal A. Spertus JA. Gosch K. Venkitachalam L. Jones PG. Van den Berghe G. Kosiborod M.



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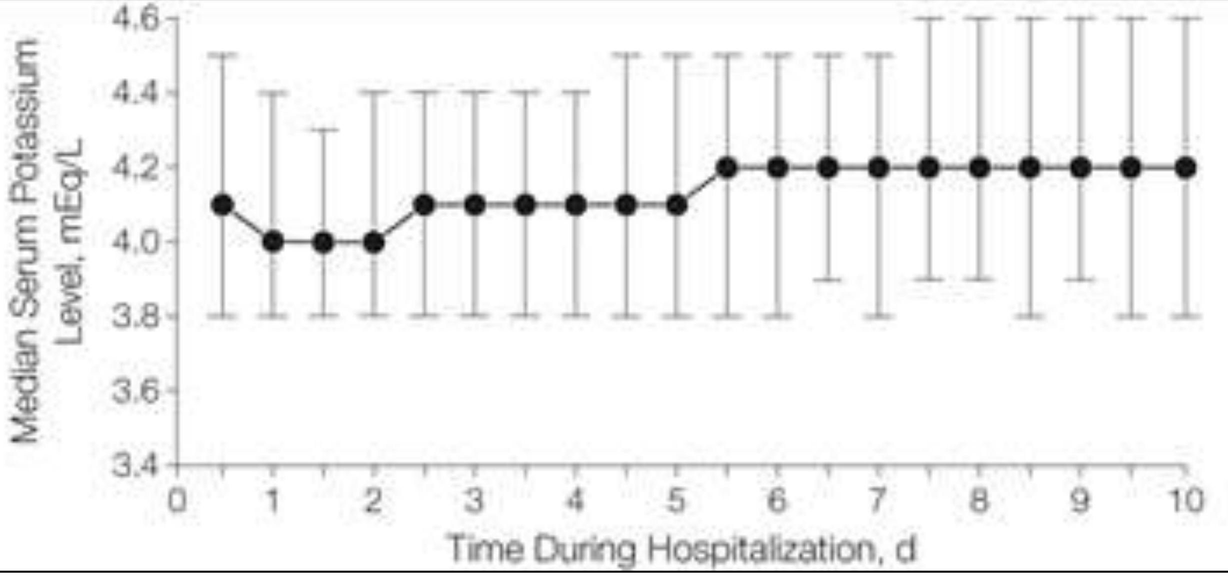
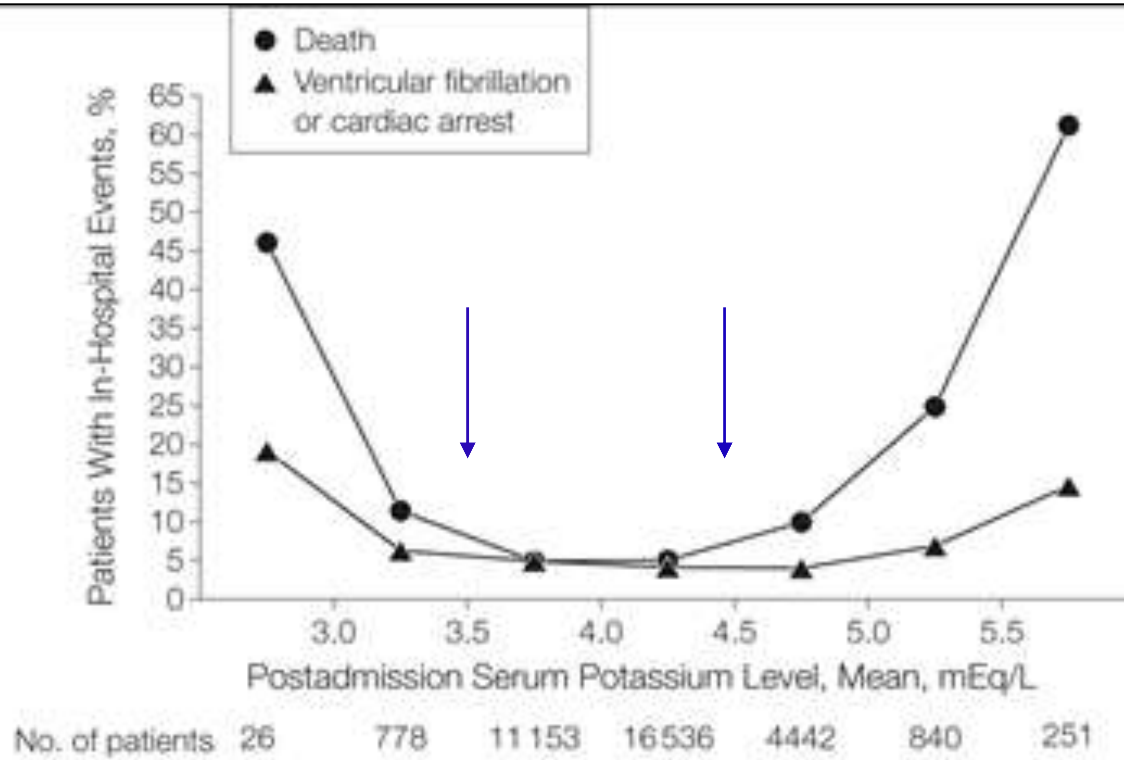


ORIGINAL CONTRIBUTION

Serum potassium levels and mortality in acute myocardial infarction.

Goyal A. Spertus JA. Gosch K. Venkitachalam L. Jones PG. Van den Berghe G. Kosiborod M.

U-shaped relationship between mean postadmission serum potassium level and in-hospital mortality that persisted after multivariable adjustment



Rates of ventricular fibrillation or cardiac arrest
were higher only among patients with potassium levels
of less than 3.0 mEq/L and at levels of 5.0 mEq/L or greater.

Intensive Care Med (2012)

ORIGINAL

McMahon GM.
Mendu ML.
Gibbons FK.
Christopher KB.

Association between hyperkalemia at critical care initiation and mortality.

- Retrospective observational study on 39.705 patients. age ≥ 18 years. 1997-2007
- Two tertiary care hospitals in Boston. Massachusetts
- Highest potassium concentration on the day of critical care initiation from 4 mmol/L to ≥ 6.5 mmol/l categorized a priori every 0.5 mmol/L
- Primary endpoint = 30 day mortality [overall mortality 5.604/39.705 (14.11%)]

Intensive Care Med (2012)

ORIGINAL

McMahon GM.
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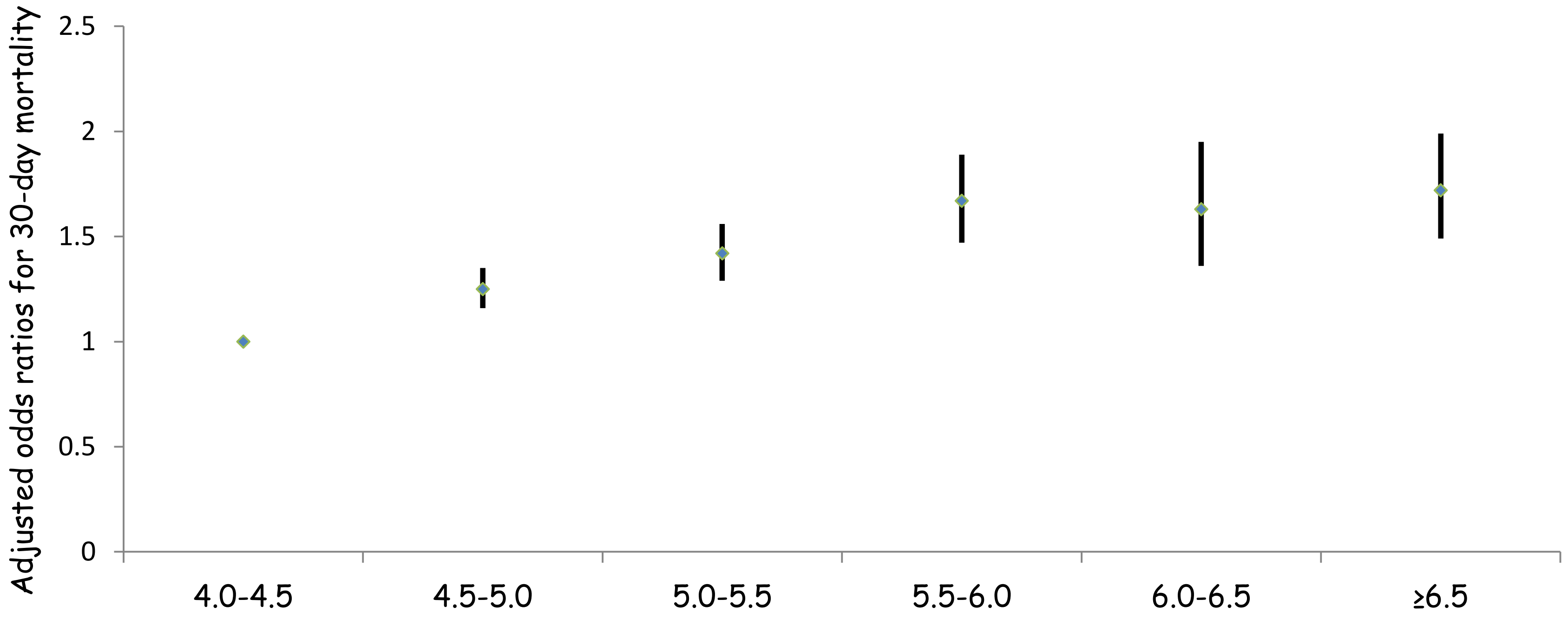
Association between hyperkalemia at critical care initiation and mortality.



Adjustments: age. race. gender. WBC. HCO3-. BUN. creatinine. Deyo-Charlson index. transfusions. patient type. sepsis. RRT. AKI. diabetes mellitus. and glucose

In patients whose hyperkalemia decreases ≥ 1 mEq/L in 48 hours post-critical care intitation. the association between high potassium levels and mortality is no longer significant.

2015

CRITICAL CARE

RESEARCH Open Access

The relationship between serum potassium, potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

- Retrospective before-after study including all patients > 15 years of age admitted for more than 24h
- One ICU in university teaching hospital between 2002-2011
- In 2006, introduction of a nurse –centered computerized potassium-glucose regulation
- Measurements:
  - Mean potassium
  - Potassium variability (defined as the standard deviation of all potassium levels)
  - Percentage of ICU time below and above the reference range (3.5 through 5.0 mmol/L)
- Two periods :
  - First ICU day = early phase
  - Subsequent ICU days = late phase day 2 to day 7
- Two end-points :
  - Primary end-point : in-hospital mortality
  - Secondary end-point : effect of GRIP-II on potassium control

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CRITICAL CARE

RESEARCH | Open Access

The relationship between serum potassium. potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

22.347 ICU admissions

10.451 patients (46.7%) ≥ 24 hours
(206.987 serum potassium measurements

	Before GRIP-II	After GRIPP-II	P-value
Age. yr. mean (SD)	58.6 (17.1)	60.4 (16.2)	<0.001
Sexe. Male	3.453 (59.7)	2.887 (61.9)	0.020
Reason for admission			
Medical	1.979 (34.3)	787 (16.9)	<0.001
Surgical	3.799 (65.7)	3.871 (83.1)	<0.001
LOS ICU. days	4.2 (21. to 10.0)	4.0 (2.0 to 10.5)	0.194
LOS hospital. days	17.5 (12 to 22)	18.1 (10.3 to 32.5)	0.005
Apache II score	17.5 (9.9 to 18.3)	16 (12 to 21)	0.222
AKI			<0.001
KDIGO stage 1	767 (39.7)	621 (41.2)	
KDIGO stage 2	376 (19.4)	304 (20.1)	
KDIGO stage 3	791 (40.9)	584 (38.7)	
RRT	564 (9.7)	435 (9.3)	0.466
K^+ measurements/days. n	1.7 (1.1 to 3.3)	5.5 (3.5 to 7.3)	<0.001

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CRITICAL CARE

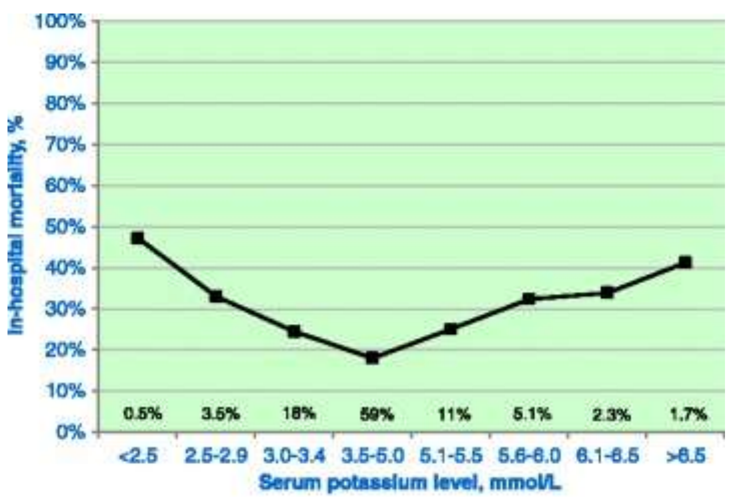
RESEARCH Open Access

The relationship between serum potassium. potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

Lowest and highest potassium levels and outcomes in the early and late phases of intensive care unit admission

EARLY PHASE



LATE PHASE

2015

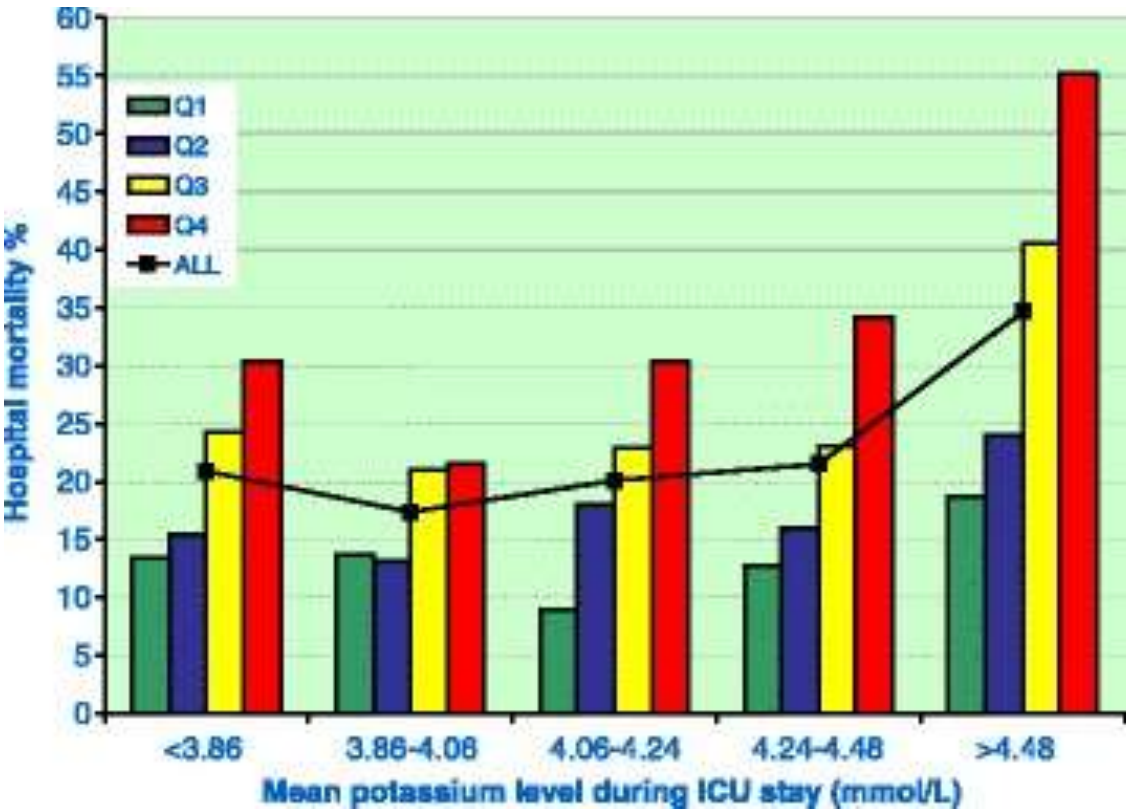
CRITICAL CARE

RESEARCH Open Access

The relationship between serum potassium. potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

Relationship of mean potassium level and potassium variability with mortality



2015

RESEARCH Open Access

The relationship between serum potassium. potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

Potassium variability quartiles used for each mean potassium quintile shown				
Mean [K^+] (mmol/L)	Quartile 1	Quartile 2	Quartile 3	Quartile 4
<3.86 (n = 2.089)	<0.17	0.17 to 0.26	0.26 to 0.38	> 038
3.86 to 4.06 (n = 2.089	<0.18	0.18 to 0.26	0.26 to 0.37	> 0.37
4.06 to 4.24 (n = 2111)	<0.19	0.19 to 0.28	0.28 to 0.38	> 0.38
4.24 to 4.48 (n = 2.080)	<0.19	0.19 to 0.28	0.28 to 0.40	> 0.40
> 4.48 (n = 2.082)	<0.21	0.21 to 0.33	0.33 to 0.51	> 0.51

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CRITICAL CARE

RESEARCH Open Access

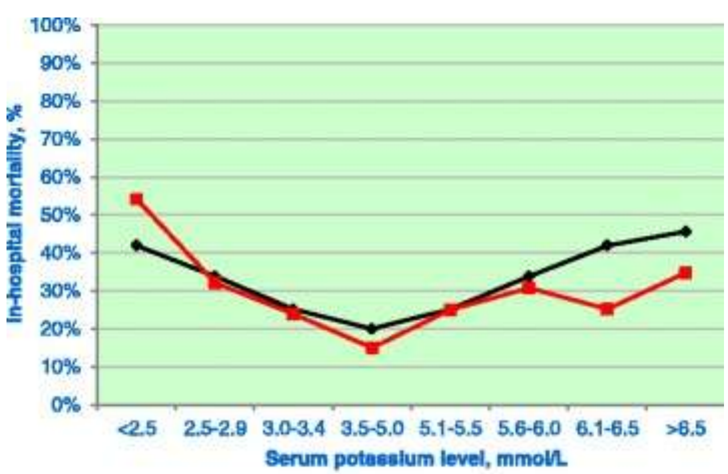
The relationship between serum potassium. potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

Relationship between lowest and hihgest potassium level and outcome during before and after glucose and potassium regulation program for ICU patients

Before GRIP-II After GRIP-II

EARLY PHASE



LATE PHASE

2015

CRITICAL CARE

RESEARCH Open Access

The relationship between serum potassium. potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

Multivariate analysis for hospital mortality

	OR (95% CI)	P-value
Model 1		
Sex. female	1.08 (0.97 to 1.20)	0.159
Age	1.018 (1.014 to 1.021)	<0.001
Mean potassium	0.002 (0.000 to 000.8)	<0.001
Mean potassium squared	2.18 (1.85 to 2.57)	<0.001
Potassium variability	9.37 (7.25 to 12.0)	<0.001
Model 2		
Sex. female	1.12 (1.01 to 1.25)	0.032
Age	1.017 (1.013 to 1.020)	<0.001
AKI	2.50 (2.25 to 2.79)	<0.001
Mean potassium	0.003 (0.001 to 0.013)	<0.001
Mean potassium squared	2.02 (1.71 to 2.38)	<0.001
Potassium variability	5.83 (4.49 to 7.58)	<0.001
Model 3		
Sex. female	1.22 (1.05 to 1.42)	0.012
Age	1.008 (1.003 to 1.013)	0.002
APACHE II score	1.104 (1.091 to 1.116)	<0.001
AKI	1.76 (1.50 to 2.06)	<0.001
Mean potassium	0.008 (0.001 to 0.082)	<0.001
Mean potassium squared	1.84 (1.40 to 2.41)	<0.001
Potassium variability	5.61 to 8.66)	<0.001

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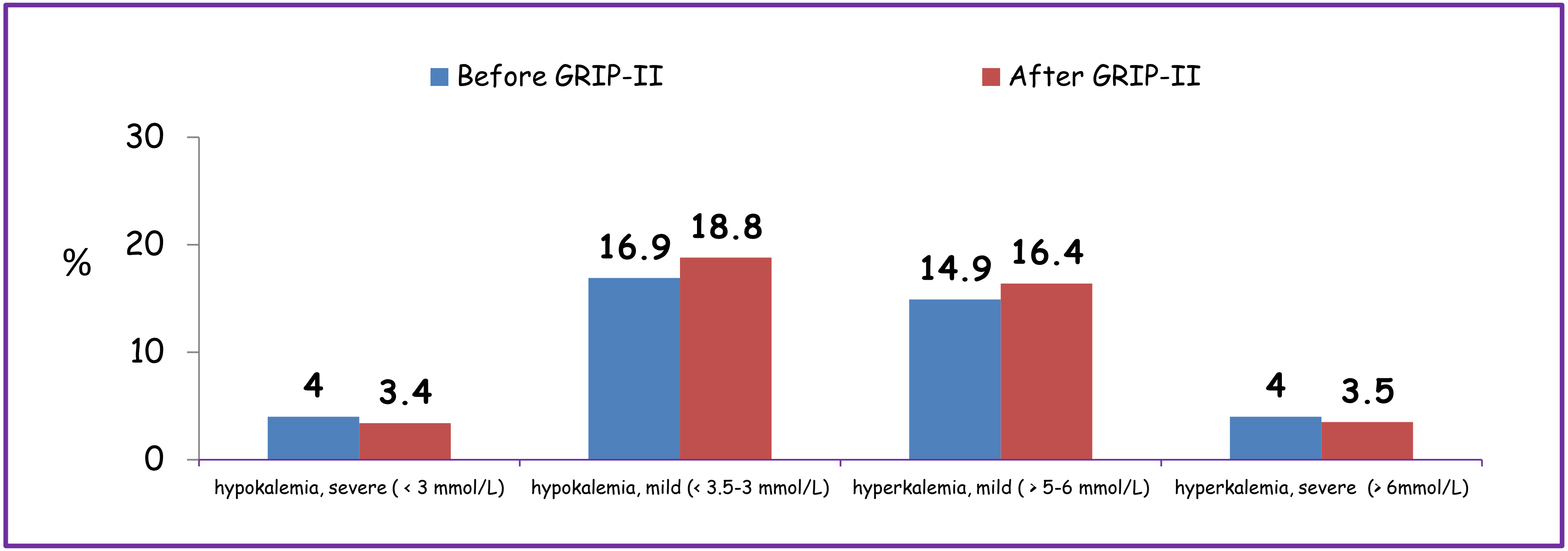
CRITICAL CARE

RESEARCH Open Access

The relationship between serum potassium. potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

EARLY PHASE



Time in hypokalemia, mean (SD): 8.9 (25.3) vs. 5.5 (15), P value < 0.001
Time in hyperkalemia, mean (SD): 8.1 (23.3) vs 6.1 (17.6), P value < 0.001

2015

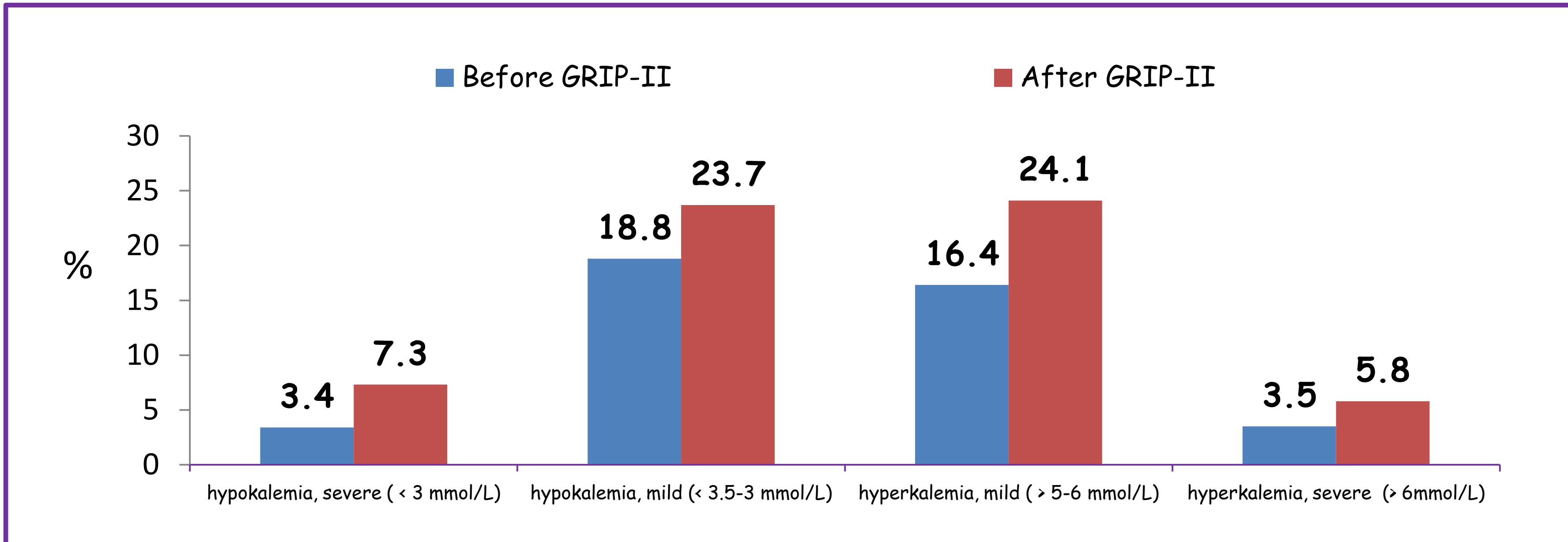
CRITICAL CARE

RESEARCH Open Access

The relationship between serum potassium. potassium variability and in-hospital mortality in critically ill patients and a before-after analysis on the impact of computer-assisted potassium control.

Hessels L. Hoekstra M. Mijzen LJ. Vogelzang M. Dieperink W. Lansink A. Nijsten MW.

LATE PHASE



Time in hypokalemia, mean (SD): 9.2 (20.9) vs. 3.0 (11.3), P value < 0.001
Time in hyperkalemia, mean (SD): 6.1 (18.2) vs 2.2 (11.8), P value < 0.001

KALICU STUDY: OBJECTIVES

- Observational study on a prospective mulicenter database (22 french ICU)

- OBJECTIVES:
  - (1) to characterize the distribution of serum potassium levels at ICU admission (prevalence of dyskalemia at ICU admission,
  - (2) to examine the relationship between dyskalemia at ICU admission and occurrence of cardiac events,
  - (3) to study both the association between dyskalemia at ICU admission and dyskalemia correction by day 2 on 28-day mortality.

KALICU STUDY: METHODS

Observational study on a prospective mulicenter database. 22 French ICU

Inclusion criteria

- Consecutive patients ≥ 18 years (April 1999 and January 2014),
- Alive on day 2.

Exclusion criteria

- Patients without a serum potassium measurement at admission,
- Patients with less than 2 serum potassium measures during ICU stay,
- Patients with at least 2 consecutive days without serum potassium measurement.

NORMAL SERUM POTASSIUM LEVEL WAS DEFINED AS 3.5 mmol/L ≥ $[K^+]$ ≤ 5 mmol/L

- Patients were classified into 6 groups according to their serum potassium level at admission
- We sorted evolution at day 2 of dyskalemia into three categories: balanced, not-balanced and overbalanced

Statistical analysis

- The primary outcome was the 28-day mortality

- Secondary outcomes were cardiac events within the first 48 hours of ICU stay prospectively recorded into the OUTCOMEREA database:
  - external electric shock
  - cardiac arrest
  - myocardial infarction
  - minimal heart rate < 40 beats per minute
  - ventricular arrhythmia,
  - supra-ventricular arrhythmia,
  - unspecified arrhythmia,
  - and atrioventricular block.

To summarize the data, we create a variable named "cardiac events" rated 1 if at least one of the cardiac events cited above occurred within the first 48 hours.

Statistical analysis

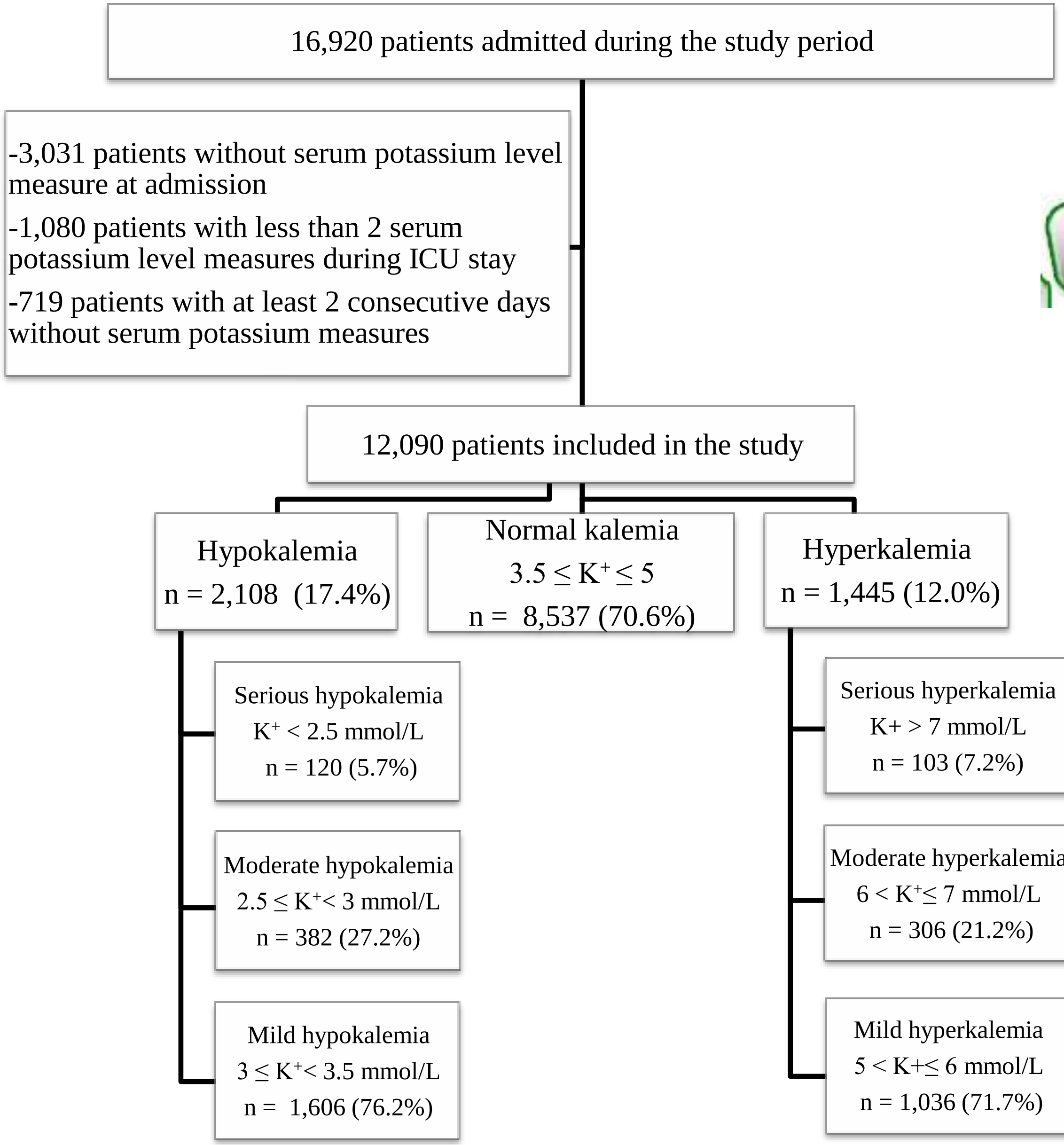
Effect of serum potassium level at admission on the 28-day mortality was assessed with a multivariate Cox model, stratified on ICU centers and adjusted on the previously identified factors independently associated with 28-day mortality.

Occurrence of cardiac events was evaluated by logistic regression stratified on ICU centers and adjusted on factors independently associated with the 28-day mortality.

Last, sensitivity analyses on patients with each category of hypokalemia or hyperkalemia at admission were performed to assess the influence of the serum potassium evolution (Not-balanced, balanced or overbalanced) on the 28-day mortality. A multivariate Cox model, stratified on ICU center, adjusted on the independent factors of 28-day mortality and adjusted on serum potassium level at admission was used.

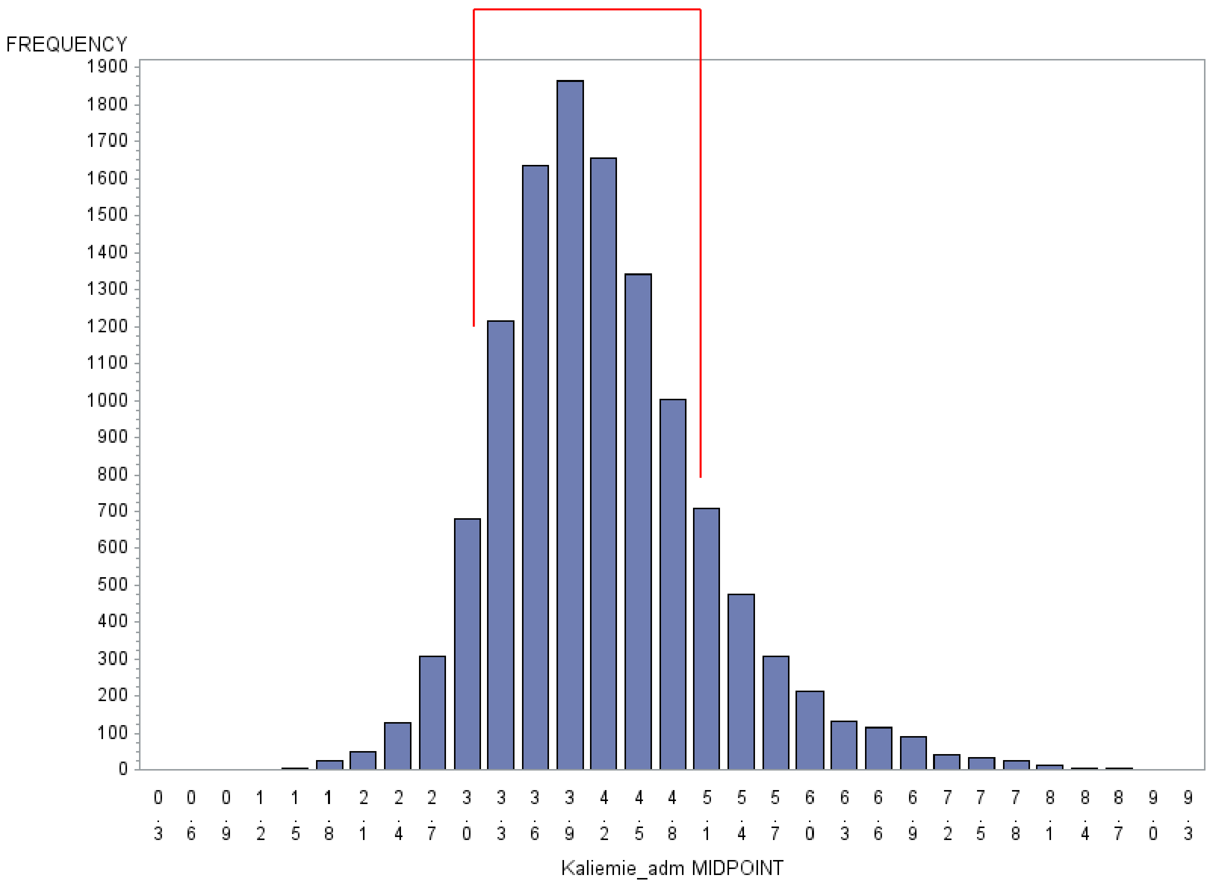
Values of $p<0.05$ were considered significant. Analyses were performed using SAS 9.4 software (SAS Institute, Cary, NC).

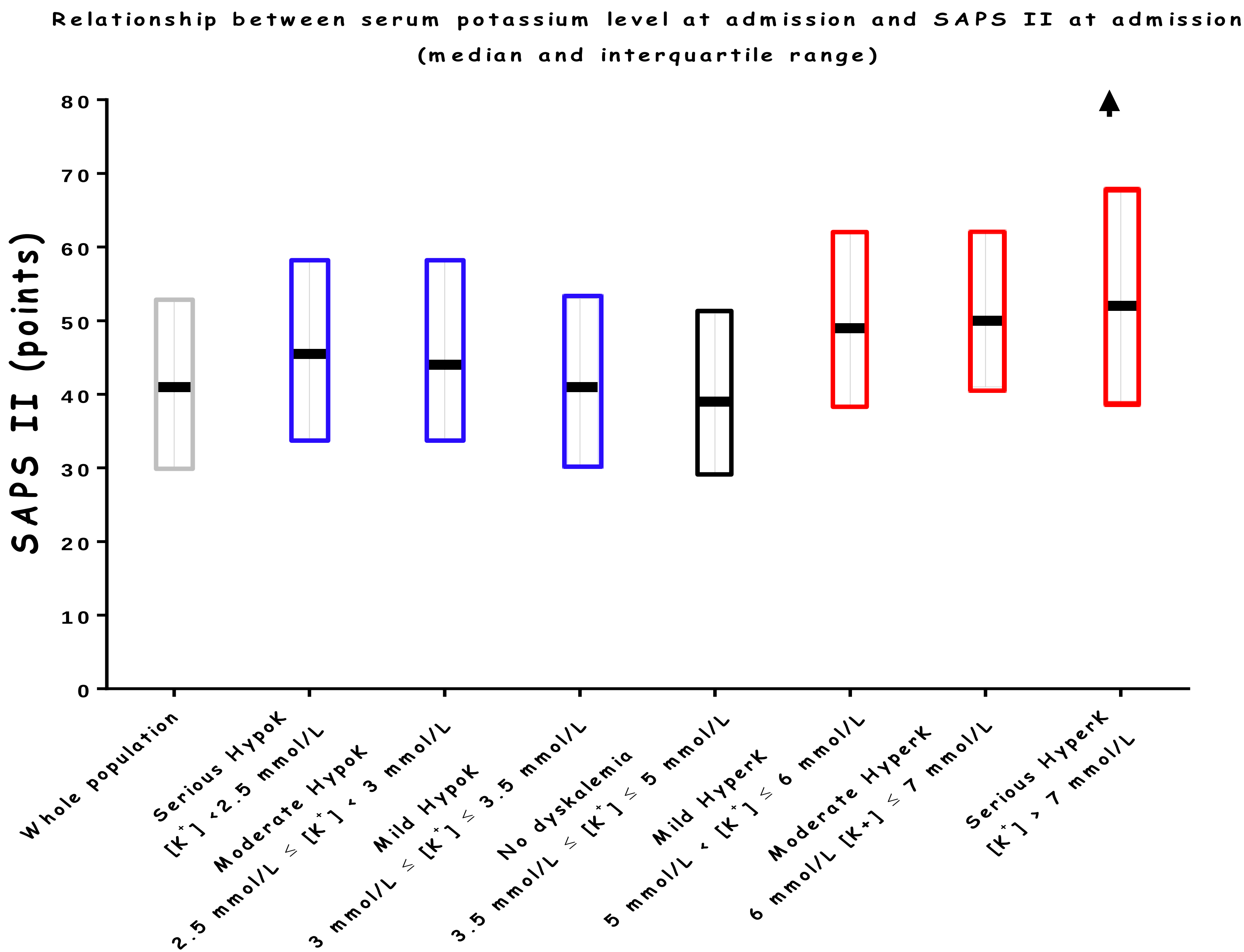
KALICU: FLOW CHART

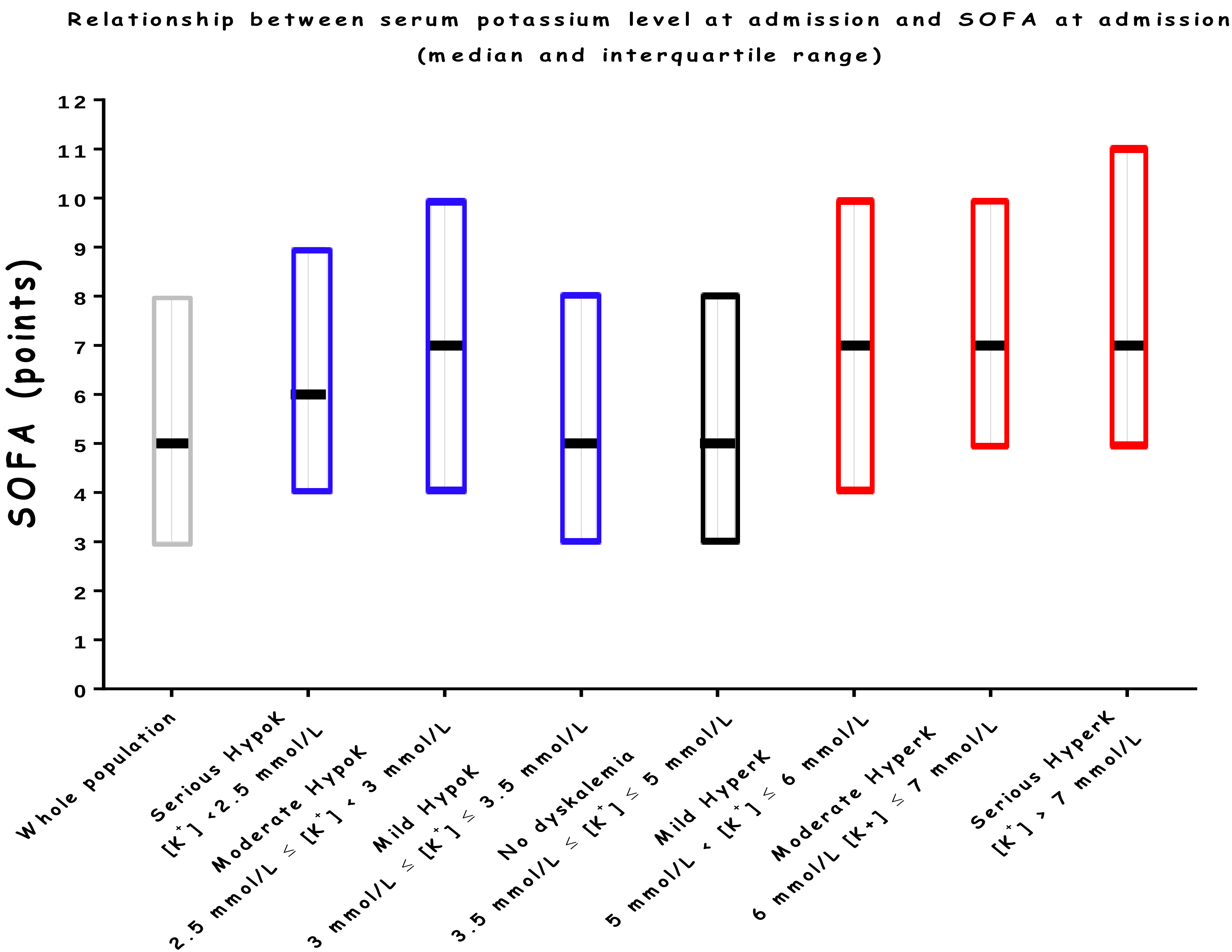


OUTCOMEREA

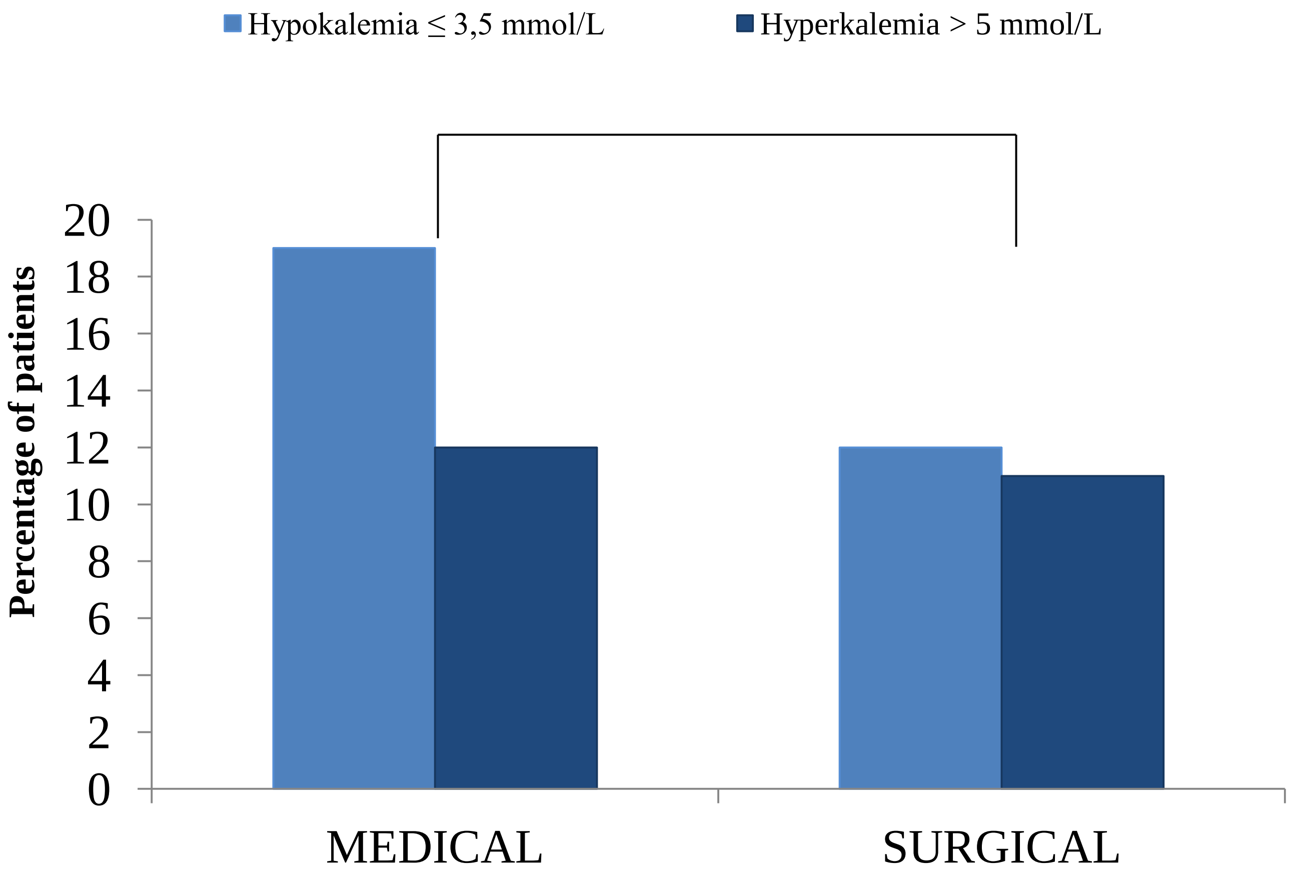
KALICU: SERUM POTASSIUM LEVEL DISTRIBUTION AT ADMISSION




Relationship between serum potassium level at admission and SAPS II at admission
(median and interquartile range)
SAPS II (points)
0
10
20
30
40
50
60
70
80
Whole population
Serious HypoK
[K+] <2.5 mmol/L
Moderate HypoK
2.5 mmol/L ≤ [K+] < 3 mmol/L
Mild HypoK
3 mmol/L ≤ [K+] ≤ 3.5 mmol/L
No dyskalemia
3.5 mmol/L ≤ [K+] ≤ 5 mmol/L
Mild HyperK
5 mmol/L < [K+] ≤ 6 mmol/L
Moderate HyperK
6 mmol/L [K+] ≤ 7 mmol/L
Serious HyperK
[K+] > 7 mmol/L

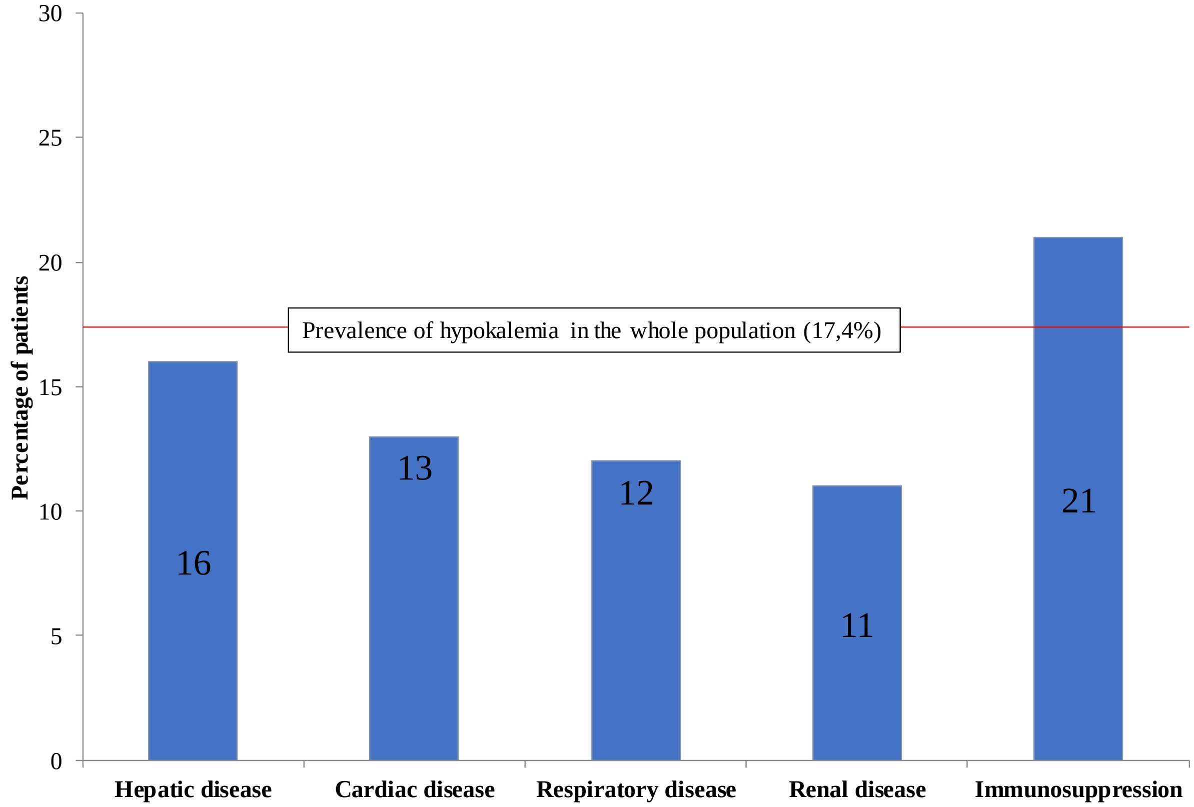

Relationship between serum potassium level at admission and SOFA at admission
(median and interquartile range)
SOFA (points)
0
1
2
3
4
5
6
7
8
9
10
11
12
Whole population
Serious HypoK
[K+] <2.5 mmol/L
Moderate HypoK
2.5 mmol/L ≤ [K+] < 3 mmol/L
Mild HypoK
3 mmol/L ≤ [K+] ≤ 3.5 mmol/L
No dyskalemia
3.5 mmol/L ≤ [K+] ≤ 5 mmol/L
Mild HyperK
5 mmol/L < [K+] ≤ 6 mmol/L
Moderate HyperK
6 mmol/L [K+] ≤ 7 mmol/L
Serious HyperK
[K+] > 7 mmol/L

Prevalence of dyskalemia in medical and surgical patients



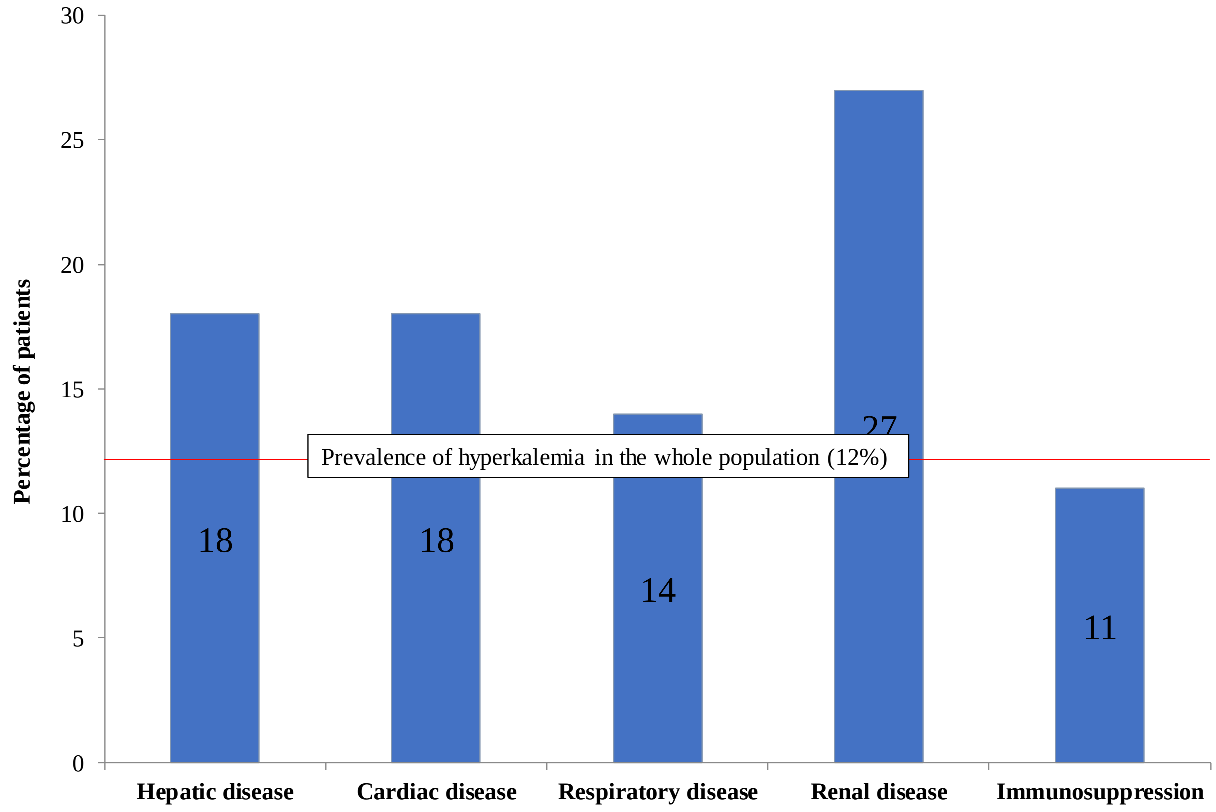
*Medical patients were more likely to have dyskalemia than surgical patients, p <0.01)

Prevalence of hypokalemia* according to the presence of underlying disease

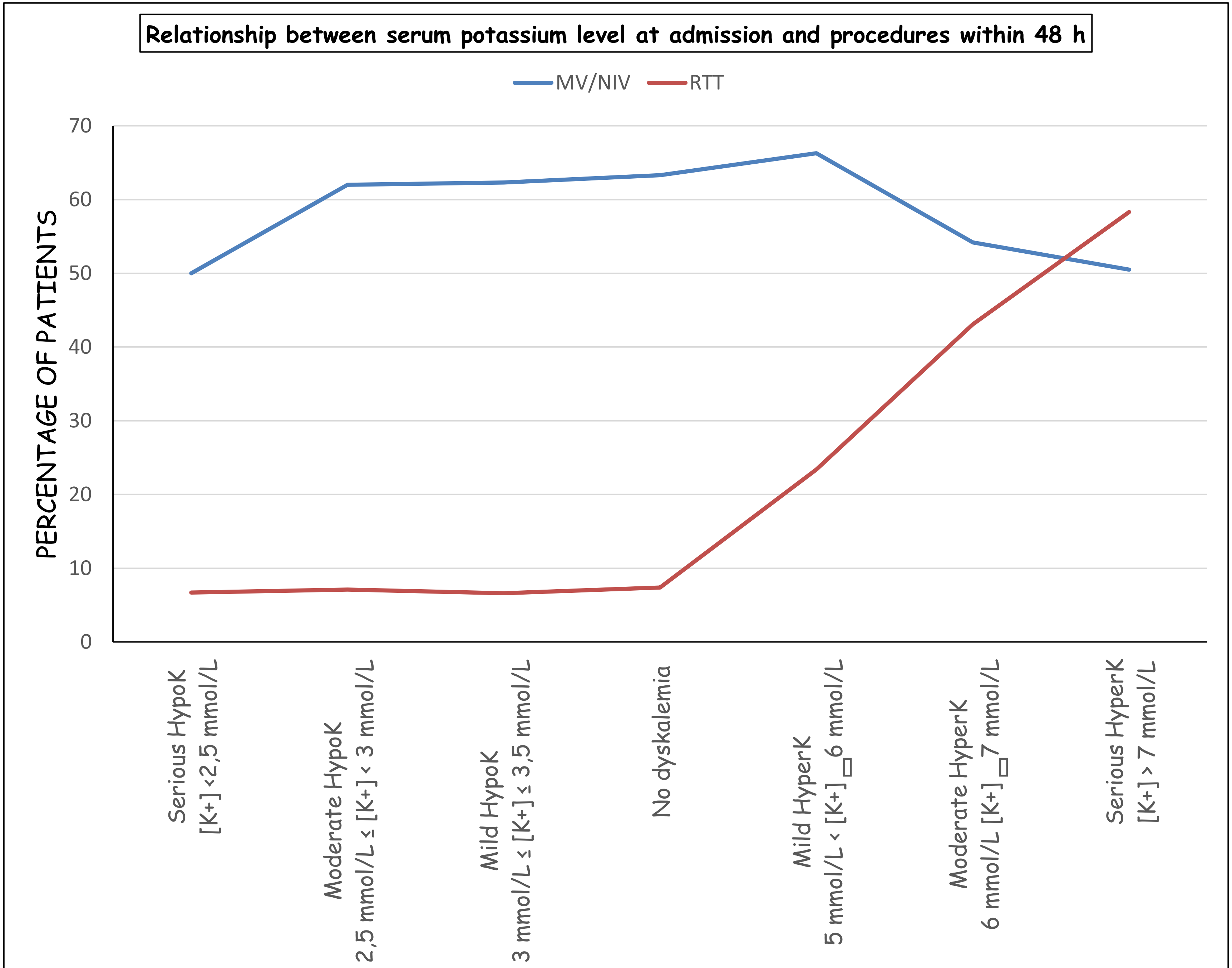


*Hypokalemia = [K+] <3.5 mmol/L

Prevalence of hyperkalemia* according to the presence of underlying disease

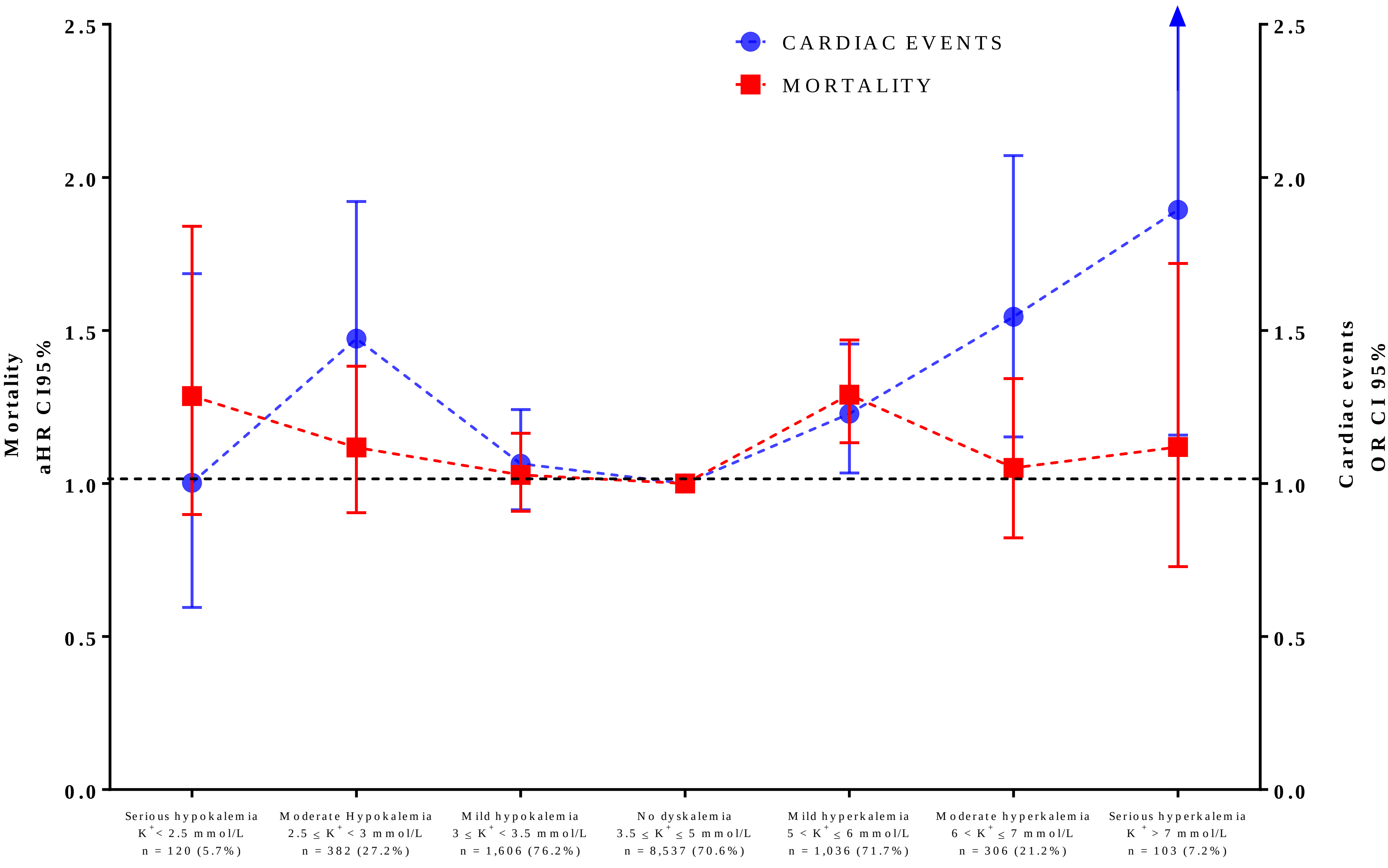


*Hyperkalemia [K+] > 5 mmol/L

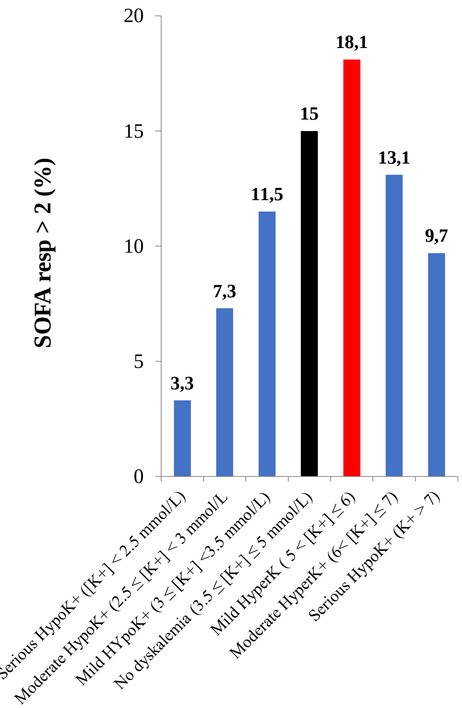


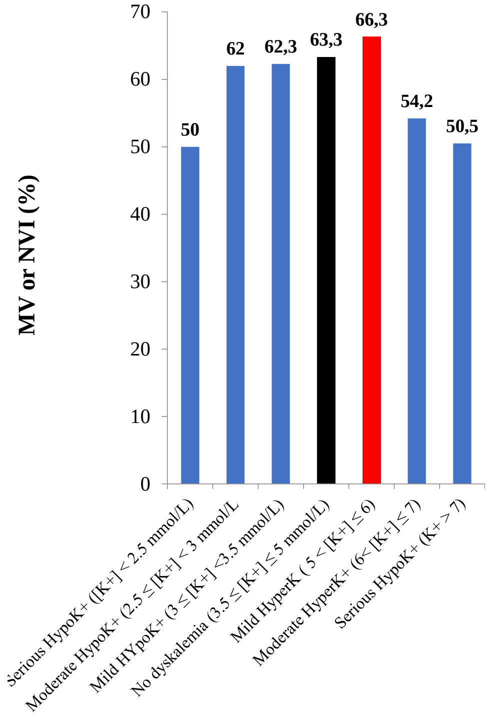
Relationship between serum potassium level at admission and procedures within 48 h
MV/NIV
RTT
PERCENTAGE OF PATIENTS
0
10
20
30
40
50
60
70
Serious HypoK [K+] <2,5 mmol/L
Moderate HypoK 2,5 mmol/L ≤ [K+] < 3 mmol/L
Mild HypoK 3 mmol/L ≤ [K+] ≤ 3,5 mmol/L
No dyskalemia
Mild HyperK 5 mmol/L < [K+] 6 mmol/L
Moderate HyperK 6 mmol/L [K+] 7 mmol/L
Serious HyperK [K+] > 7 mmol/L

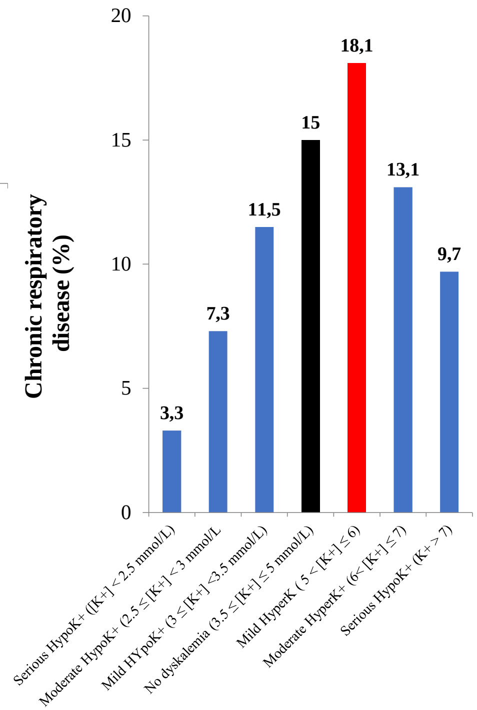
KALICU: 28-day mortality* and cardiac events* within the first 48 hours in ICU by the potassium blood level at admission

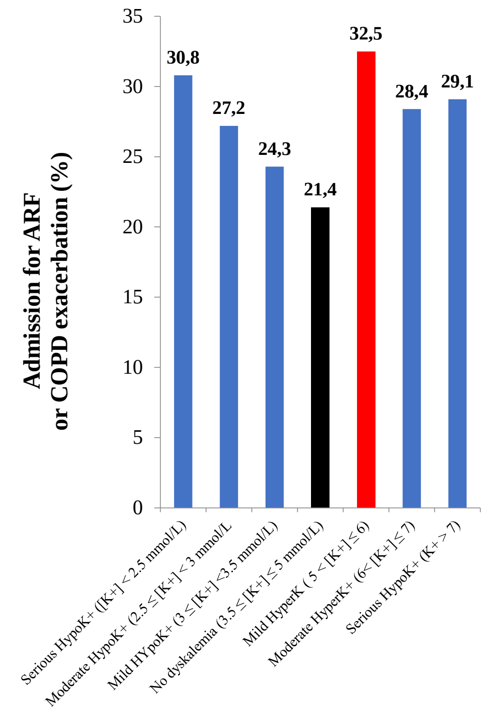


Respiratory conditions in mild hyperkalemic patients (in red) in comparison to no-dyskaliemic patients (in black) and to other dyskaliemic patients (in blue) at admission







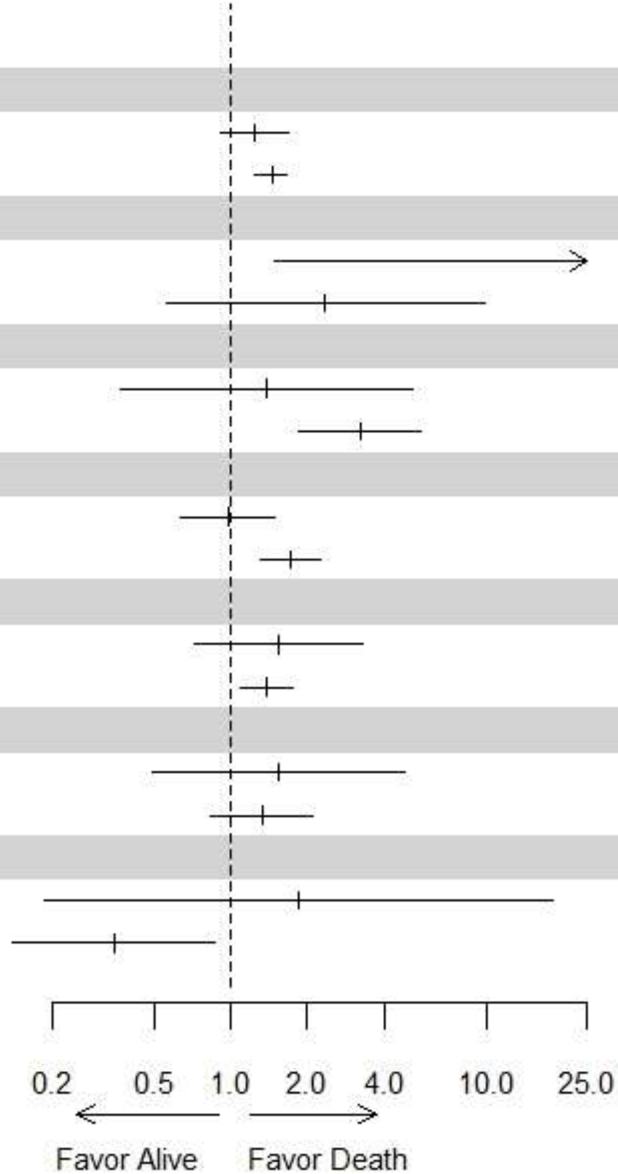


KALICU: Evolution de la kaliémie dans les premiers jours

J1	**Hypokaliémie** **2108 (17.4)**	**Kaliémie normale** **8537 (70.6)**	**Hyperkaliémie** **1445 (12.0)**
	1005 (47.7) restent en Hypokaliémie • DC à J28 : 228 (22.69) 1067 (50.6) passent en kaliémie normale • DC à J28 : 191 (17.9) 36 (1.7) passent en hyperkaliémie • DC à J28 : 13 (36.11)	1157 (13.6) passent en Hypokaliémie • DC à J28 : 228 (19.71) 7008 (82.1) restent en kaliémie normale • DC à J28 : 1131 (16.14) 372 (4.4) passent en hyperkaliémie • DC à J28 : 101 (27.15)	110 (7.6) passent en Hypokaliémie • DC à J28 : 33 (30) 908 (62.8) passent en kaliémie normale • DC à J28 : 198 (21.81) 427 (29.6) restent en hyperkaliémie • DC à J28 : 146 (34.19)
J2	**Hypokaliémie** **2272 (18.8)**	**Kaliémie normale** **8983 (74.3)**	**Hyperkaliémie** **835 (6.9)**
	930 (48.5) restent en Hypokaliémie • DC à J28 : 179 (19.25) 940 (49.0) passent en kaliémie normale • DC à J28 : 179 (19.04) 49 (2.6) passent en hyperkaliémie • DC à J28 : 30 (61.22) 353 sont censurés	977 (13.6) passent en Hypokaliémie • DC à J28 : 184 (18.83) 6021 (83.6) restent en kaliémie normale • DC à J28 : 1014 (16.84) 203 (2.8) passent en hyperkaliémie • DC à J28 : 80 (39.41) 1782 sont censurés	35 (5.4) passent en Hypokaliémie • DC à J28 : 6 (17.14) 436 (67.0) passent en kaliémie normale • DC à J28 : 96 (22.02) 180 (27.7) restent en hyperkaliémie • DC à J28 : 74 (41.11) 184 sont censurés
J3	**Hypokaliémie** **1942 (19.9)**	**Kaliémie normale** **7397 (75.7)**	**Hyperkaliémie** **432 (4.4)**

Adjusted hazard ratio for 28-day mortality by persitent dykalemia at day 2

All Patients n=3553	
Overbalanced	1.24 (0.91-1.68), p=0.176
Not Balanced	1.45 (1.25-1.67), p<0.001
Serious Hyperkalemia (K>7mmol/l) n=103	
Overbalanced	38.24 (1.49-981.26), p=0.028
Not Balanced	2.35 (0.56-9.88), p=0.244
Moderate Hyperkalemia (6<K<=7mmol/l) n=306	
Overbalanced	1.39 (0.37-5.20), p=0.623
Not Balanced	3.22 (1.85-5.59), p=<0.001
Mild Hyperkalemia (5<K<=6mmol/l) n=1036	
Overbalanced	0.97 (0.64-1.49), p=0.905
Not Balanced	1.71 (1.31-2.24), p=<0.001
Mild Hypokalemia (3<=K<3.5mmol/l) n=1606	
Overbalanced	1.54 (0.72-3.27), p=0.263
Not Balanced	1.38 (1.09-1.74), p=0.008
Moderate Hypokalemia (2.5<=K<3mmol/l) n=382	
Overbalanced	1.54 (0.49-4.83), p=0.460
Not Balanced	1.33 (0.84-2.11), p=0.223
Serious Hypokalemia (K<2.5mmol/l) n=120	
Overbalanced	1.85 (0.19-18.34), p=0.600
Not Balanced	0.35 (0.14-0.87), p=0.024



CONCLUSION

- Dyskalemia is common at ICU admission
- Dyskalemia is associated with increased mortality
- Occurrence of cardiac events increase with dyskalemia depth
- A correction of serum potassium level by day 2 improved prognosis

Efficacy and safety of potassium infusion therapy in hypokalemic critically ill patients.

Hamill RJ. Robinson LM. Wexler HR. Moote C.

Potassium chloride infusions (20-30-40 mmol in 100 mL normal saline over 1 hour

Primary diagnosis responsible for ICU admission

	Potassium infusion rates		
	20 mmol [3.5-3.2[mmol/L N = 26	30 mmol [3.2-3[mmol/l N =11	40 mmol < 3 mmol/l N =11
Postoperative open heart surgery	4	3	2
Heart transplant	1	0	0
Complicated MI	3	3	1
Aortic aneurysm (emergent or elective repair	2	0	0
Multiple trauma	1	0	1
Closed-head injury	1	0	1
Major CVA or SAH	2	0	0
Postoperative craniotomy	3	0	0
Sepsis. MOSF. ARDS	3	3	3
Respiratory failure	4	1	0
Liver failure	1	0	1
Liver transplant	1	1	2

CRITICAL CARE MEDICINE
1991

Efficacy and safety of potassium infusion therapy in hypokalemic critically ill patients.

Hamill RJ. Robinson LM. Wexler HR. Moote C.

Patient data

	Potassium infusion rates		
	20 mmol [3.5-3.2[mmol/L N = 26	30 mmol [3.2-3[mmol/l n = 11	40 mmol < 3 mmol/l N = 11
Age	29-86 (59.4)	53-81 (62.1)	25-37 (41.3)
Sex (% male)	68	50	57
Weight (kg)	51-90 (72)	55-113 (71)	44-100 (71)
Magnesium (mmol/L)	0.77 ± 0.13	0.60 ± 0.14	0.60 ± 0.13
Glucose (mmol/L)	8.8 ± 2.3	9.8 ± 3.4	11.9 ± 4.1
Creatinine (mmol/L)	166 ± 149	166 ± 100	122 ± 73
Age (yr) (mean)	7.45 ± 0.06	7.43 ± 0.05	7.48 ± 0.07
HCO_3 (mmol/L)	24 ± 4	23 ± 4	28 ± 5
No. Ventilated (%)	93	100	100
On renal dose dopamine (%)	9	12	14
On one or more other catecholamines	29	28	43
On antidysrhythmics (%)	43	43	57
On scheduled diuretics (%)	79	62	28

CRITICAL CARE MEDICINE
1991

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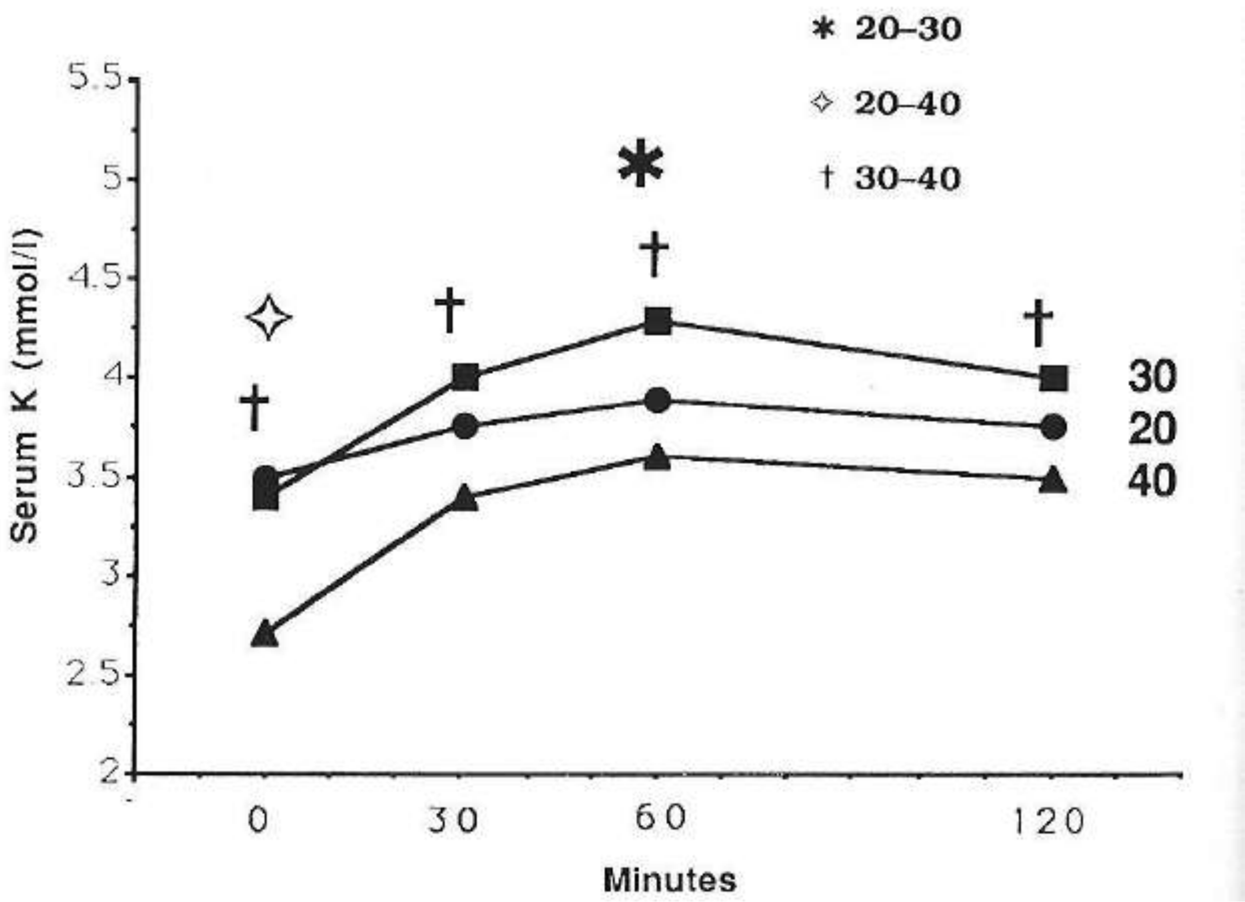

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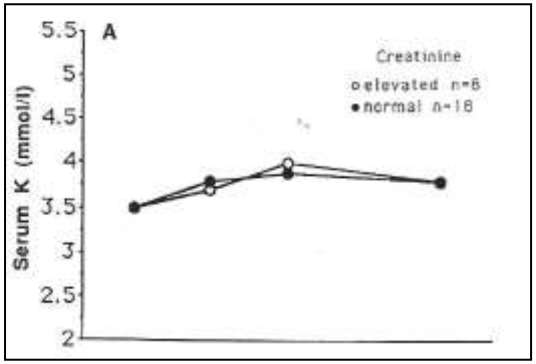
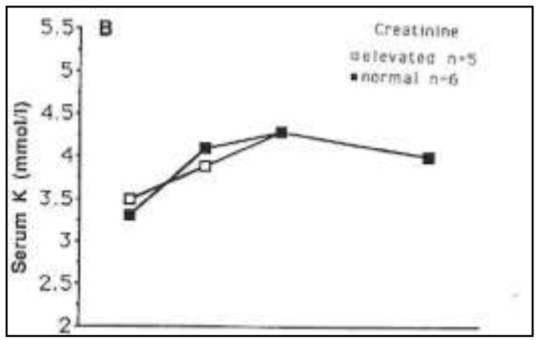
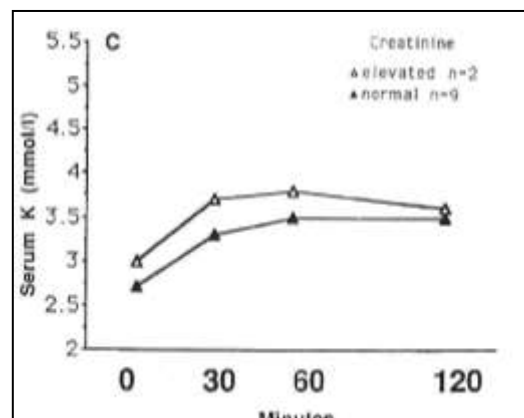


20 mmol potassium



30 mmol potassium

40 mmol potassium



Efficacy and safety of potassium infusion therapy in hypokalemic critically ill patients.

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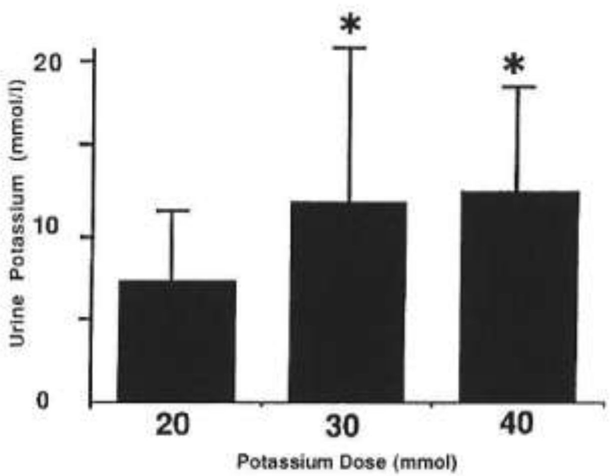

Figure 3. Mean increase in urinary potassium excretion after potassium chloride infusions of 20, 30, or 40 mmol (*$p < .05$).

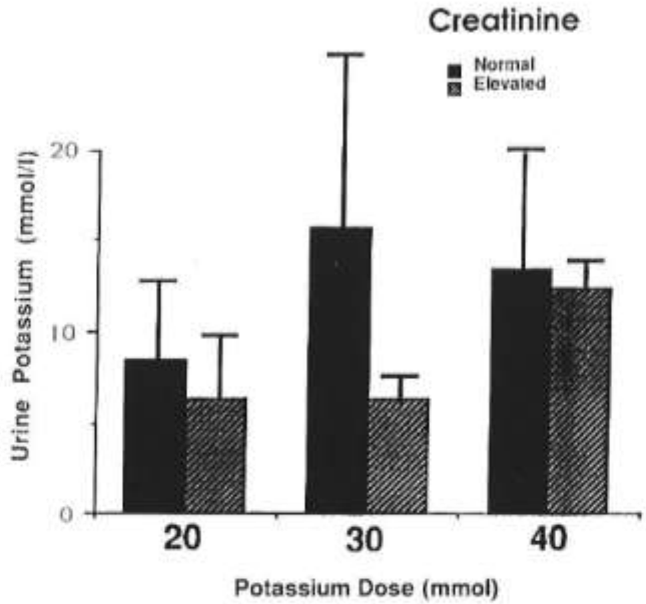

Figure 4. Comparison by renal function of mean changes in urinary potassium excretion in patients receiving 20, 30, or 40 mmol potassium chloride.

CRITICAL CARE MEDICINE
1991

Efficacy and safety of potassium infusion therapy in hypokalemic critically ill patients.

Hamill RJ. Robinson LM. Wexler HR. Moote C.

Mean change in serum potassium (K) level (mmol/l) by renal function

	Potassium infusion rates		
	20 mmol [3.5-3.2[mmol/L N = 26	30 mmol [3.2-3[mmol/l n = 11	40 mmol < 3 mmol/l N = 11
Normal creatinine	0.5 ± 0.2	0.8 ± 0.5	1.1 ± 0.4
Mean K level (range)	(0.2-1.1)	(0.4-1.6)	(0.4-1.6)
Elevated creatinine	0.5 ± 0.4	0.9 ± 0.3	1.2 ± 0.1
Mean K level (range)	(0.1 -1.1)	(0.4-1.1)	(1.0-1.5)

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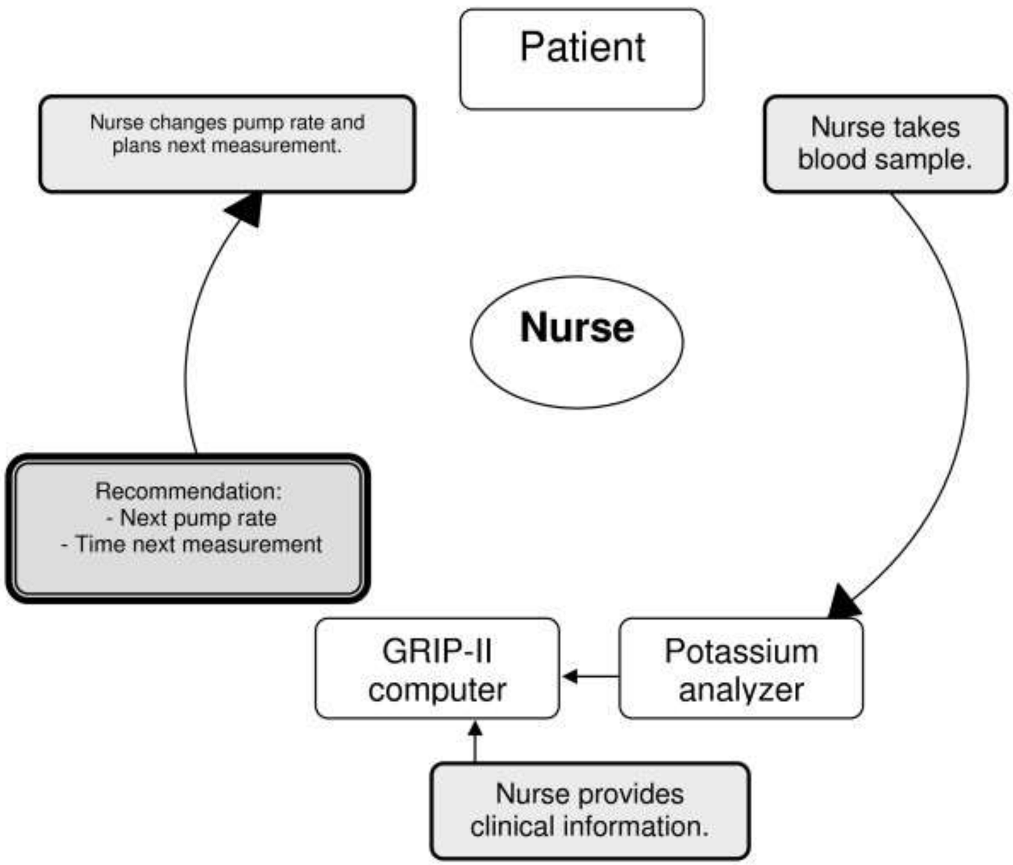
Implementation and evaluation of a nurse-centered computerized potassium regulation protocol in the intensive care unit--a before and after analysis.

Hoekstra M[1]. Vogelzang M. Drost JT. Janse M. Loef BG. van der Horst IC. Zijlstra F. Nijsten MW.



Targeted a potassium level in the middle of the normal range of 3.5-5.0 mmol/L.

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Hoekstra M[1]. Vogelzang M. Drost JT. Janse M. Loef BG. van der Horst IC. Zijlstra F. Nijsten MW.

Comparison of patient groups before and after the implementation of computerized potassium regulation with GRIP-II.

	Before GRIP-II (N = 775)	After GRIP-II (N = 1435)	P-value
Age (mean ± SD)	62 ± 16	61 ± 15	ns
Male sex (%)	67	65	ns
Reason of admission (%)			
Abdominal surgery	13.5	12.3	
Cardiac	16.8	18.1	
Medical	7.4	6.8	
Miscellaneous	4.8	4.3	
Neurological	1.3	2.9	
Oncologic	2.3	2.1	
Cardiothoracic surgery	**40.8**	**43.2**	
Trauma	7.5	5.5	
Vascular surgery	5.7	4.9	
APACHE II (mean ± SD) *	15 ± 7	14 ± 7	ns
Admission creatinine level. μmol/L (mean ± SD)	91 ± 56	98 ± 78	0.035
Acute kidney injury during ICU admission (%)†	10.2	11.8	ns
Renal replacement therapy (%)+	5.6	4.1	ns
Point of Care potassium/glucose measurements (patient-day)$^{-1}$	**5.3**	**5.9**	**<0.001**
Length of stay (days) at the ICU			
Cardiothoracic ICU	1.0 (0.9-3.1)	1.0 (0.9-2.6)	ns
Surgical ICU	3.5 (1.3-8.8)	3.6 (1.1-9.7)	ns
Hospital mortality (%)			
Cardiothoracic ICU	8	7	ns
Surgical ICU	13	15	ns

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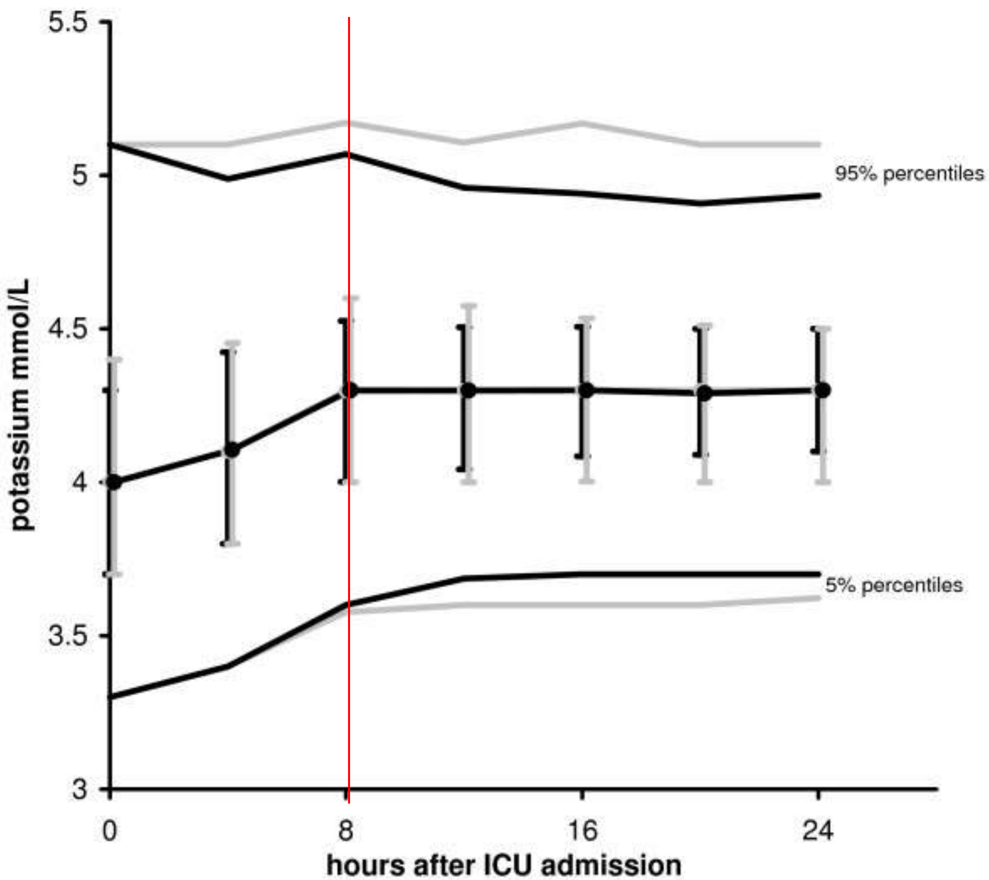

Incidence of hypokalemia decreased from 2.4% to 1.7% ($p < 0.001$) and hyperkalemia from 7.4% to 4.8% ($p < 0.001$).

Under GRIP-II 92% of all patients received potassium infusion during their stay at the ICU.

The median (IQR) fraction of time on potassium infusion was 87% (62-97%) of total ICU length of stay.

Mean ± SD potassium administration rate was 2.3 ± 1.5 mmol/h.

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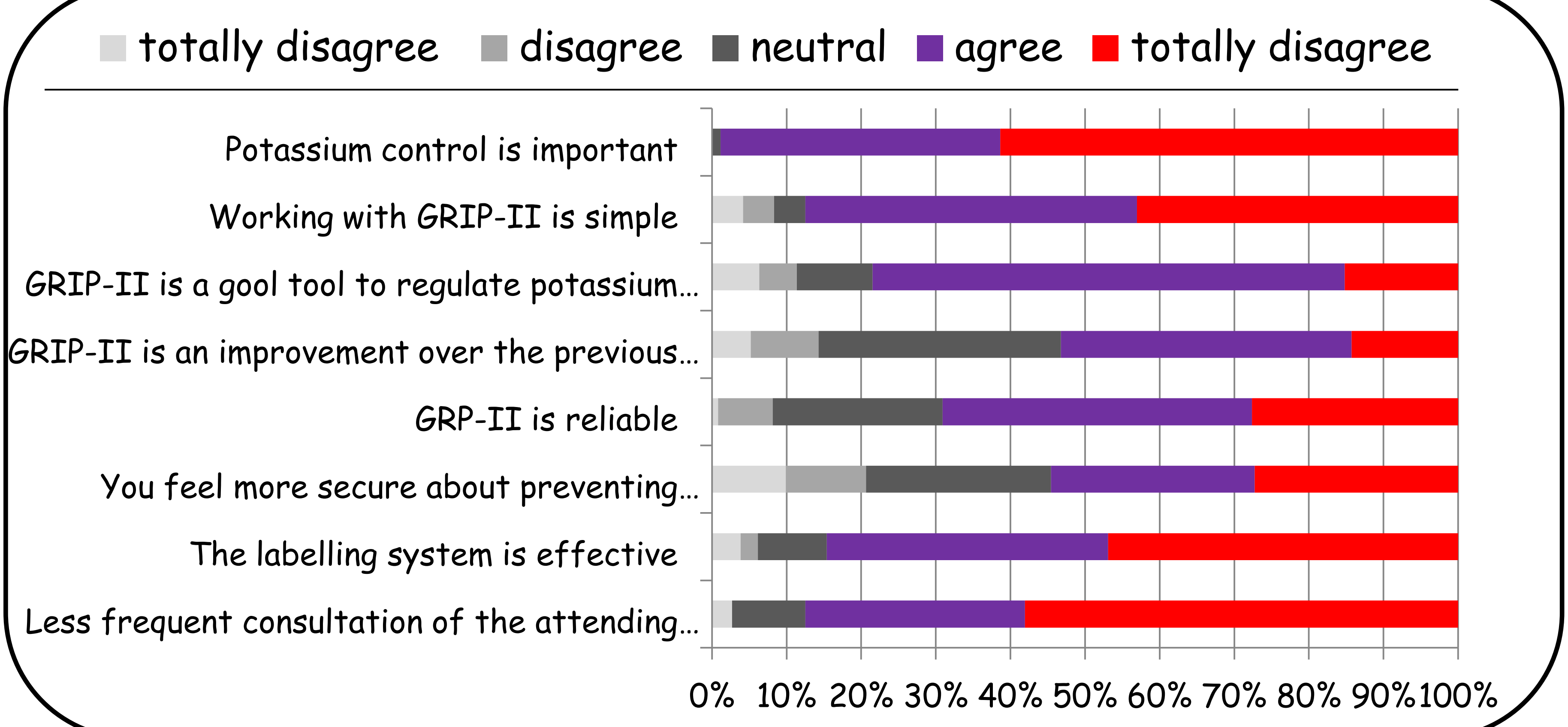
Hoekstra M[1]. Vogelzang M. Drost JT. Janse M. Loef BG. van der Horst IC. Zijlstra F. Nijsten MW.

Nurses opinion on computerized potassium control (GRIP-II)



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BMC Anesthesiology

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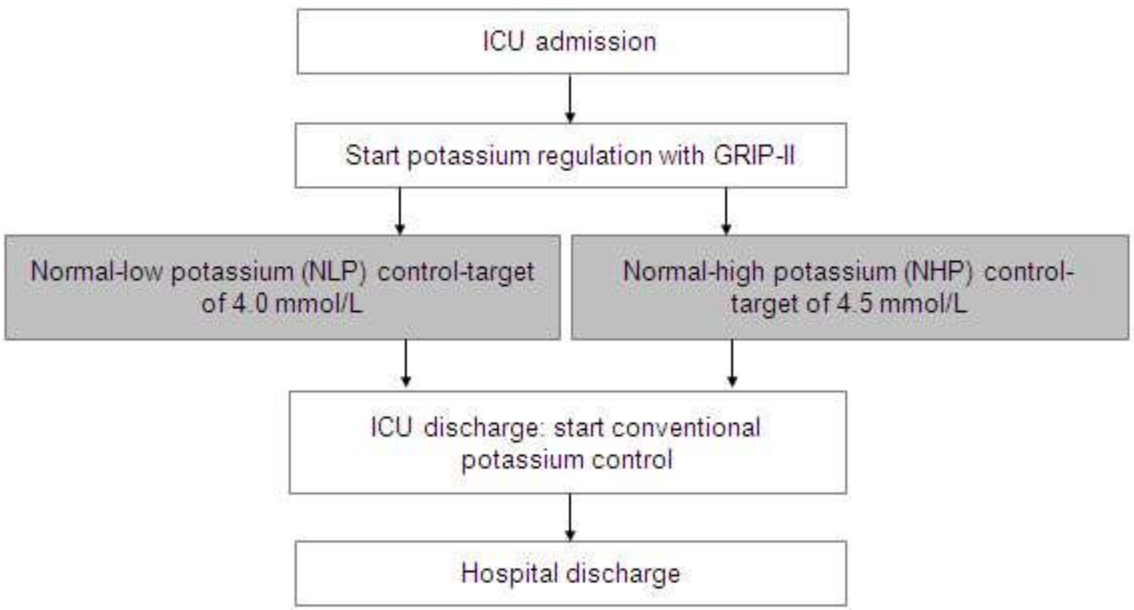
Trial design: Computer guided normal-low versus normal-high potassium control in critically ill patients: Rationale of the GRIP-COMPASS study.

Hoekstra M[1], Vogelzang M, van der Horst IC, Lansink AO, van der Maaten JM, Ismael F, Zijlstra F, Nijsten MW.



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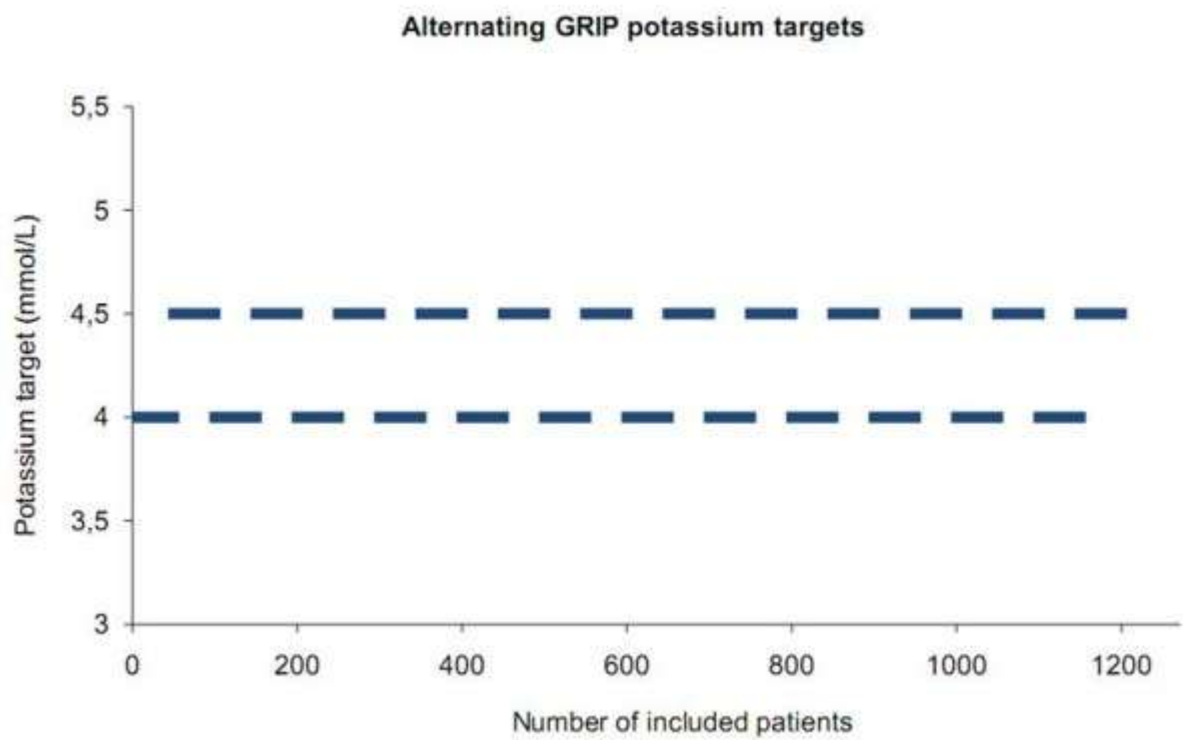

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Hoekstra M[1], Vogelzang M, van der Horst IC, Lansink AO, van der Maaten JM, Ismael F, Zijlstra F, Nijsten MW.

Primary endpoint is the in-hospital incidence of AFF after cardiac surgery.

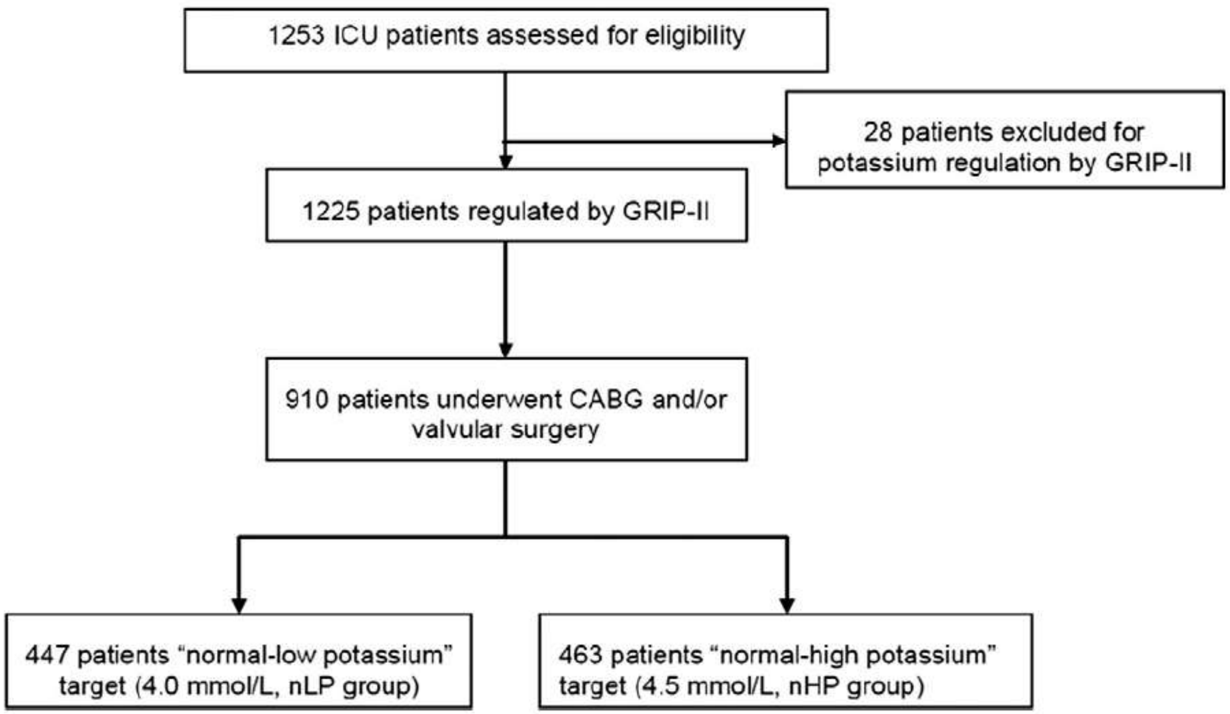
Secondary endpoints are:

- in-hospital AFF in medical patients or patients after non-cardiac surgery,
- actually achieved potassium levels and their variation,
- electrolyte and glucose levels, potassium and insulin requirements, cumulative fluid balance,
- ICU length of stay, ICU mortality, hospital mortality and 90-day mortality.

Computer-guided normal-low versus normal-high potassium control after cardiac surgery: No impact on atrial fibrillation or atrial flutter

Miriam Hoekstra, MD,[a] Lara Hessels[b] Michiel Rienstra, MD, PhD,[c] Lu Yeh, MD,[a] Annemieke Oude Lansink, MD,[b] Mathijs Vogelzang, MD, PhD,[b] Iwan C. C. van der Horst, MD, PhD,[b] Joost M. A. A. van der Maaten, MD,[a,b] Massimo A. Mariani, MD, PhD,[d] Anne Marie G. A. de Smet, MD, PhD,[b] Michel M. R. F. Struys, MD, PhD,[a] Felix Zijlstra, MD, PhD,[e] and Maarten W. Nijsten, MD, PhD[b] *Groningen, and Rotterdam, The Netherlands*

Figure 1

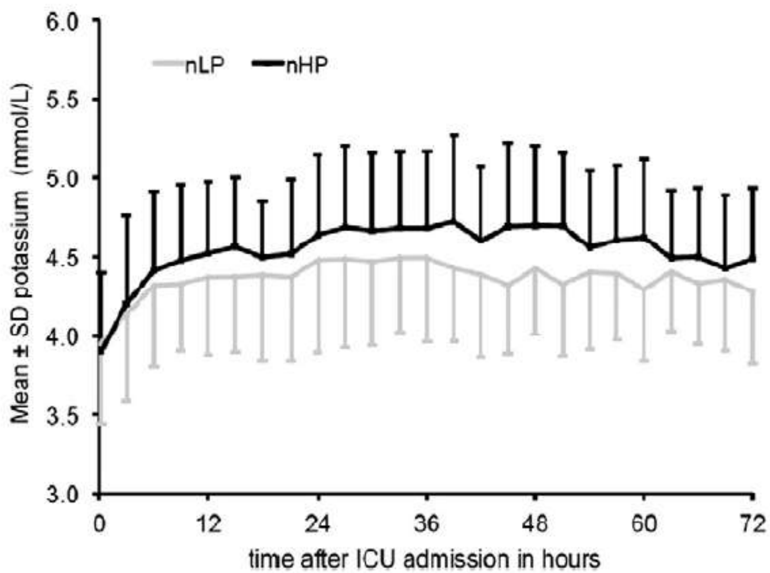


Flowchart of the GRIP-COMPASS study. At ICU admission, patients after cardiac surgery were assigned to either the nLP or nHP in blocks of 50 patients.

Computer-guided normal-low versus normal-high potassium control after cardiac surgery: No impact on atrial fibrillation or atrial flutter

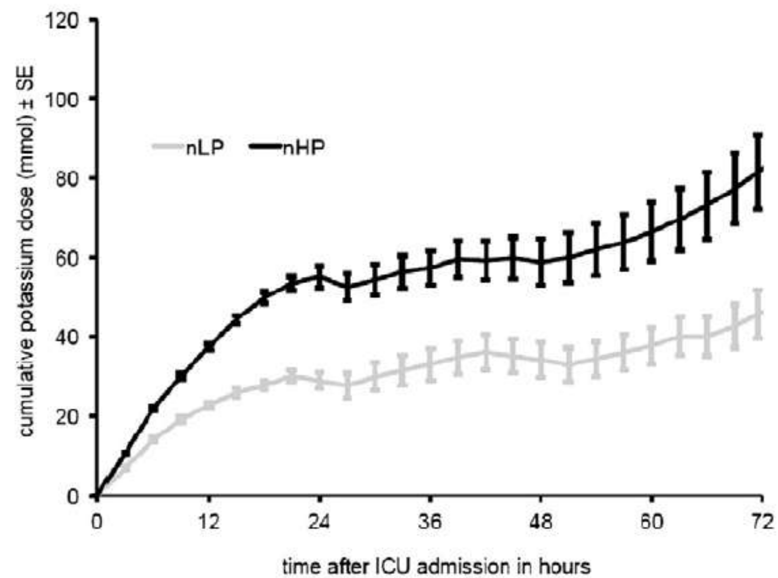
Miriam Hoekstra, MD,[a] Lara Hessels[b] Michiel Rienstra, MD, PhD,[c] Lu Yeh, MD,[a] Annemieke Oude Lansink, MD,[b] Mathijs Vogelzang, MD, PhD,[b] Iwan C. C. van der Horst, MD, PhD,[b] Joost M. A. A. van der Maaten, MD,[a,b] Massimo A. Mariani, MD, PhD,[d] Anne Marie G. A. de Smet, MD, PhD,[b] Michel M. R. F. Struys, MD, PhD,[a] Felix Zijlstra, MD, PhD,[e] and Maarten W. Nijsten, MD, PhD[b] *Groningen, and Rotterdam, The Netherlands*

Figure 2



Potassium concentration during the first 72 hours after ICU admission. This figure demonstrates the mean potassium concentration after ICU admission during 72 hours for both the nLP and nHP groups.

Figure 3



Potassium administration during ICU admission. This figure demonstrates the cumulative amount of potassium administered for both the nLP and nHP groups during the first 72 hours after ICU admission.

Computer-guided normal-low versus normal-high potassium control after cardiac surgery: No impact on atrial fibrillation or atrial flutter

Miriam Hoekstra, MD,[a] Lara Hessels[b] Michiel Rienstra, MD, PhD,[c] Lu Yeh, MD,[a] Annemieke Oude Lansink, MD,[b] Mathijs Vogelzang, MD, PhD,[b] Iwan C. C. van der Horst, MD, PhD,[b] Joost M. A. A. van der Maaten, MD,[a,b] Massimo A. Mariani, MD, PhD,[d] Anne Marie G. A. de Smet, MD, PhD,[b] Michel M. R. F. Struys, MD, PhD,[a] Felix Zijlstra, MD, PhD,[c] and Maarten W. Nijsten, MD, PhD[b] *Groningen, and Rotterdam, The Netherlands*

2015

Figure 4

Atrial fibrillation or atrial flutter after cardiac surgery

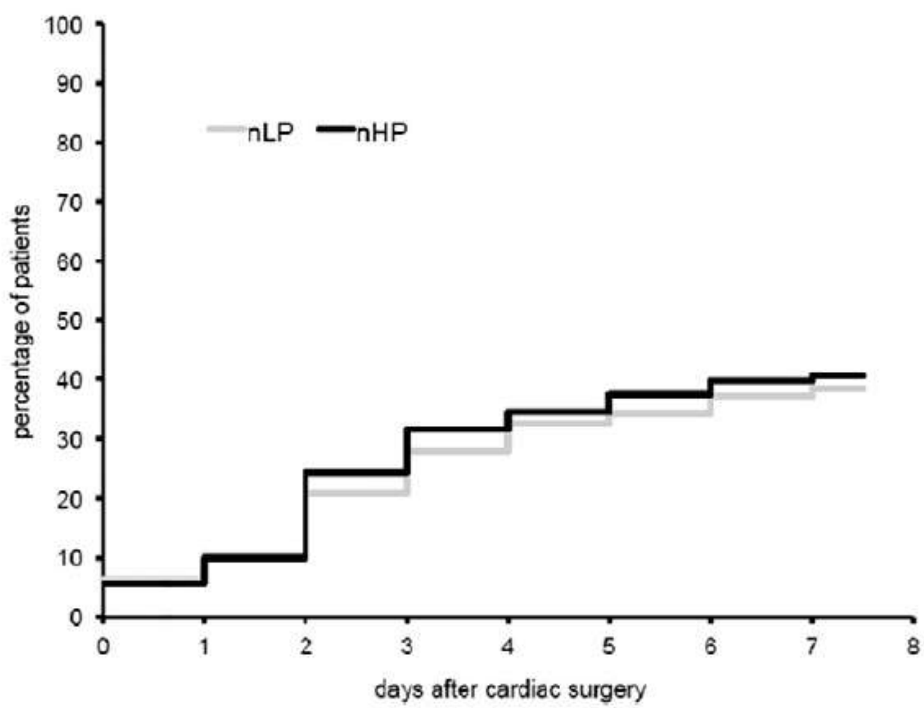


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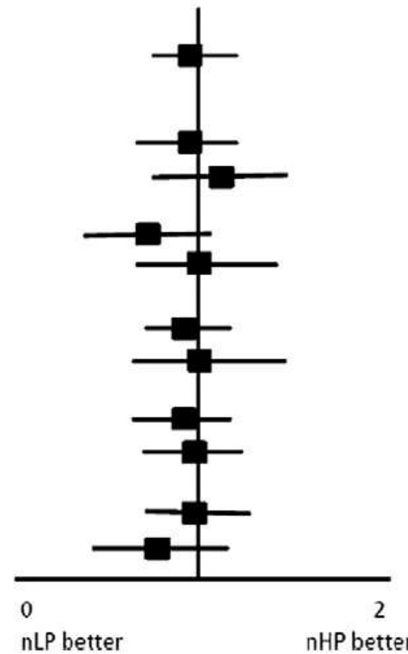
Figure 5

Subgroup		Number of patients nLP	Number of patients nHP	Number of events nLP	Number of events nHP	Relative Risk (95% CI)
Cardiothoracic surgery *primary endpoint*		447	463	172 (38%)	188 (41%)	0.95 (0.80-1.12)
Sex	Male	300	311	113 (38%)	128 (41%)	0.92 (075-1.10)
	Female	147	152	59 (40%)	60 (40%)	1.02 (0.77-1.34)
Age (y)	<65	169	185	42 (25%)	59 (32%)	0.78 (0.56-1.09)
	≥65	278	278	130 (47%)	129 (46%)	1.01 (0.84-1.20)
Euroscore	≤5.0	370	391	131 (35%)	149 (38%)	0.93 (0.77-1.12)
	> 5.0	75	72	41 (55%)	39 (54%)	1.01 (0.75-1.36)
New-onset AF/AFL		362	381	111 (31%)	127 (33%)	0.92 (0.75-1.14)
Prior AF/AFL		85	82	61 (72%)	61 (74%)	0.97 (0.80-1.16)
on-pump		300	294	135 (45%)	134 (46%)	0.99 (0.83-1.18)
off-pump		147	169	37 (25%)	54 (32%)	0.79 (0.55-1.12)



Subgroup analysis. In several subgroups, there were no statistical differences in the incidence of postoperative AF/AFL.

CONCLUSIONS

QQ données épidémiologiques

Peu de données sur:

- la $[K^+]$ optimale en réanimation ?

- la prise en charge optimale en réanimation