Solutés balancés en médecine d'urgences 2022

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- Définitions des solutés balancés

- Rappels biochimiques
- Utilisation des solutés balancés chez l'adulte
- Indications des solutés balancés chez l'adulte
- Un peu d'histoire
- Les différent types de solutés
- Utilisation des solutés balancés en pédiatrie
- Indication des solutés balancés en pédiatrie

Définition des solutés balancés

Les solutés sont dits balancés lorsque leur composition est proche de celle du plasma humain (notamment la concentration en chlore) par opposition aux solutés non balancés (NaCl 0,9 % principalement)

A Harrois, Anesthésie & Réanimation 2021

	Lactate	Acétate	Malate	Gluconate	Cl-	Osmolarité
Ringer lactate	27,7				108	253
Isofundine		24	5		127	309
Plasmalyte		27		23	98	295
Isopédia		30			118	351/295
SSI					154	308

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- **Rappels biochimiques**
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Si vous ne pouvez expliquer un concept à un enfant de 6 ans, c'est que vous ne le comprenez pas complètement

Albert Einstein

Ce qui est simple est toujours faux

Ce qui ne l'est pas est inutilisable

Paul Valéry

La théorie de Stewart

Electroneutralité
Conservation de la masse
Équilibres de dissociation

- Le plasma
  - 3 variables indépendantes

Cl^-, Albumine

$$[H^+]^4 + \{K_A + [SID]\}*[H^+]^3$$
$$+ \{K_A*([SID] - [A_{tot}]) - (K_c*P_c + K'_w\}*[H^+]^2$$
$$- \{K_A*(K_c*P_c+K'_w) + K_3*K_c*P_c\}*[H^+]$$
$$- K_A*K'_w = 0$$

SID : (Na + K + 2Mg + 2Ca) - (Cl + lactate)

- Le liquide interstitiel

Selon Stewart, pour décrire le milieu interstitiel à partir du plasma

- 26 équations (6 pour le plasma)
- 10 variables indépendantes (3 pour le plasma)

- La cellule ?

Albumine

Charges « mesurées »

$Pr^-_m = [SID] + [H^+] - [OH^-] - [HCO_3^-] - [CO_3^{2-}] - [Pi^-]$

$[H^+] = 10^{-pH}$

$[CO_3^{2-}] = Kc_1 * Kc_2 * PCO_2/[H^+]^2$

$[Pi^-] = Pi_{tot} * Z$

$Z = (K_1*[H^+]^2 + 2*K_1*K_2*[H^+] + 3*K_1*K_2*K_3)/([H^+]^3 + K_1*[H^+]^2 + K_1*K_2*[H^+] + K_1*K_2*K_3)$

Charges « calculées »

$$
\begin{aligned}
&SID + [H^+] \times 1000 - K'w/[H^+] \times 1000 \\
&- Kc1 \times Pco_2/[H^+] \times 1000 \\
&- Kc1 \times Kc2 \times Pco_2/[H^+]^2 \times 1000 \\
&- Pi_{tot} \times Z \\
&+ \{-1 \times 3.16E\text{-}9/(3.16E\text{-}9 + [H^+]) \\
&- 98 \times 3.98E\text{-}5/(3.98E\text{-}5 + [H^+]) \\
&+ N7 - (N7 - N6) \times 1.0E\text{-}11/(1.0E\text{-}11 + [H^+]) \\
&- N6 \times 3.98E\text{-}10/(3.98E\text{-}10 + [H^+]) \\
&- 18 \times 1.0E\text{-}10/(1.0E\text{-}10 + [H^+]) \\
&+ 1 - 1.0E\text{-}8/(1.0E\text{-}8 + [H^+]) \\
&- 1 \times 7.94E\text{-}4/(7.94E\text{-}4 + [H^+]) \\
&+ N1 - N1 \times 1.000E\text{-}7/(1.000E\text{-}7 + [H^+]) \\
&+ N2 - N2 \times 7.9433E\text{-}8/(7.9433E\text{-}8 + [H^+]) \\
&+ N3 - N3 \times 6.3096E\text{-}8/(6.3096E\text{-}8 + [H^+]) \\
&+ N4 - N4 \times 5.0119E\text{-}8/(5.0119E\text{-}8 + [H^+]) \\
&+ N5 - N5 \times 3.9811E\text{-}8/(3.9811E\text{-}8 + [H^+])\} \\
&\times 1000 \times 10 \times [Alb]/66500 = 0
\end{aligned}
$$

$$
\begin{aligned}
&SID_e + 1000 \times ([H^+] - K'w/[H^+] - Kc1 \times Pco_2/[H^+] \\
&\quad - Kc1 \times Kc2 \times Pco_2/[H^+]^2) - [Pi_{tot}] \times Z \\
&+ \{ \quad -1 \times 3.1623E\text{-}09/(3.1623E\text{-}09 + [H^+]) \\
&\quad -98 \times 1.0000E\text{-}04/(1.0000E\text{-}04 + [H^+]) \\
&\quad -18 \times 2.5119E\text{-}10/(2.5119E\text{-}10 + [H^+]) \\
&\quad -1 \times 7.9433E\text{-}04/(7.9433E\text{-}04 + [H^+]) \\
&+ 1 \quad -1 \times 1.0000E\text{-}08/(1.0000E\text{-}08 + [H^+]) \\
&+16 \quad -1 \times 7.5858E\text{-}08/(7.5858E\text{-}08 + [H^+]) \\
&\quad -1 \times 6.0256E\text{-}08/(6.0256E\text{-}08 + [H^+]) \\
&\quad -1 \times 7.9433E\text{-}08/(7.9433E\text{-}08 + [H^+]) \\
&\quad -1 \times 3.2359E\text{-}08/(3.2359E\text{-}08 + [H^+]) \\
&\quad -1 \times 9.7724E\text{-}08/(9.7724E\text{-}08 + [H^+]) \\
&\quad -1 \times 4.8978E\text{-}08/(4.8978E\text{-}08 + [H^+]) \\
&\quad -1 \times 1.7783E\text{-}07/(1.7783E\text{-}07 + [H^+]) \\
&\quad -1 \times 4.3652E\text{-}07/(4.3652E\text{-}07 + [H^+]) \\
&\quad -1 \times 1.4125E\text{-}05/(1.4125E\text{-}05 + [H^+]) \\
&\quad -1 \times 1.7378E\text{-}06/(1.7378E\text{-}06 + [H^+]) \\
&\quad -1 \times 6.7608E\text{-}07/(6.7608E\text{-}07 + [H^+]) \\
&\quad -1 \times 1.8621E\text{-}07/(1.8621E\text{-}07 + [H^+]) \\
&\quad -1 \times 1.5136E\text{-}06/(1.5136E\text{-}06 + [H^+]) \\
&\quad -1 \times 10^{-N1}/(10^{-N1} + [H^+]) \\
&\quad -1 \times 10^{-N2}/(10^{-N2} + [H^+]) \\
&\quad -1 \times 10^{-N3}/(10^{-N3} + [H^+]) \\
&+N4 - N4 \times 3.9811E\text{-}10/(3.9811E\text{-}10 + [H^+]) \\
&+N5 - N5 \times 1.0000E\text{-}11/(1.0000E\text{-}11 + [H^+])\} \\
&\times 1000 \times 10 \times [Alb]/66{,}500 = 0
\end{aligned}
$$

$$
\begin{aligned}
&SID + 1000 \times ((aH^+) - Kw / (aH^+) - Kc_1 \times Pco_2 / (aH^+) - Kc_1 \times Kc_2 \times Pco_2 / (aH^+)^2) - [Pi_{tot}] \times Z \\
&+ \{-1 / (1 + 10^{-(pH - 8.5)}) \\
&- 98 / (1 + 10^{-(pH - 4.0)}) \\
&- 18 / (1 + 10^{-(pH - 11.7)}) \\
&+ 24 / (1 + 10^{+(pH - 12.5)}) \\
&+ 2 / (1 + 10^{+(pH - 5.80)}) \\
&+ 2 / (1 + 10^{+(pH - 6.15)}) \\
&+ 2 / (1 + 10^{+(pH - 7.53)}) \\
&+ 2 / (1 + 10^{+(pH - 7.705)}) \\
&+ 1 / (1 + 10^{+(pH - 7.88)}) \\
&+ 50 / (1 + 10^{+(pH - 10.3)}) \\
&+ 1 / (1 + 10^{+(pH - 7.12 + NB)}) \\
&+ 1 / (1 + 10^{+(pH - 7.22 + NB)}) \\
&+ 1 / (1 + 10^{+(pH - 7.10 + NB)}) \\
&+ 1 / (1 + 10^{+(pH - 7.49 + NB)}) \\
&+ 1 / (1 + 10^{+(pH - 7.01 + NB)}) \\
&+ 1 / (1 + 10^{+(pH - 7.31)}) \\
&+ 1 / (1 + 10^{+(pH - 6.75)}) \\
&+ 1 / (1 + 10^{+(pH - 6.36)}) \\
&+ 1 / (1 + 10^{+(pH - 4.85)}) \\
&+ 1 / (1 + 10^{+(pH - 5.76)}) \\
&+ 1 / (1 + 10^{+(pH - 6.17)}) \\
&+ 1 / (1 + 10^{+(pH - 6.73)}) \\
&+ 1 / (1 + 10^{+(pH - 5.82)}) \\
&+ 1 / (1 + 10^{+(pH - 5.10)}) \\
&+ 1 / (1 + 10^{+(pH - 6.70)}) \\
&+ 1 / (1 + 10^{+(pH - 6.20)}) \\
&+ 1 / (1 + 10^{+(pH - 8.0)}) \\
&- 1 / (1 + 10^{-(pH - 3.1)})\} \times 1000 \times 10 \times [Albumine] / 66500 = 0
\end{aligned}
$$

$$
\begin{aligned}
&[SID]+1000 \left(H^+ - \frac{K_w}{H^+} - K_{C1} \frac{PCO_2}{H^+} - K_{C1} K_{C2} \frac{PCO_2}{(H^+)^2} \right) \\
&-[P_{i,TOT}] Z_p - [Citrate_{TOT}] Z_c \\
&+ \frac{-1}{1 + 10^{-(pH-8.5)}} - \frac{98}{1 + 10^{-(pH-4.0)}} - \frac{18}{1 + 10^{-(pH-11.7)}} \\
&+ \frac{24}{1 + 10^{+(pH-12.5)}} + \frac{2}{1 + 10^{+(pH-5.80)}} + \frac{2}{1 + 10^{+(pH-6.00)}} \\
&+ \frac{1}{1 + 10^{+(pH-7.60)}} + \frac{2}{1 + 10^{+(pH-7.80)}} + \frac{2}{1 + 10^{+(pH-8.00)}} \\
&+ \frac{50}{1 + 10^{+(pH-10.3)}} + \frac{1}{1 + 10^{+(pH-7.19+NB)}} + \frac{1}{1 + 10^{+(pH-7.29+NB)}} \\
&+ \frac{1}{1 + 10^{+(pH-7.17+NB)}} + \frac{1}{1 + 10^{+(pH-7.56+NB)}} + \frac{1}{1 + 10^{+(pH-7.08+NB)}} \\
&+ \frac{1}{1 + 10^{+(pH-7.38)}} + \frac{1}{1 + 10^{+(pH-6.82)}} + \frac{1}{1 + 10^{+(pH-6.43)}} \\
&+ \frac{1}{1 + 10^{+(pH-4.92)}} + \frac{1}{1 + 10^{+(pH-5.83)}} + \frac{1}{1 + 10^{+(pH-6.24)}} \\
&+ \frac{1}{1 + 10^{+(pH-6.80)}} + \frac{1}{1 + 10^{+(pH-5.89)}} + \frac{1}{1 + 10^{+(pH-5.20)}} \\
&+ \frac{1}{1 + 10^{+(pH-6.80)}} + \frac{1}{1 + 10^{+(pH-5.50)}} + \frac{1}{1 + 10^{+(pH-8.0)}} \\
&- \frac{1}{1 + 10^{-(pH-3.1)}} \; 1000 \; 10 \; \frac{[Albumin]}{66500} = 0
\end{aligned}
$$

$10*[alb]*(0,123*pH – 0,631)$

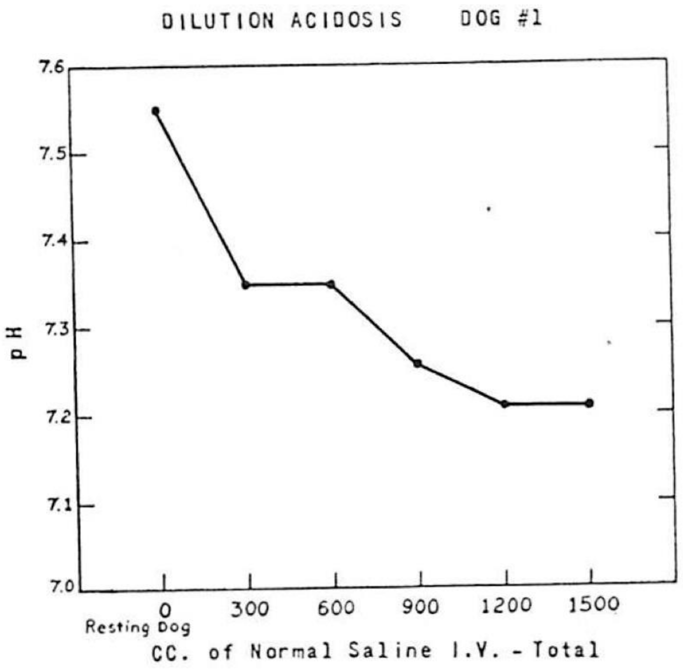
Figge et al

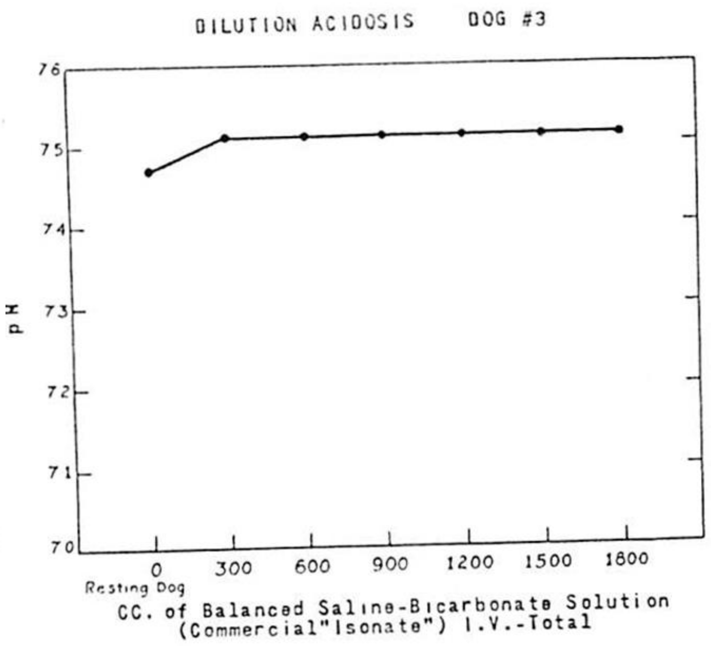
Le concept d'acidose hyperchlorémique

- La perfusion de SSI s'accompagne d'une acidose et d'une hyperchlorémie
- Nombreuses études rétrospectives
  - Augmentation de la morbi-mortalité
- Mais diminution de la concentration en HCO_3^-

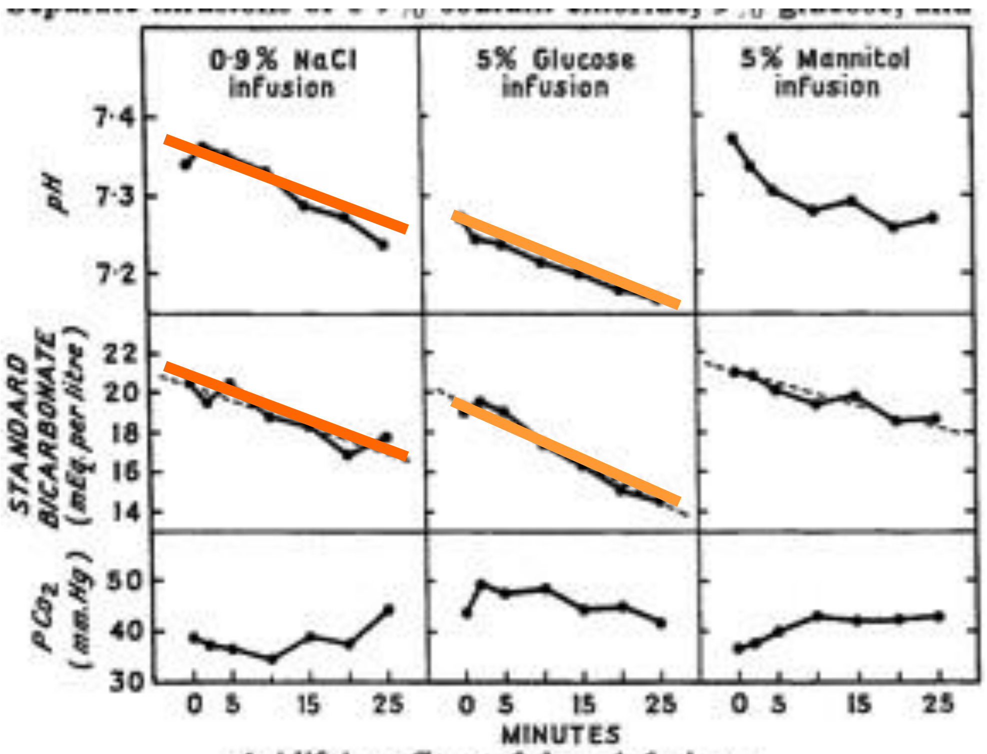
- Chiens anesthésiés
- Sérum physio 300 ml/min
  - pH : 7,55 à 7,21

- Chiens, anesthésie par nembutal
- Perfusion de SSI et de G5%





Administration d'une solution contenant 30 mmol/l de HCO_3Na



Acidifying effects of three infusions.

L'administration de SSI s'accompagne d'une acidose
Prévenue par l'ajout de HCO3Na

L'administration de SSI ou de G5% s'accompagne d'une acidose métabolique

Shires GT, Ann Int Med 1947

Asano et al, Lancet 1966

Physicochemical Models of Acid-Base

Matthew B. Wolf, PhD

Table 1. Model Predictions of the Effects of a 20% Dilution of 5 L of Arterial Blood at P_{CO_2} of 40 mm Hg by a 154 mmol/L NaCl Solution and the Individual Effects of Adding Just the Contained H_2O or NaCl or Just Na^+ or Cl^- Individually

	Normal	Individual Additions				
		1 L of 154 mmol/L NaCl	1 L of H_2O	154 mmol NaCl	154 mmol Na^+	154 mmol Cl^-
Venous plasma						
pH	7.4	7.33	7.33	7.4	7.74	6.8
$[Na^+]$, mmol/L	140	143	115	173	171	146
$[Cl^-]$, mmol/L	104	115	86	139	105	133
$[HCO_3^-]$, mmol/L	23.8	20.6	20.6	23.8	53.2	6.1
ΔM_{Cl-}, mmol	0	144	-2	146	36	70
ΔM_{HCO3-}, mmol	0	10.4	3.5	6.6	108	-56
ΔSID, mEq/L_{pw}	0	-8.9	-7.4	-1.7	32	-22

Acidose hypochlorémique → 1 L of 154 mmol/L NaCl

acidose hyperchlorémique → 1 L of H_2O

hyperchlorémie sans acidose → 154 mmol NaCl

Acidose avec SID diminuée et non acidose hyperchlorémique

Semin Nephrol 39:328–339 © 2019

Le lactate et les autres

- Administration de solutés balancés
  - Moins d'acidoses métaboliques
  - Quid du lactate ?
- Ringer lactate (lactate 27,7 mmol/l)
  - Lactate dosé en pratique clinique
  - Augmentation modérée
  - Clearance rapide
- Autres solutés
  - Composés non dosés en pratique clinique
  - Augmentation modérée
  - Clearance relativement rapide variable selon le composé

- Définitions des solutés balancés
- Rappels biochimiques
- **Utilisation des solutés balancés chez l'adulte**
- Indications des solutés balancés chez l'adulte
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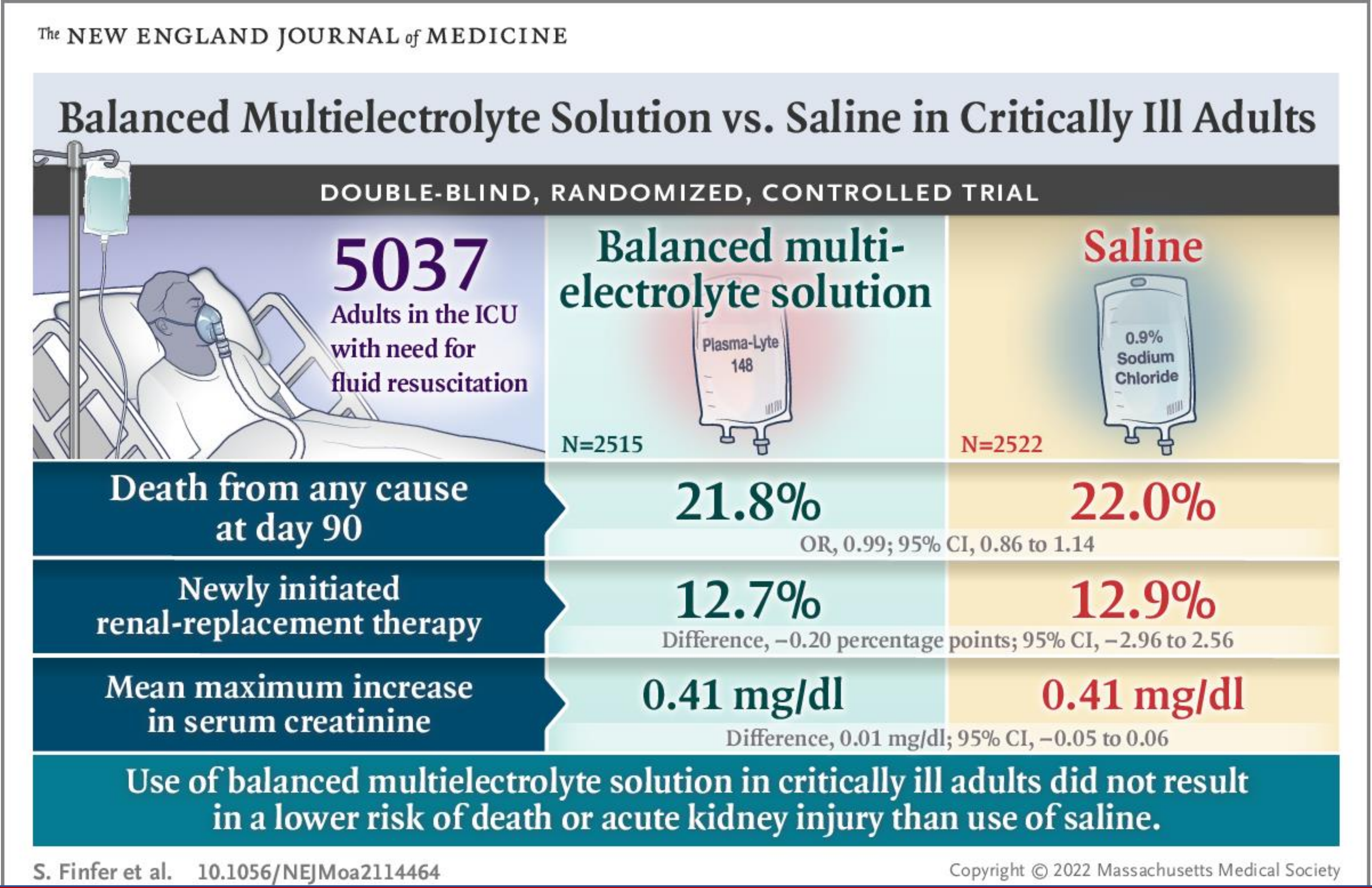
- Indication des solutés balancés en pédiatrie

	SMART +	SMART -	BaSICS	PLUS
Make30	0,04	NS		
Mortalité	NS		NS	NS
IRA	NS		NS	NS
Dialyse	NS		NS	NS
Sepsis	2336		1987	2094
Double aveugle	-		+	+

- Etude SMART
  - Seule à trouver un effets délétère du SSI
  - Pas d’aveugle, randomisation du mois de départ
  - Un patient randomisé le 31/01 : change de soluté le 01/02
    - Si exclusion des patients cross-over : p=0,25
  - Volume administré avant randomisation plus faible et non homogène entre les groupes, très hétérogène entre les réanimations
  - Volume administré après randomisation plus faible. Pas de détail par réanimation


The NEW ENGLAND JOURNAL of MEDICINE
Balanced Multielectrolyte Solution vs. Saline in Critically Ill Adults
DOUBLE-BLIND, RANDOMIZED, CONTROLLED TRIAL
5037
Adults in the ICU with need for fluid resuscitation
Balanced multi-electrolyte solution
Plasma-Lyte 148
N=2515
Saline
0.9% Sodium Chloride
N=2522
Death from any cause at day 90
21.8%
22.0%
OR, 0.99; 95% CI, 0.86 to 1.14
Newly initiated renal-replacement therapy
12.7%
12.9%
Difference, −0.20 percentage points; 95% CI, −2.96 to 2.56
Mean maximum increase in serum creatinine
0.41 mg/dl
0.41 mg/dl
Difference, 0.01 mg/dl; 95% CI, −0.05 to 0.06
Use of balanced multielectrolyte solution in critically ill adults did not result in a lower risk of death or acute kidney injury than use of saline.
S. Finfer et al. 10.1056/NEJMoa2114464
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Sepsis

- PLUS : sepsis NS
- BasicS : sepsis NS
  - Analyse à postériori si SB seul : ?

Balanced Multielectrolyte Solution versus Saline in Critically Ill Adults

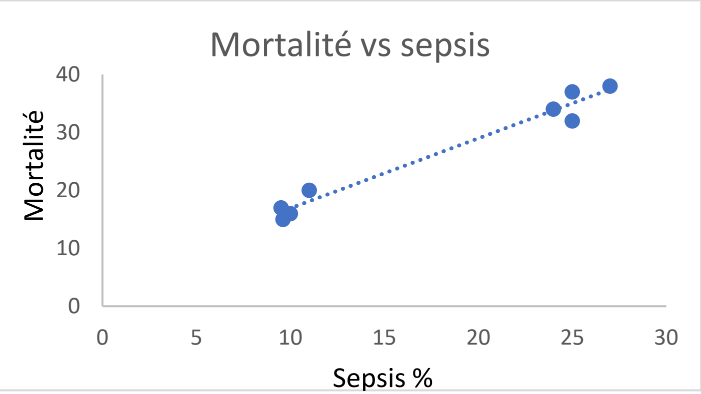
Simon Finfer, M.D., Sharon Micallef, B.N., Naomi Hammond, Ph.D., Leanlove Navarra, B.S.N., Rinaldo Bellomo, M.D., Ph.D., Laurent Billot, M.Res., Anthony Delaney, M.D., Ph.D., Martin Gallagher, M.D., Ph.D., David Gattas, M.D., Qiang Li, M.Biostat., Diane Mackle, M.N., Jayanthi Mysore, M.S., Manoj Saxena, M.D., Ph.D., Colman Taylor, Ph.D., Paul Young, M.D., Ph.D., and John Myburgh, M.D., D.Sc., for the PLUS Study Investigators and the Australian and New Zealand Intensive Care Society Clinical Trials Group*

JAMA | Original Investigation

Effect of Intravenous Fluid Treatment With a Balanced Solution vs 0.9% Saline Solution on Mortality in Critically Ill Patients
The BaSICS Randomized Clinical Trial

Fernando G. Zampieri, MD, PhD; Flávia R. Machado, MD, PhD; Rodrigo S. Biondi, MD; Flávio G. R. Freitas, MD, PhD; Viviane C. Veiga, MD, PhD; Rodrigo C. Figueiredo, MD; Wilson J. Lovato, MD; Cristina P. Amêndola, MD, PhD; Ary Serpa-Neto, MD, PhD; Jorge L. R. Paranhos, MD; Marco A. V. Guedes, MD, PhD; Eraldo A. Lúcio, MD, PhD; Lúcio C. Oliveira-Júnior, MD; Thiago C. Lisboa, MD, PhD; Fábio H. Lacerda, MD; Israel S. Maia, MD; Cintia M. C. Grion, MD, PhD; Murillo S. C. Assunção, MD, PhD; Airton L. O. Manoel, MD, PhD; João M. Silva-Junior, MD, PhD; Péricles Duarte, MD; Rafael M. Soares, PhD; Tamiris A. Miranda, MSc; Lucas M. de Lima, IT; Rodrigo M. Gurgel, Biomed Sci; Denise M. Paisani, PhD; Thiago D. Corrêa, MD, PhD; Luciano C. P. Azevedo, MD, PhD; John A. Kellum, MD; Lucas P. Damiani, MSc; Nilton Brandão da Silva, MD, PhD; Alexandre B. Cavalcanti, MD, PhD; for the BaSICS investigators and the BRICNet members

	SB SB	SB SSI	Mix SB	Mix SSI	SSI SB	SSI SSI	0 SB	0 SSI
Sepsis	10	11	9, 5	9,6	24	25	25	27
SOFA	4	4	4	4	5	5	4	4
Vasopresseurs	39	39	52	51	39	38	31	32
SB (L)	2	2	1,5	1,5	0	0	0	0
SSI (L)	0	0	1	1	1	1,375	0	0
Mortalité	16	20	17	15	34	32	37	38



Mortalité

SB avant réa, SSI en réa : 20%

SSI avant réa, SB en réa : 34%

Mix avant réa, SSI en réa : 15%

Mix avant réa, SB en réa : 17%

Mais

ATCD

Traitements associés (ATB, chir)

Remplissage en réa

Zampieri et al. AJRCCM 2022

Sepsis

- SMART : Brown et suite
  - Brown et al. « erreur » surprenante entre le sujet de l'étude et la référence *clinicaltrial.gov*
- PLUS : sepsis NS
- BasicS : sepsis NS
  - Analyse à postériori si SB seul : ?

Balanced Crystalloids versus Saline in Critically Ill Adults

Matthew W. Semler, M.D., Wesley H. Self, M.D., M.P.H., Jonathan P. Wanderer, M.D., Jesse M. Ehrenfeld, M.D., M.P.H., Li Wang, M.S., Daniel W. Byrne, M.S., Joanna L. Stollings, Pharm.D., Avinash B. Kumar, M.D., Christopher G. Hughes, M.D., Antonio Hernandez, M.D., Oscar D. Guillamondegui, M.D., M.P.H., Addison K. May, M.D., Liza Weavind, M.B., B.Ch., Jonathan D. Casey, M.D., Edward D. Siew, M.D., Andrew D. Shaw, M.B., Gordon R. Bernard, M.D., and Todd W. Rice, M.D., for the SMART Investigators and the Pragmatic Critical Care Research Group*

Balanced Multielectrolyte Solution versus Saline in Critically Ill Adults

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Balanced Crystalloids versus Saline in Sepsis
A Secondary Analysis of the SMART Clinical Trial

Ryan M. Brown[1], Li Wang[2], Taylor D. Coston[3], Nathan I. Krishnan[3], Jonathan D. Casey[1], Jonathan P. Wanderer[4,5], Jesse M. Ehrenfeld[4,5,6,7], Daniel W. Byrne[2], Joanna L. Stollings[8], Edward D. Siew[9], Gordon R. Bernard[1], Wesley H. Self[10], Todd W. Rice[1], and Matthew W. Semler[1]; for the SMART Investigators* and the Pragmatic Critical Care Research Group

Effect of Early Balanced Crystalloids before ICU Admission on Sepsis Outcomes

Karen E. Jackson, MD, Li Wang, MS, Jonathan D. Casey, MD, MSc, Gordon R. Bernard, MD, Wesley H. Self, MD, MPH, Todd W. Rice, MD, MSc, Matthew W. Semler, MD, MSc, for the , SMART Investigators and the Pragmatic Critical Care Research Group

Volumes administré (SB + SSI) à J30 et durant le séjour en réanimation

			BC group		Saline group		delta	
			Te	T2	Te	T2	Te	T2
SMART		ICU	2575		2387		188	
		D30	3106		2943		163	
Brown *et al.*		ICU	3206		2609		597	
		D30	4341		4083		258	
Jackson *et al.*	All	ICU	4035		2460		1575	
		D30	4892		3578		1314	
	ICU only	ICU	4547		2495		2052	
		D30	5555	5317	3550	4404	2005	913
	ED-ICU	ICU	3928		2447		1481	
		D30	4754	4138	3588	3962	1166	176

Te : tableau dans les annexes, T2 : tableau situé dans le texte

- Définitions des solutés balancés
- Rappels biochimiques
- Utilisation des solutés balancés chez l’adulte
- **Indications des solutés balancés chez l’adulte**
- Un peu d’histoire
- Les différent types de solutés
- Utilisation des solutés balancés en pédiatrie
- Indication des solutés balancés en pédiatrie

Les solutés balancés chez l'adulte

- En obstétrique
- Dans le choc hémorragique
- Chez les patients cérébro-lésés
- Dans le sepsis

Recommandations Formalisées d'Experts

« Choix du Soluté pour le remplissage vasculaire en situation critique »

Intravenous fluids for vascular loading

2021

RFE commune SFAR - SFMU

Société Française d'Anesthésie et de Réanimation (SFAR)
Société Française de Médecine d'Urgence (SFMU)

Sepsis

- RFE SFAR 2021
  - chez les patients atteints de sepsis ou de choc septique, il est probablement recommandé d'utiliser des solutés cristalloïdes balancés pour le remplissage vasculaire pour diminuer la mortalité et/ou la survenue d'évènements indésirables rénaux

- Surviving sepsis campaign 2021
  - For adults with sepsis or septic shock, we suggest using balanced crystalloids instead of normal saline for resuscitation
  - Therefore, we considered the desirable and undesirable consequences to favour balanced solutions, but as the quality of the evidence is low, we issued a weak recommendation. Two ongoing large RCTs will provide additional data and inform future guideline updates

Surviving sepsis campaign: international guidelines for management of sepsis and septic shock 2021, *Intensive Care Med (2021) 47:1181–1247*

Patients cérébro-lésés

- Les experts ne peuvent pas se positionner sur une éventuelle supériorité des solutés isotoniques balancés par rapport au NaCl 0,9% dans la prise en charge des patients cérébrolésés du fait du faible niveau de preuves
- Deux études randomisées et contrôlées ne retrouvaient pas d'effets sur le pronostic en dehors d'une diminution significative du risque d'hyperchlorémie (n=36 et n=42)
- Les experts soulignent la nécessité de recherche dans ce domaine

Patients cérébro-lésés

- SMART
  - Lombardo *et al.* : plus de patients institutionnalisés dans le groupe SB
- BaSICS : surmortalité dans le groupe SB

Balanced Crystalloids versus Saline in Critically Ill Adults

Matthew W. Semler, M.D., Wesley H. Self, M.D., M.P.H., Jonathan P. Wanderer, M.D., Jesse M. Ehrenfeld, M.D., M.P.H., Li Wang, M.S., Daniel W. Byrne, M.S., Joanna L. Stollings, Pharm.D., Avinash B. Kumar, M.D., Christopher G. Hughes, M.D., Antonio Hernandez, M.D., Oscar D. Guillamondegui, M.D., M.P.H., Addison K. May, M.D., Liza Weavind, M.B., B.Ch., Jonathan D. Casey, M.D., Edward D. Siew, M.D., Andrew D. Shaw, M.B., Gordon R. Bernard, M.D., and Todd W. Rice, M.D., for the SMART Investigators and the Pragmatic Critical Care Research Group*

JAMA | Original Investigation

Effect of Intravenous Fluid Treatment With a Balanced Solution vs 0.9% Saline Solution on Mortality in Critically Ill Patients
The BaSICS Randomized Clinical Trial

Fernando G. Zampieri, MD, PhD; Flávia R. Machado, MD, PhD; Rodrigo S. Biondi, MD; Flávio G. R. Freitas, MD, PhD; Viviane C. Veiga, MD, PhD; Rodrigo C. Figueiredo, MD; Wilson J. Lovato, MD; Cristina P. Amêndola, MD, PhD; Ary Serpa-Neto, MD, PhD; Jorge L. R. Paranhos, MD; Marco A. V. Guedes, MD, PhD; Eraldo A. Lúcio, MD, PhD; Lúcio C. Oliveira-Júnior, MD; Thiago C. Lisboa, MD, PhD; Fábio H. Lacerda, MD; Israel S. Maia, MD; Cintia M. C. Grion, MD, PhD; Murillo S. C. Assunção, MD, PhD; Airton L. O. Manoel, MD, PhD; João M. Silva-Junior, MD, PhD; Péricles Duarte, MD; Rafael M. Soares, PhD; Tamiris A. Miranda, MSc; Lucas M. de Lima, IT; Rodrigo M. Gurgel, Biomed Sci; Denise M. Paisani, PhD; Thiago D. Corrêa, MD, PhD; Luciano C. P. Azevedo, MD, PhD; John A. Kellum, MD; Lucas P. Damiani, MSc; Nilton Brandão da Silva, MD, PhD; Alexandre B. Cavalcanti, MD, PhD; for the BaSICS investigators and the BRICNet members

Lombardo et al, J Neurotrauma. 2022 Sep;39(17-18):1159-1167

Choc hémorragique

- Chez les patients en situation de choc hémorragique, il est probablement recommandé d'utiliser des solutés cristalloïdes balancés en première intention plutôt que du NaCl 0,9% comme soluté de remplissage vasculaire pour diminuer la mortalité et/ou les évènements indésirables rénaux
- Ainsi, les données disponibles sont insuffisantes pour recommander de façon formelle à ce jour (recommandation GRADE 1) un type de soluté cristalloïde au cours du choc hémorragique

- Si TC grave : SB ?

Obstétrique

- Du fait de l'absence de donnée disponible dans la littérature, aucune recommandation spécifique ne peut être émise concernant le choix du soluté de remplissage vasculaire à utiliser dans la prise en charge réanimatoire des femmes en péripartum

COUT

Sérum salé isotonique (SSI)

- C'est un soluté « non balancé » ;
- Il n'est pas physiologique (autant d'apport de sodium que de chlore) ;
- Sa principale complication est l'acidose métabolique « minérale » hyperchlorémique en cas d'administration de volumes importants dont l'impact clinique (insuffisance rénale, dysfonction plaquettaire, inflammation, diminution de la sensibilité aux catécholamines, hyperkaliémie de transfert) n'est pas démontré.
- Prix : 0,50 € pour 500ml

Ringer Lactate

- C'est un soluté « balancé » dont l'anion organique est le lactate
- A éviter car non évalué :

- Chez le patient cérébrolésé car légèrement hypotonique ;
- En cas d'hyperkaliémie (contient du potassium) même si l'absence d'induction d'acidose hyperchlorémique diminuerait le risque d'hyperkaliémie de transfert comparativement au SSI ;
- Chez le patient cirrhotique avec acidose lactique sévère car le lactate est métabolisé par le foie ;
- En cas d'hypercalcémie (contient du calcium).

- Prix : 0,60 € pour 500ml

Plasmalyte® et Isofundine®

- Ce sont des solutés « balancés » dont l'anion organique est l'acétate ;
- L'acétate a des effets vasodilatateur et inotrope négatif lorsqu'il est utilisé dans les solutés de dialyse et de substitution d'hémofiltration, il n'est donc plus utilisé dans ces indications. Sa tolérance pour le remplissage des patients en état de choc reste non étudiée.
- Prix : 0,70 € pour 500ml

C$1.80 for 1 L of RL versus C$1.41 for 1 L of 0.9% saline) and less readily available than 0.9% saline

- Définitions des solutés balancés
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- Indications des solutés balancés chez l’adultes
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- Utilisation des solutés balancés en pediatrie
- Indication des solutes balances en paediatrie

Thomas Latta 1831

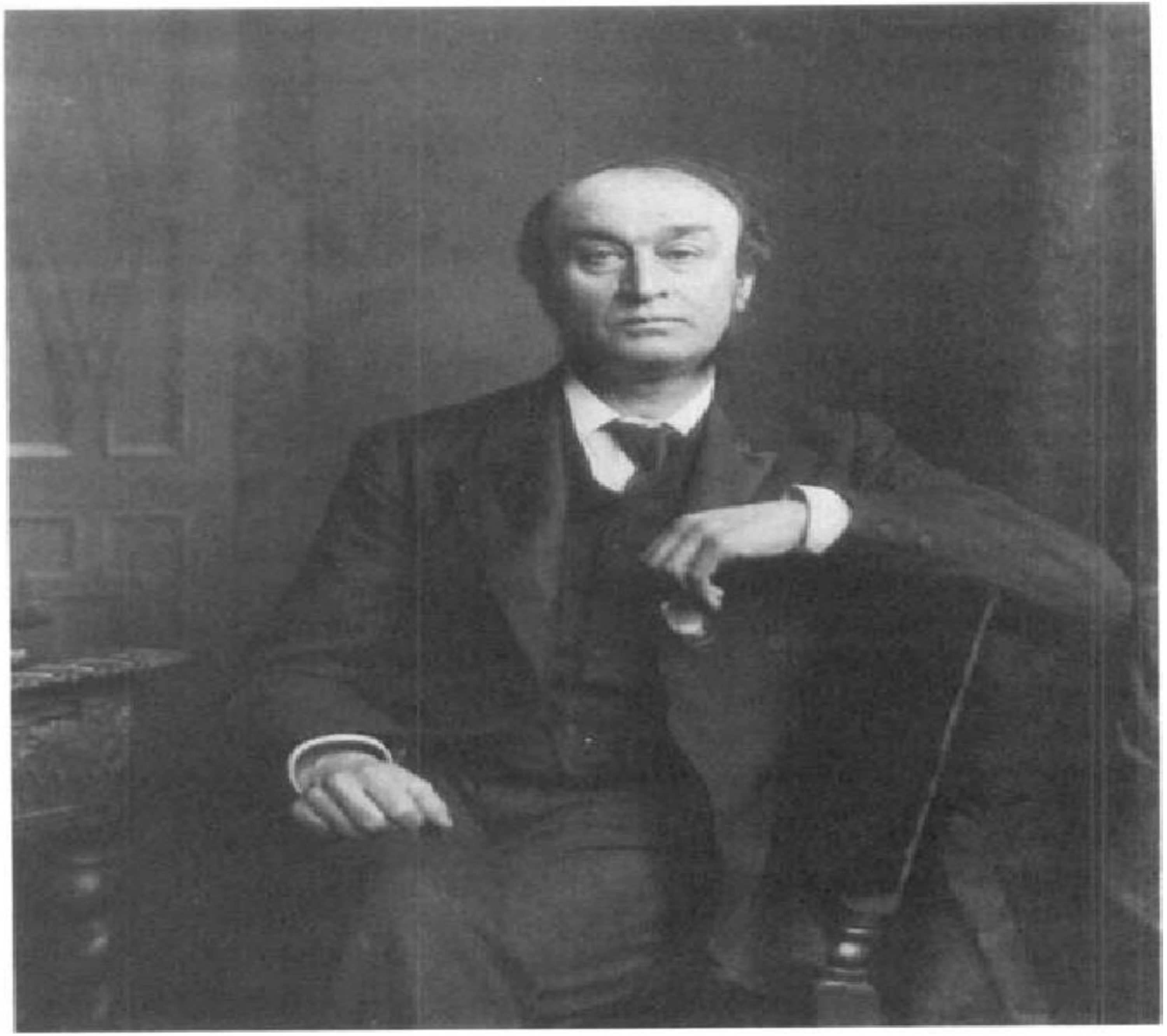
Thomas Aitchison Latta (1796 – 19 October 1833) was a medical pioneer who was responsible for the introduction of the saline solution ("saline drip") methodology into the treatment of patients.

I though she began to breathe less laboriously, soon the sharpened features, and sunken eye, and fallen jaw, pale and cold, bearing the manifest impress o f death's signet, began to glow with returning animation; the pulse, which had long ceased, returned to the wrist; at first small and quick, by degrees it became more and more distinct ... and in the short space of half an hour, when six pints had been injected, she expressed in a firm voice that she was free from all uneasiness, actually became jocular, and fancied all she needed was a little sleep.

The Lancet on 23 June 1832 and the methodology began to spread; by then the epidemic was on the wane.

Sydney Ringer 1877

His most celebrated work in research was conducted at University College's incipient Department of Physiology. He established the minimal ionic composition (simple chloride salts of sodium, potassium and calcium) of a physiological saline. His demonstration of the necessity for extracellular calcium to sustain cardiac muscle contraction in the spontaneously beating frog heart was the first to reveal the physiological importance of calcium subsequently discovered for many cellular processes (see e.g. Calcium metabolism, Calcium in biology). This work provided the basis of Ringer's solution of which there followed many derivatives, modified to suit different species and experimental conditions. Clinically important derivatives include Ringer's lactate also known as Hartmann's solution.



Hartog Jacob Hamburger 1896

1896, he invented the crystalloid solution known as Hamburger's solution or normal saline.
Based on plant-based experiments by botanist Hugo de Vries, he developed a salt solution
that was thought to have the same osmolality as human blood and therefore did not cause haemolysis of red blood cells.
It is uncertain whether the saline was ever originally intended for intravenous administration.

In 1901 he joined the University of Groningen as professor of physiology.[2] In 1911
he was instrumental in opening a dedicated physiological institute, and two years later chaired the 25th International Physiological Congress in Groningen.[1][2]

Alexis Frank Hartmann 1932

Alexis Frank Hartmann (1898-1964) was an American pediatrician and clinical biochemist.

Hartmann pursued a scientific research career, with research centred around treating acidosis in sick children. He developed a technique to measure sugar in patients' blood whilst a medical student – a significant step towards the discovery of insulin. He was also one of the first clinicians to use insulin in the treatment of infants.

Hartmann also created a fluid and electrolyte replacement therapy for infants universally known as Lactated Ringer's solution, or Hartmann's Solution. Hartman saw the use of alkaline therapy in the treatment of children with acidosis and the need for more sodium than chloride in parenteral solutions.

In 1932, modified Ringer's solution by adding sodium lactate to it with the idea of combating acidosis in his young patients.

In Britain, the modification is called **Hartmann's solution** after the American, although Hartmann never used this name himself.

In America it is called **Ringer's Lactate** after the Englishman, Sydney Ringer

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Les différents types de solutés

	Plasma	NaCl 0,9 %	Ringer Lactate	Plas-malyte	Stéro-fundine	ELOMEL Isoton
Na	140	154	130	140	145	140
Cl	100	154	109	98	127	98
K	5	0	4	5	4	5
Mg	1	0	0	1,5	1	1,5
Ca	2,2	0	2,7	0	2,5	2,5
Acétate/Lactate	0	0	0/28	27/0	24/0	45/0
Gluconate/Malate	0	0	0	23/0	0/5	0
Bicarbonates	24	0	0	0	0	0
SID	40	0	26	50	20	42
Osmolalité	280-296	308	273	295	309	302

Anatole Harrois Mapar 2016

Composition (mmol/l)	Plasma	NaCl 0.9%	Ringer Lactate	Ringer Acétate		Unité
				Plasmalyte*	Isofundine*	
Na^+	140	154	130	140	145	mmol/l
K^+ v	4	0	5,4	5	4	mmol/l
Mg^{2+}	1	0	0	1,5	1	mmol/l
Ca^{2+}	2,2	0	1,8	0	2,5	mmol/l
Cl^-	**100**	**154**	**111**	**98**	**127**	mmol/l
Lactates	1	0	27,7	0	0	mmol/l
Malates	0	0	0	0	5	mmol/l
Acétate	0	0	0	27	24	mmol/l
Pyruvate	0	0	0	0	0	mmol/l
Gluconate	0	0	0	23	0	mmol/l
Osmolarité	285	308	277	295	309	mOsm/l
pH	7,40	4,5-7,0	6,0-7,5	6,5-8,0	5,1-5,9	-

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Saline is not the first choice for crystalloid resuscitation fluids

Matthew W. Semler, MD[1] and **Todd W. Rice, MD, MSc**[1]

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Are Balanced Crystalloid Solutions Better Than Normal Saline Solution for the Resuscitation of Children and Adult Patients?

TAKE-HOME MESSAGE

Compared with 0.9% normal saline solution, balanced crystalloid solutions are not associated with differences in mortality, acute kidney injury, or organ-system dysfunction among critically ill patients. It is reasonable to use either fluid in patients undergoing resuscitation with small volumes (1 to 2 L) in the emergency department (ED).

Annals *of* Emergency Medicine   Volume 75, NO. 4 : April 2020

Resuscitation With Balanced Fluids Is Associated With Improved Survival in Pediatric Severe Sepsis*

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Objective: To evaluate outcomes in patients receiving balanced fluids for resuscitation in pediatric severe sepsis.
Design: Observational cohort review of prospectively collected data from a large administrative database.
Setting: PICUs from 43 children's hospitals.
Patients: PICU patients diagnosed with severe sepsis.
Interventions: None.
Measurements and Main Results: We reviewed data from the Pediatric Health Information System database from 2004 to 2012. Children with pediatric severe sepsis receiving balanced fluids for resuscitation in the first 24 and 72 hours of treatment were compared to those receiving unbalanced fluids. Thirty-six thousand nine hundred eight patients met entry criteria for analysis. Two thousand three hundred ninety-eight patients received exclusively balanced fluids at 24 hours and 1,641 at 72 hours. After propensity matching, the 72-hour balanced fluids group had lower mortality (12.5% vs 15.9%; $p = 0.007$; odds ratio, 0.76; 95% CI, 0.62–0.93), lower prevalence of acute kidney injury (16.0% vs 19.2%; $p = 0.028$; odds ratio, 0.82; 95% CI, 0.68–0.98), and fewer vasoactive infusion days (3.0 vs 3.3 d; $p < 0.001$) when compared with the unbalanced fluids group.

CC 2017

TABLE 1. Twenty-Four–Hour Fluid Groups Demographics

Clinical Characteristics	Balanced Fluids Only ($n = 2,398$)	Unbalanced Fluids Only ($n = 30,166$)	p

TABLE 5. Propensity-Matched Outcomes for 72-Hour Fluid Groups

Outcome	Only Balanced Fluids ($n = 1,000$), Mean (95% CI) or n (%)	Only Unbalanced Fluids ($n = 6,000$), Mean (95% CI) or n (%)	Adjusted OR	p
Total length of stay[a]	21.0 (19.1–23.0)	18.1 (16.0–19.3)	–	< 0.001
Total length of stay in survivors in days[a]	21.5 (19.6–23.5)	19.0 (17.7–20.3)	–	0.001
Total length of stay in nonsurvivors in days[a]	18.9 (14.0–25.4)	14.2 (12.0–16.8)	–	0.050
PICU length of stay[a]	7.8 (6.8–8.9)	7.4 (6.6–8.2)	–	0.202
Vasoactive infusion days[b]	3.0 (2.6–3.4)	3.3 (2.9–3.8)	–	< 0.001
Mortality[c]	125 (12.5)	954 (15.9)	0.76 (0.62–0.93)	0.007
Acute kidney injury[c]	160 (16.0)	1,153 (19.2)	0.82 (0.68–0.98)	0.028
Continuous renal replacement therapy use[c]	54 (5.4)	433 (7.2)	0.75 (0.56–1.01)	0.054

Conclusions: In this retrospective analysis carried out by propensity matching, exclusive use of balanced fluids in pediatric severe sepsis patients for the first 72 hours of resuscitation was associated with improved survival, decreased prevalence of acute kidney injury, and shorter duration of vasoactive infusions when compared with exclusive use of unbalanced fluids. (*Crit Care Med* 2017; 45:1177–1183)

Association between the use of balanced fluids and outcomes in critically ill children: a before and after study

Matthew F. Barhight[1,2*], Delphine Nelson[3], Thomas Moran[4], Jessica Christiano[1,2] and L. Nelson Sanchez-Pinto[1,2]

Abstract

Background: Hyperchloremia and chloride load have been associated with worse clinical outcomes in critically ill patients. We sought to evaluate the electrolyte profile and clinical outcomes associated with a unit-wide transition from saline to balanced fluids for resuscitation and maintenance fluids in a pediatric intensive care unit (PICU).

Methods: A before and after analysis of all patients admitted to the PICU in a large, urban, academic hospital between August 2018 and March 2020. The transition from the use of saline to the use of balanced fluids for both resuscitation and maintenance fluid as standard care occurred in June 2019. The primary outcome was day 3 acute kidney injury (AKI). The secondary outcomes included mortality, ventilator-free days (VFDs), need for renal replacement therapy (RRT), hospital length of stay (LOS), and electrolyte abnormalities.

Results: Overall, 2863 patients (47% female) with a day 3 AKI rate of 12.9% ($n = 130$) and a mortality rate of 2.8% ($n = 79$) were included. After adjusting for confounders (age, PRISM III, mechanical ventilation, and immunocompromised state, septic shock), there were no significant differences in the odds of day 3 AKI (pre 13%, post 12.5%; adjusted odds ratio [aOR] 0.96, 95%CI 0.65–1.42). There were no differences in the secondary outcomes. The post-intervention period had fewer patients with hyperchloremia (pre 15.5% vs. post 10.4%, $p = < 0.0001$) and hyperkalemia (pre 3.2% vs. post 1.4%, $p = 0.02$) and more patients with hypochloremia (pre 9.5% vs. post 14.4%, $p = < 0.0001$) and hypokalemia (pre 38.2% vs. post 47.2%, $p = < 0.0001$). In reference to the normochloremic cohort, the hypochloremic cohort had an increase in day 3 AKI, need for RRT, hyperchloremia, and hyperkalemia, and a decrease in hypokalemia; and the hyperchloremic cohort had an increase in VFD and a decrease in hospital LOS.

Conclusions: Following a unit-wide implementation of balanced fluids as standard care, there were no differences in rates of day 3 AKI or other clinical outcomes. However, there were lower rates of hyperkalemia and hyperchloremia and higher rates of hypokalemia and hypochloremia. Further evaluation of the effect of balanced fluids and the clinical significance of electrolyte abnormalities in critically ill children is needed.

Keywords: Balanced fluids, Acute kidney injury, Mortality, Pediatric critical care

- N =2863
- Rétrospective
- Cl bas
- K bas

CC 2021

Balanced Versus Unbalanced Fluid in Critically Ill Children: Systematic Review and Meta-Analysis*

PCCM 2022

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OBJECTIVES: The ideal crystalloid fluid bolus therapy for fluid resuscitation in children remains unclear, but pediatric data are limited. Administration of 0.9% saline has been associated with hyperchloremic metabolic acidosis and acute kidney injury. The primary objective of this systematic review was to compare the effect of balanced versus unbalanced fluid bolus therapy on the mean change in serum bicarbonate or pH within 24 hours in critically ill children.

DATA SOURCES: We searched MEDLINE including Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Embase, CENTRAL Trials Registry of the Cochrane Collaboration, ClinicalTrials.gov, and World Health Organization International Clinical Trials Registry Platform.

STUDY SELECTION: Using the Preferred Reporting Items for Systematic Review and Meta-analysis Protocols guidelines, we retrieved all controlled trials and observational cohort studies comparing balanced and unbalanced resuscitative fluids in critically ill children. The primary outcome was the change in serum bicarbonate or blood pH. Secondary outcomes included the prevalence of hyperchloremia, acute kidney injury, renal replacement therapy, and mortality.

DATA EXTRACTION: Study screening, inclusion, data extraction, and risk of bias assessments were performed independently by two authors.

DATA SYNTHESIS: Among 481 references identified, 13 met inclusion criteria. In the meta-analysis of three randomized controlled trials with a population of 162 patients, we found a greater mean change in serum bicarbonate level (pooled estimate 1.60 mmol/L; 95% CI, 0.04–3.16; $p = 0.04$) and pH level (pooled mean difference 0.03; 95% CI, 0.00–0.06; $p = 0.03$) after 4–12 hours of rehydration with balanced versus unbalanced fluids. No differences were found in chloride serum level, acute kidney injury, renal replacement therapy, or mortality.

CONCLUSIONS: Our systematic review found some evidence of improvement in blood pH and bicarbonate values in critically ill children after 4–12 hours of fluid bolus therapy with balanced fluid compared with the unbalanced fluid. However, a randomized controlled trial is needed to establish whether these findings have an impact on clinical outcomes before recommendations can be generated.

KEY WORDS: balanced fluid; critically ill children; crystalloid fluid; normal saline; Ringer's lactate; resuscitation

N=162

- pH
- RA
- Pas de Différence
- AKI
- IRA
- Mortalité
- Cl

A total of 13 studies with 11,848 patients ages 28 days to 18 years treated with greater than or equal to 20 mL/kg fluid bolus therapy were included. Nine of the studies were randomized controlled trials (RCTs), though only three (162 total patients) were included in the meta-analysis of the primary endpoint. Most studies focused on septic/dengue shock or diarrheal dehydration, but two studied diabetic ketoacidosis. LR was the most common balanced/buffered fluid.

STUDY PROTOCOL Open Access

PRagMatic Pediatric Trial of Balanced vs nOrmaL Saline FlUid in Sepsis: study protocol for the PRoMPT BOLUS randomized interventional trial

Scott L. Weiss[1,2*], Fran Balamuth[2,3], Elliot Long[4,5,6], Graham C. Thompson[7], Katie L. Hayes[2], Hannah Katcoff[8], Marlena Cook[3], Elena Tsemberis[3], Christopher P. Hickey[2], Amanda Williams[4], Sarah Williamson-Urquhart[7], Meredith L. Borland[9], Stuart R. Dalziel[10], Ben Gelbart[5,6,11,12], Stephen B. Freedman[13], Franz E. Babl[4,5,6], Jing Huang[3,14], Nathan Kuppermann[15] and for the Pragmatic Pediatric Trial of Balanced Versus Normal Saline Fluid in Sepsis (PRoMPT BOLUS) Investigators of the PECARN, PERC, and PREDICT Networks

Methods: The Pragmatic Pediatric Trial of Balanced versus Normal Saline Fluid in Sepsis (PRoMPT BOLUS) study is an international, open-label pragmatic interventional trial being conducted at > 40 sites in the USA, Canada, and Australia/New Zealand starting on August 25, 2020, and continuing for 5 years. Children > 6 months to < 18 years treated for suspected septic shock with abnormal perfusion in an emergency department will be randomized to receive either balanced/buffered crystalloids (intervention) or 0.9% saline (control) for initial resuscitation and maintenance fluids for up to 48 h. Eligible patients are enrolled and randomized using serially numbered, opaque envelopes concurrent with clinical care. Given the life-threatening nature of septic shock and narrow therapeutic window to start fluid resuscitation, patients may be enrolled under "exception from informed consent" in the USA or "deferred consent" in Canada and Australia/New Zealand. Other than fluid type, all decisions about timing, volume, and rate of fluid administration remain at the discretion of the treating clinicians. For pragmatic reasons, clinicians will not be blinded to study fluid type. Anticipated enrollment is 8800 patients. The primary outcome will be major adverse kidney events within 30 days (MAKE30), a composite of death, renal replacement therapy, and persistent kidney dysfunction. Additional effectiveness, safety, and biologic outcomes will also be analyzed.

Discussion: PRoMPT BOLUS will provide high-quality evidence for the comparative effectiveness of buffered/balanced crystalloids versus 0.9% saline for the initial fluid management of children with suspected septic shock in emergency settings.

Trial registration: PRoMPT BOLUS was first registered at ClinicalTrials.gov (NCT04102371) on September 25, 2019. Enrollment started on August 25, 2020.

Keywords: Sepsis, Septic shock, Pediatric, Intravenous fluid, Crystalloid, Saline, Renal failure, Pragmatic trial

Weiss *et al. Trials* (2021) 22:776
https://doi.org/10.1186/s13063-021-05717-4

Pragmatic Pediatric Trial of Balanced Versus Normal Saline Fluid in Sepsis: The PRoMPT BOLUS Randomized Controlled Trial Pilot Feasibility Study

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N
NS 26
RL 24

Volume
NS 98 ml/kg
RL 108 ml/kg

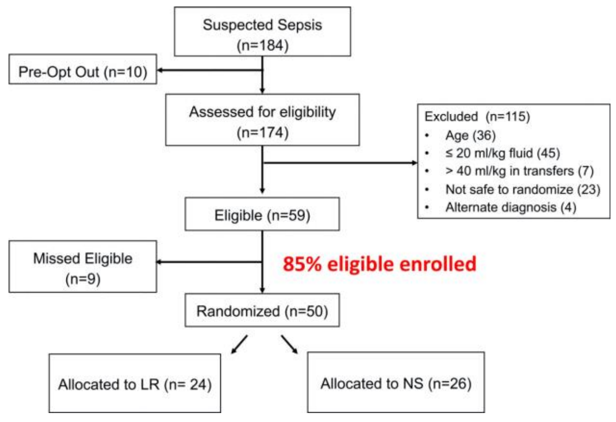

Figure 1.
Diagram of subject enrollment.

Patient Characteristics

Variable	LR Group (n = 24)	NS Group (n = 26)
Age (years)		
Median (IQR)	3.8 (2.0–10.4)	9.7 (2.6–16.3)
6 months to <1 year	1 (4)	2 (8)
1 to <6 years	14 (58)	8 (31)
6 to <13 years	5 (21)	7 (27)
13 to 17 years	4 (17)	9 (35)
Sex		
Female	11 (46)	12 (46)
Race/ethnicity		
Non-Hispanic white	11 (46)	11 (42)
Non-Hispanic black	3 (13)	4 (15)
Hispanic	10 (42)	9 (35)
Asian	0 (0)	1 (4)
Unknown/not reported	0 (0)	1 (4)
Comorbid conditions		
Cancer	4 (17)	5 (19)
Kidney disease (no dialysis)	2 (8)	1 (4)
Neurologic dysfunction	7 (29)	5 (19)
Chronic ventilator dependence	6 (25)	5 (19)
Bone marrow or solid organ transplant	3 (13)	2 (8)
Sickle cell disease	0 (0)	2 (8)
Indwelling central venous catheter	6 (25)	4 (15)
Any comorbid condition	16 (67)	16 (62)
Site of infection		
Bacteremia	2 (8)	4 (15)
Pneumonia/lung infection	5 (21)	5 (19)
Abdominal infection	1 (4)	0 (0)
Urinary tract infection	4 (17)	3 (12)
CNS infection	2 (8)	3 (12)
Skin/soft tissue infection	2 (8)	3 (12)
Other	6 (25)	6 (23)
Unknown	3 (13)	4 (15)
Alternative diagnosis other than infection	1 (4)	1 (4)
Enrollment method		
EFIC	22 (92)	22 (85)

Variable	LR Group	NS Group	Difference (95% CI)
Total crystalloid volumes administered			
Crystalloid fluid volume (mL/kg)			
Total fluid	107 (60 to 155)	98 (63 to 128)	−9 (−57 to 35)
Bolus fluid			
Prerandomization	20 (19 to 23)	20 (17 to 27)	0 (−1 to 4)
Postrandomization	38 (20 to 60)	33 (20 to 40)	−5 (−28 to 18)
Maintenance fluid			
Total	49 (18 to 88)	35 (24 to 78)	−14 (−50 to 18)
NS	0 (0 to 0)	21 (2 to 41)	21 (4 to 39)
LR	40 (9 to 78)	0 (0 to 0)	−40 (−68 to −11)
Other	0 (0 to 0)	0 (0 to 21)	0 (0 to 17)
Proportion of patients receiving ≥60 mL/kg as bolus fluid	9 (38)	11 (42)	
Adherence to study arm			
Fluid compliance among isotonic fluids[a,b]			
Pre- and postrandomization fluid[c]	15 (63)	23 (88)	
Postrandomization fluid	20 (83)	24 (92)	
Proportion of isotonic fluid as NS			
Pre- and postrandomization[c]	20 (13 to 35)	100 (100 to 100)	80 (69 to 85)
Postrandomization	0 (0 to 0)	100 (100 to 100)	100 (100 to 100)
Proportion of isotonic fluid as LR			
Pre- and postrandomization	80 (65 to 87)	0 (0 to 0)	−80 (−85 to −69)
Postrandomization	100 (100 to 100)	0 (0 to 0)	−100 (−100 to −100)

Data are reported as n (%) or median (IQR).

IQR = interquartile range; LR = lactated Ringer's; NS = 0.9% normal saline.

[a]Fluid compliance was defined as receipt of ≥75% of study fluid as LR in LR group and ≥90% of study fluid as NS in NS group.

Effectiveness and Safety Outcomes

Outcomes	LR Group	NS Group
Effectiveness outcomes		
[illegible]	[illegible]	[illegible]
All-cause hospital mortality, censored at 90 days	0	1 (4)
Hospital length of stay (days)	5 (3–8)	3 (2–9)
Hospital-free days out of 28 (days)	23 (20–25)	25 (20–26)
New inpatient RRT	0	0
Safety outcomes		
Hyperlactatemia	2 (8)	4 (15)
Hyperkalemia	1 (4)	2 (8)
Hypercalcemia	0	4 (15)
Hypernatremia	0	1 (4)
Hyponatremia	0	0
Hyperchloremia	3 (13)	7 (27)
Thrombosis	0	0
Cerebral edema	1 (4)	0
Additional adverse events		
Vasoactive infusion	3 (13)	3 (12)
Mechanical ventilation	7 (29)	6 (23)
Seizure	1 4)	2 (8)
Acute kidney injury	0	1 (4)
Hepatic dysfunction	0	1 (4)
Rash	4 (17)	4 (15)
Pressure injury	1 (4)	0

- Définitions des solutés balancés
- Rappels biochimiques
- Utilisation des solutés balancés chez l'adultes
- Indications des solutés balancés chez l'adultes
- Un peu d'histoire
- Les different types de solutes
- Utilisation des solutés balancés en pediatrie
- Indication des solutés balances en pédiatrie

Indications en Pédiatrie

Recommendation #20	**Strength & Quality of Evidence**
We ***suggest*** using crystalloids, rather than albumin, for the initial resuscitation of children with septic shock or other sepsis-associated organ dysfunction. **Remarks:** Although there is no difference in outcomes, this recommendation takes into consideration cost and other barriers of administering albumin compared with crystalloids.	☐ Weak ☐ Moderate-Quality of Evidence
Recommendation #21	**Strength & Quality of Evidence**
We ***suggest*** using balanced/buffered crystalloids, rather than 0.9% saline, for the initial resuscitation of children with septic shock or other sepsis-associated organ dysfunction.	☐ Weak ☐ Very Low-Quality of Evidence

SCC 2021

Au total ADULTE

- Peu ou pas d'études de qualité
  - PLUS, BaSICS
  - Mais pas de contrôle des solutés avant la réa
- Sepsis : SB dès le départ ? (Jackson *et al.*, Zampieri *et al.*)
  - Mais limites méthodologiques de ces études
- SSI ou SB ?
  - En dehors peut-être de situations particulières (TC…) : peu d'arguments pour privilégier de façon formelle un type de soluté
  - Hyperkaliémie ?
    - Résultats discordants après transplantation rénale

Zampieri et al., AJRCCM 2022;205(12):1419-1428

Au total PEDIATRIE

- Peu ou pas d'études de qualité
  - En attente de étude Weiss
- Sepsis : SB dès le départ
- Balancé oui
- RL oui MAIS suivre la litterature

Méta analyses sepsis

Resuscitation fluid types in sepsis, surgical, and trauma patients: a systematic review and sequential network meta-analyses

- Sepsis
  - Une grande partie ne comparaient pas SSI et SB
  - Année de publication : 1983-2018 (SSI) vs 2008-2018 (SB)
  - Mortalité des études incluses allait de 15,3 à 66,7%
    - SMART : 79% des patients ayant reçu un SB contre 41% pour le SSI
  - Mortalité retenue : la plus tardive publiée (J28 à J90)
    - Caironi *et al. :* mortalité passe de 32 à 44% entre J28 et J90
  - Score SOFA plus élevé dans le groupe SSI (8.6±1.3 vs. 6.0±1.1)
  - 1 étude publiée uniquement sous forme d'abstract comparant albumine et SSI administré sans objectifs hémodynamiques
  - 1 étude publiée en chinois

Tseng *et al. Crit Care* (2020) 24:693
https://doi.org/10.1186/s13054-020-03419-y

Balanced Crystalloids versus Normal Saline in Adults with Sepsis: A Comprehensive Systematic Review and Meta-Analysis

Table 1. Study and patient characteristics of the included studies.

	Study, Year	Study Design	Country	Total n (BC/NS)	Male, n	Age, Mean ± SD or Median (IQR), Years	Severity of Sepsis (BC/NS)	Enrollment Location	Type of BC	Fluid Volume (BC/NS), Mean ± SD or Median (IQR) mL	Follow-Up Duration
	Annane, 2013	RCT	France	594 (37/557)	NR	NR	NR	ICU	LR	NR	90 days
	Duffy, 2018	RC	USA	1218 (680/538)	581	60.6 (18.7)/60.6 (18.7)	qSOFA: 0.68 (0.76)/ 0.68 (0.76)	ED	Normosol-R	Total: 6000 ± 4600/ 6500 ± 4800	NR
PLUS	Finfer, 2022	RCT	Australia and New Zealand	2094 (1068/1026)	NR	NR	NR	ICU	Plasma-Lyte 148	NR	90 days
	Golla, 2020	RCT	India	160 (80/80)	85	43.46 ± 17.99/ 42.44 ± 19.37	SOFA: 7.64 ± 2.56/ 7.63 ± 2.49	ED	LR	NR	30 days
	Jaynes, 2017	RC	USA	410 (201/209)	220	61 ± 14.1/58 ± 14.7	APACHE II: 16.7 ± 6.1/ 17.3 ± 5.9	ICU	LR and Electrolyte-A	Total: 6750 (4013–10,000)/6500 (4550–12,000)	NR
	Limapichat, 2021	RC	Thailand	120 (20/100)	75	69 (59.8–80)/ 68 (57–82.2)	NEWS: 9 (7, 10.2)/ 10 (8, 12)	ED	LR	NR	2 days
	Mao, 2018	RC	China	198 (98/100)	105	72 ± 9/73 ± 10	NR	ICU	LR	First 72 h: 5092 ± 929/ 5470 ± 1078	NR
	Pagano, 2020	RCT	Italy	84 (35/49)	51	75.9 (12.3)/75.8 (12.1)	SOFA: 5.9 (2.9)/6 (2.8)	ED	LR	First 1 h: 1410/2130	NR
	Raghunathan, 2014	RC	USA	6730 (3365/3365)	NR	NR	NR	ICU	NR	NR	2 days
	Semler, 2017	RCT	USA	260 (130/130)	NR	NR	NR	ICU	LR or Plasmalyte	NR	30 days
SMART	Semler, 2018	RCT	USA	2336 (1167/1169)	NR	NR	NR	ICU	LR or Plasmalyte	NR	30 days
	Shaw, 2017	RC	USA	3116 (1558/1558)	1333	NR	NR	ED, ICU and ward	Plasma-Lyte or Normosol	NR	NR
	Tseng, 2021	RC	Taiwan	938 (302/636)	707	71.3 ± 15.6	APACHE II: 29 (6.4)/ 29 (6.4)	ICU	LR	First 24 h: 3172 (2442)/4587 (3776)	90 days
	Young, 2015	RCT	Australia and New Zealand	84 (41/43)	NR	NR	APACHE II: 14.1 (6.9)/14.1 (6.9)	ICU	Plasma-Lyte 148	First 24 h: 1200 (0–3000)/1000 (0–3000)	90 days
BaSICS	Zampieri, 2021	RCT	Brazil	1987 (970/1017)	NR	NR	NR	ICU	Plasma-Lyte 148	NR	90 days

Abbreviations: APACHE II: acute physiology and chronic health enquiry, BC: balanced crystalloids, ED: emergency department, n: sample size, ICU: intensive care unit, IQR: interquartile range, LR: lactated ringer, NS: normal saline, NR: not reported, RCT: randomized controlled trials, RC: retrospective cohort, SD: standard deviation, SOFA: sequential organ failure assessment.

J. Clin. Med. 2022, 11, 1971. https://doi.org/10.3390/jcm11071971

Outcomes (Number of Studies)	RR (95% CI)	*p*-Value	I^2	Subgroup Analysis Based on the Study Design			
				Study Design (Number of Studies)	RR (95% CI)	*p*-Value	I^2
Overall mortality (15)	0.88 (0.81–0.96)	0.005	51%	RCT (8)	0.92 (0.82–1.02)	0.11	41%
				Cohort (7)	0.83 (0.71–0.97)	0.02	58%
28/30-day mortality (6)	0.87 (0.79, 0.95)	0.003	0%	RCT (4)	0.87 (0.77–0.97)	0.02	0%
				Cohort (2)	N/A	N//A	N/A
90-day mortality (5)	0.96 (0.90–1.03)	0.31	0%	RCT (4)	0.98 (0.90–1.05)	0.52	0%
				Cohort (1)	N/A	N/A	N/A
AKI (7)	0.85 (0.77, 0.93)	0.0006	0%	RCT (2)	0.71 (0.47–1.06)	0.09	0%
				Cohort (5)	0.84 (0.75–0.94)	0.003	14%
Need for RRT (6)	0.91 (0.76, 1.08)	0.28	0%	RCT (2)	0.71 (0.36–1.41)	0.33	0%
				Cohort (4)	0.92 (0.77–1.11)	0.39	0%
ICU LOS (3)	−0.25 (−3.44, 2.95)	0.88	98%	RCTs (0)	N/A	N/A	N/A
				Cohort (3)	−0.25 (−3.44, 2.95)	0.88	98%

Abbreviations: AKI: acute kidney injury, CI: confidence interval, ICU: intensive care unit, LOS: length of stay, N/A: not applicable, RCTs: randomized controlled trials, RRT: renal replacement therapy, RR: risk ratio. N/A: for outcomes that were reported by <2 studies.

études rétrospectives : effets délétères du SSI

études randomisées : pas (peu) d’effets délétères du SSI