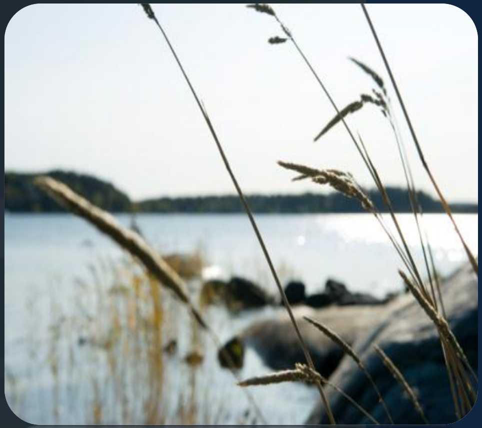



Evidence based EM
Management of fluids in children

CARLOS GARCIA ROSAS MD

Mexican Academy of Emergency Medicine

President

Fluids in children…….

- Deaths of children often occur within 24 h of admission ER.
- **Many of these could be prevented**
- **Appropriate treatment** immediately.

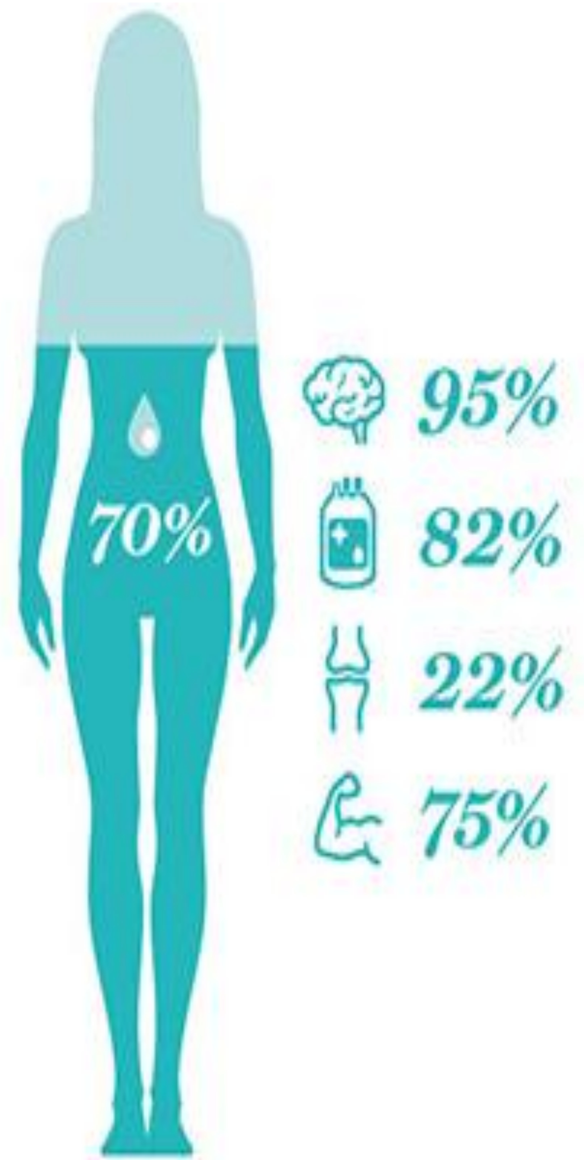
Fluids in children

- IV fluids constitute **one of the most important therapeutic measures** and frequently used ER.
- Its objective **is the correction of the electrolyte balance** in critical patients.

Fluids in children

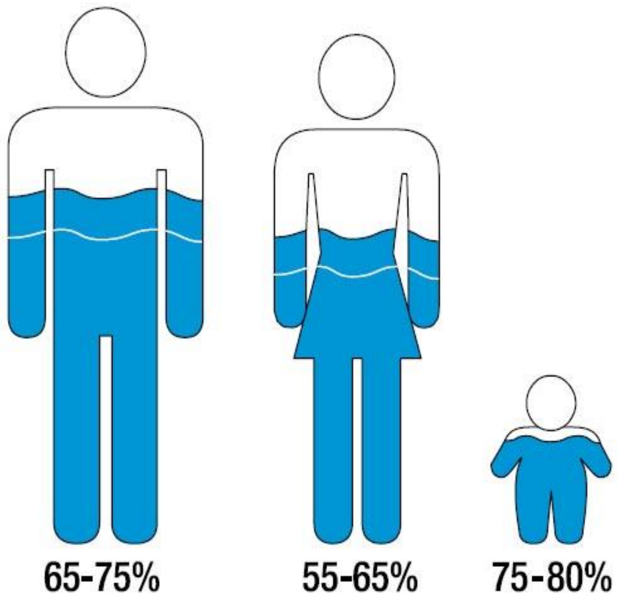
- The **management requires precise knowledge about the distribution** of body fluids and the **physiopathology** of hydroelectrolytic and acid-base imbalances.
- **The knowledge** is fundamentals to **adopt the appropriate measures in each circumstance choosing** correctly the **type of IV solution** and the **rhythm of administration**.

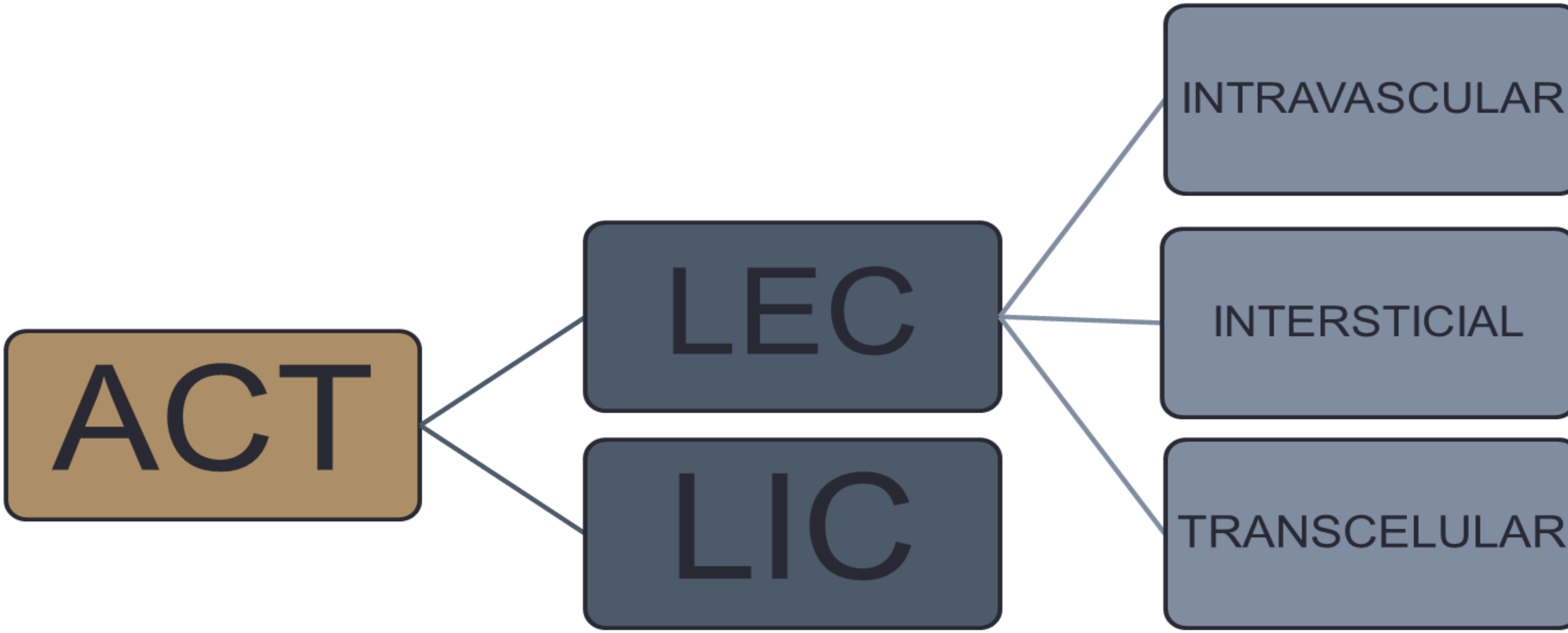

Porcentaje de agua en el cuerpo humano
100%
80%
70%
50%
Feto
Bebé en el nacimiento
Adulto normal
Persona anciana


70%
95%
82%
22%
75%

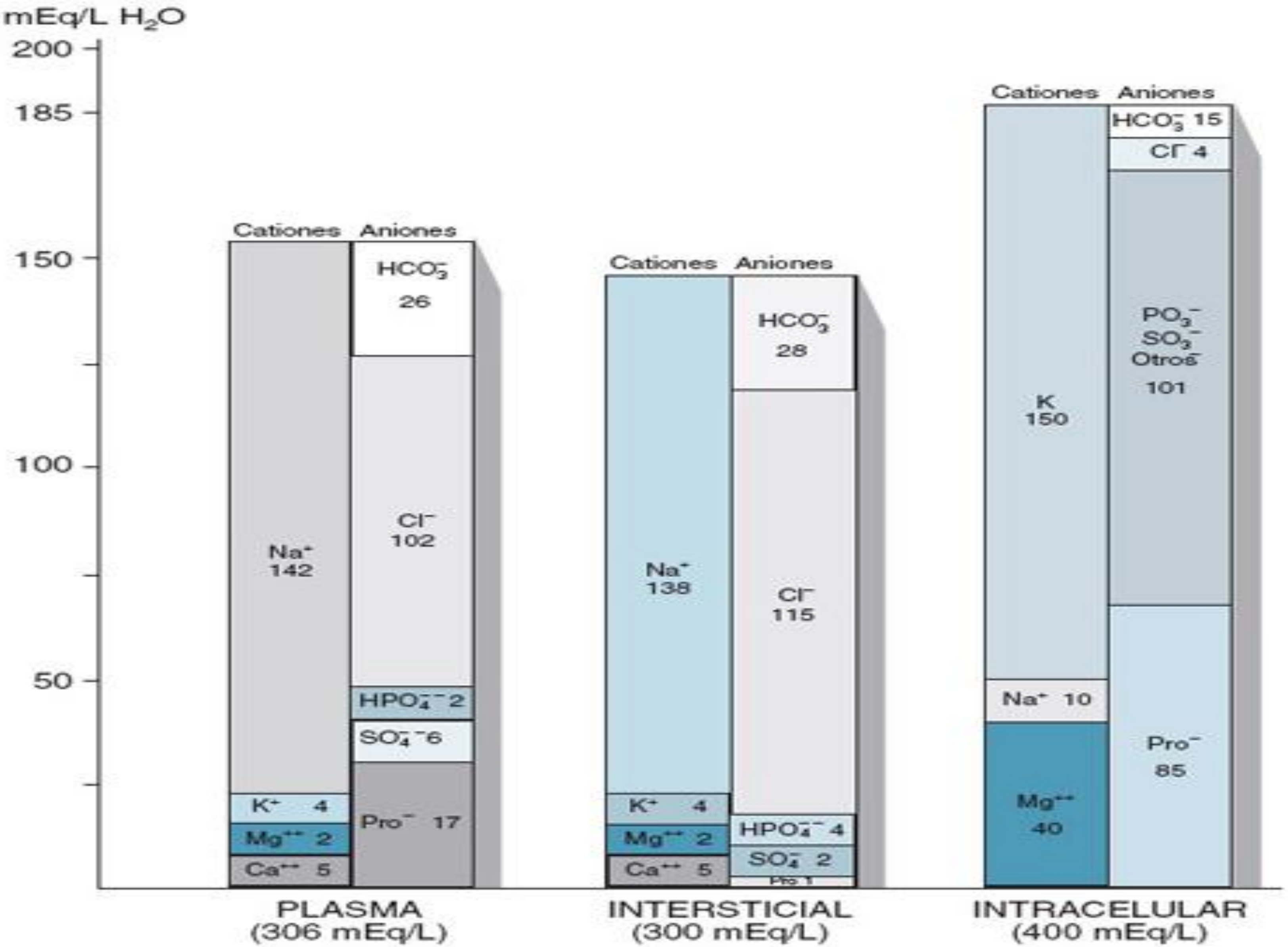
Body fluids

Age	Total body water	Extra cellular	intra cellular
PREMATURE	75-80%	50%	25-30%
New Born	65-70%	25%	40-45%
Teenager Female	55%	15%	40%
Teenager Male	60-65%	20%	40-45%




ACT
LEC
LIC
INTRAVASCULAR
INTERSTICIAL
TRANSCELULAR

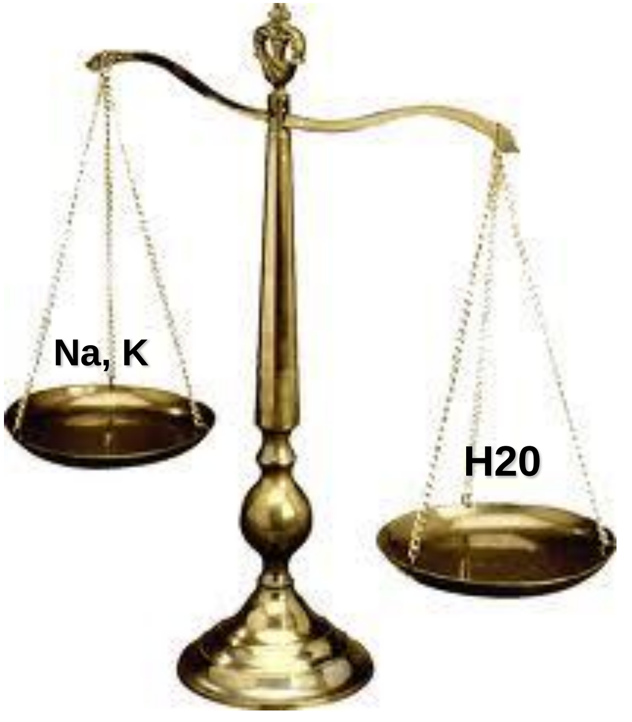
Distribution of electrolytes in different compartments



Homeostasis

- **State of equilibrium** that keeps the **internal body environment** and that is **due to the incessant interaction between all the regular processes of the body.**

- **An important aspect is the maintenance of the volume and composition of body fluids and electrolytes.**



Essential priorities of fluid therapy

1.- Preserve a constant effective volume

2.- Preserve **the normal plasma osmotic pressure**

3.-Preserve **ionic composition of each compartment….**

Keep a **normal pressure of hydrogenions in the different compartments**.

Essential priorities of fluid therapy Utilization

- ✓ Maintain hydration status
- ✓ **Replenishment of electrolytes** and nutrients in case of metabolic alterations (**diarrhea, vomiting,** heart failure, renal, diabetic **ketoacidosi**s)
- ✓ State of shock

Indications

1. Hypovolemic shock
- Hemorrhagic
- Non-hemorrhagic (burns, dehydration)

2.-Depletion of extracellular fluid
- Vomit
- Diarrhea
- Fistulas
- Ascitis 3rd space
- Ileus
- Kidney disorders

3.-Aqueous depletion
- Intake reduction
- Increase in losses
  - -Excessive withdrawal
  - -diabetes insipid
  - -Mechanical ventilation, etc.

4.-Saline depletion
- Diuretics
- Nephropathies
- Digestive losses
- Suprarrenal insufficiency

5. Hypernatremia
- Kidney causes
- Extra renal causes
- Insipid diabetes

Monitored Clinical

Clinical signs of hyper or hypovolemia

1. Diuresis
2. Tonicity of the skin (skin folds, edema)
3. Heart rate
4. Respiratory rate
5. Temperature
6. Alert status

Laboratory monitoring

- **Hematocrit** (hemo concentration)
- **Electrolytes:** Na +, K +, Cl-
- **Blood chemistry**: Glycemia, Urea, Creatinine
- **ABG:** Acid-base status and / or deficit
- Plasma **osmolarity:** arterial

2 x [Na +] + [glucose / 18] + Urea / 5.6] = Normal 285-305mOsm / l

- **Lactate: its increase is linked** to the decrease of **tissue perfusion** and the increase of **anaerobic metabolism**

Invasive monitoring

- Central venous pressure
- Pulmonary capillary pressure
- Saturation of hemoglobin
- Cardiac output
- Oxygen supply
- Oxygen consumption

Requirements

Mode	Requirements
Body Weight	100-200 ml/Kg/ día
Body surface	1500-1800 ml/sqm bs/día
Caloric expenditure	<10 Kg: 100 cal x Kg 10-20 Kg: 50 cal x (peso-10Kg) + 1000cal. >20Kg: 20cal x (peso-20Kg) + 1500cal.

Requirements

WATER REQUIREMENTS

- Calculate in cc / kg / weight up to 2 years or 10 kg
- Calcúlate in cc / Sqm SCT in greater than 10kg

MINIMUM WATER REQUIREMENT

INSENSIBLE LOSSES
+
RENAL COMPULSORY WATER

800 CC / M2 SCT / DAY OR 80 CC / KG / DIA

The Holliday – Segar 4-2-1 Rule

to estimate Maintenance Hourly Fluid (WATER) Requirements

Weight (kg)	Hourly	Daily
<10 kg	4 mL/kg/hr.	100 mL/kg/day
10 –20 kg	40 mL + 2 mL/kg for every kg >10 kg	1000 mL + 50 mL/kg/day for every kg >10
>20 kg	60 mL + 1 mL/kg for every kg >20 kg	1500 mL + 20 mL/kg/day for every kg > 20

CALCULATION OF BASAL REQUIREMENTS

1000-1500 CC/sqm tbs/Day

Calculation of body surface according to weight

TBS = Weight X 4 + 7 / w + 90> 10 Kg

TBS = W X 4 + 9/100 <10 Kg

Routine maintenance

- **Calculate routine maintenance IV fluid rates for children and young people using the Holliday–Segar formula**

- **(100 ml/kg/day for the first 10 kg of weight,**
- **50 ml/kg/day for the next 10 kg and**
- **20 ml/kg/day for the weight over 20 kg).**
- Be aware that over a 24-hour period,
- males rarely need more than 2500 ml and females rarely need more than 2000 ml of fluids.

- **Calculate routine maintenance IV fluid rates for term neonates according to their age, using the following as a guide:**

- From birth to day 1: 50–60 ml/kg/day.
- Day 2: 70–80 ml/kg/day.
- Day 3: 80–100 ml/kg/day.
- Day 4: 100–120 ml/kg/day.
- Days 5–28: 120–150 ml/kg/day.

HYDRIC BALANC

WATER INCOME Variable 1200-1800cc / sqm / day Oral water

Preformed water

(water in the LIC that is released to the LEC by hyper metabolic states)

Oxidation water (oxidation of carbohydrates and fat)

HYDRIC BALANC

WATER EXPENSES Variable 1500 cc / m2 / day

Insensitive losses (35 -45 ml / 100cal / day)

- Urine
- Stool
- Sweat
- Temperature
- breathing

Different periods of time driven
By physiology for children who require IV fluids

1.-Resuscitation phase. is the window of **acute presentation, when IVF is needed to restore adequate tissue perfusion and prevent lesions.**

2.-**Titration phase.** is the moment when IVF goes from bowling to maintenance; This **is a critical window to determine what intravascular repletion has been achieved and the trajectory of fluid gains versus losses** in children who are seriously ill.

Different periods of time driven
By physiology for children who require IV fluids

3.-Maintenance phase. has the fluids administered during the 2 previous stabilization phases and **it is a moment in which the fluids must be supplied to achieve a precise homeostatic equilibrium between the needs and the losses.**

4.- Convalescence phase. reflects **the period in which the administration of exogenous fluid is stopped and the patient returns to the intrinsic regulation of the fluid**

XIV National Congress in Emergency Medicine

ACADEMIA MEXICANA DE MEDICINA DE URGENCIA
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COMITE MEXICANO PARA EL CUIDADO DEL CORAZÓN Y TRAUMA

Be careful……..

“The dose of fluid during these 4 phases needs to be adjusted on the basis of the unique physiologic needs of each patient, and **a specific protocoled dose is not able to be applied to all Patients”**

- **The need for IV fluids in patients in ER**, there is little consensus about the type and amount of liquids to be administered, **in practice with respect to liquids, it varies widely.**
- These patients often have conditions that impair the normal homeostasis of water and electrolytes, **so the choice of the appropriate type and amount of volume requires great care.**
- **They can be classified according to the concentration of sodium plus potassium in the fluid**

Type of solutions

Crystalloids:

Colloids

Type of solutions

Crystalloids:

- **Expanding capacity given by Na +**
- Hypo <300mOsm, Iso 300mOsm, Hypertonic> 300mOsm compared to plasma
- Allows to **maintain hydroelectrolitic balance** between compartments.
- Base components: H2O, CLNa, Electrolytes and / or Glucoside
- **75-80 % the vol passes to Interstitial space**
- **20-25% stay intravascular space**
- **Time 15 min**

Type of solutions

Colloids:

Starches

- **Maintains plasma colloid pressure**
- Does not leave the intravascular space so quickly
- **Excellent volume expander.**

Gelatin

- Derived from glycopeptins
- Modified by group addition. Hydroxyethyl
- Derivatives of bovine collagen (not available in many countries, 2 types of urea bridge and succinylated forms
- Dosage: 20-40ml in / 24h

Dextran-albumin

- Most used expanders initially
- Greater side effects and toxicity
- Excreted mainly by the kidneys
- Dosage 1.5gr / Kg or 1500ml / 24h

Cristaloides

	Tonicidad (mOsm/l)	Na+ (mEq/l)	Cl- (mEq/l)	K+ (mEq/l)	Ca2+ (mEq/l)	Glucosa (g/dl)	Tampón (mEq/l)
S. Salina 0,9%	308	154	154				
Ringer Lactato	273	130	109	4	2,7		27 Lactato
Glucosado 5%	253					50	
Glucosalino	313	60	60			35	
Isofundin®	304	145	127	4	2,5 Mg2+ 1		24 Acetato 5 Malato
Plasmalyte®	295	140	98	5			23 Gluconato 27 Acetato
Plasma	291	135-145	95-105	3,5-5	4,5-5	80-120	

Table of intravenous fluid types

Intravenous fluid types for children and young people

Fluid with recommendation reference	Fluid type[a]	Osmolality (compared with plasma)	Tonicity (with reference to cell membrane)	Sodium content (mmol/litre)	Potassium content (mmol/litre)
Isotonic crystalloids that contain sodium in the range 131–154 mmol/litre [10, 11, 17, 26, 29, 32]	0.9% sodium chloride	Isosmolar	Isotonic	154	0
	Hartmann's solution	Isosmolar	Isotonic	131	5
Isotonic crystalloids with glucose that contain sodium in the range 131–154 mmol/litre [21]	0.9% sodium chloride with 5% glucose	Hyperosmolar	Isotonic	150	0
Hypotonic fluids [29, 32]	0.45% sodium chloride with 5% glucose	Hyperosmolar	Hypotonic	75	0
	0.45% sodium chloride with 2.5% glucose	Isosmolar	Hypotonic	75	0
	0.45% sodium chloride	Hyposmolar	Hypotonic	75	0
	5% glucose	Isosmolar	Hypotonic	0	0
	10% glucose	Hyperosmolar	Hypotonic	0	0

a Fluids given are examples of appropriate fluids; for further details, see the British national formulary for children.

Indications of the most used liquids

Fluid	indications
◆ **Artificial colloids** **Dextrans, Haemacell**	Volume replacement, hypovolemia
◆ **Natural colloids** **Albumin**	Burns, Ascites, Nephrotic syndrome
◆ **Physiological solution**	Volume reposition Hypovolemic shock Hypochloremia
◆ **Hypertonic saline**	Hypovolemic Shock Big Burns Head trauma
◆ **Lactated Ringer**	Hypovolemic Shock volume reposition
◆ **Glucose 5%**	Hypertonic dehydration hypernatremia

Characteristics of different stages of resuscitation

NPO, nil per os; ATN, acute tubular necrosis; SSC, surviving sepsis campaign

	Rescue	Optimization	Stabilization	De-escalation
Principles	Lifesaving	Organ rescue	Organ support	Organ recovery
Goals	Correct shock	Optimize and maintain tissue perfusion	Aim for zero or negative fluid balance	Mobilize fluid accumulated
Time (usual)	Minutes	Hours	Days	Days to weeks
Phenotype	Severe shock	Unstable	Stable	Recovering
Fluid therapy	Rapid boluses	Titrate fluid infusion conservative use of fluid challenges	Minimal maintenance infusion only if oral intake inadequate	Oral intake if possible Avoid unnecessary i.v. fluids
Typical clinical scenario	- Septic shock - Major trauma	- Intraoperative GDT - Burns - DKA	- NPO postoperative patient - 'Drip and suck' management of pancreatitis	- Patient on full enteral feed in recovery phase of critical illness - Recovering ATN
Amount	Guidelines, for example, SSC, pre-hospital resuscitation, trauma, burns, etc.			

Table 1 Characteristics of different stages of resuscitation: 'Fit for purpose fluid therapy'. GDT, goal directed therapy; DKA, diabetic keto acidosis; NPO, nil per os; ATN, acute tubular necrosis; SSC, surviving sepsis campaign

Figura 1. *Comportamiento del volumen administrado en las diferentes fases de la resucitación.*

Aggregate Evidence Quality	Benefit or Harm Predominates	Benefit and Harm Balanced
Level A Intervention: well designed and conducted trials, meta-analyses on applicable populations Diagnosis: independent gold standard studies of applicable populations	Strong recommendation	Weak recommendation (based on balance of benefit and harm)
Level B Trials or diagnostic studies within minor limitations; consistent findings in from multiple observational studies	Moderate recommendation	
Level C Single or few observational studies or multiple studies with inconsistent findings or major limitations		
Level D Expert opinion, case reports, reasoning from first principles	Weak recommendation (based on low quality evidence)	No recommendation may be made

Level X Exceptional situations in which validating studies cannot be performed, and there is a clear preponderance of benefit or harm	Strong recommendation Moderate recommendation

November 30, 2018

New Pediatric Intravenous Fluid Guideline

John D. Cowden, MD, MPH reviewing Feld LG et al. Pediatrics 2018 Nov 26

The AAP strongly recommends the use of isotonic maintenance intravenous fluids for most pediatric patients.

Sponsoring Organization: American Academy of Pediatrics (AAP)

Target Population: Medical and surgical patients aged 28 days to 18 years on critical care and general inpatient services

Background and Objective

Children requiring maintenance intravenous fluids (IVFs) have long been given hypotonic solutions such as quarter or half normal saline. Concerns about iatrogenic hyponatremia have led to growing use of isotonic solutions instead. The AAP's Subcommittee on Fluid and Electrolyte Therapy performed a systematic review of the literature, which they used to inform the creation of a clinical practice guideline on the tonicity of pediatric maintenance IVFs.

Key Recommendation

- Patients aged 28 days to 18 years requiring maintenance IVFs should receive isotonic solutions with appropriate potassium chloride (KCl) and dextrose.
- The guideline does not apply to patients in the neonatal intensive care unit or those with neurosurgical disorders, cardiac disease, hepatic disease, cancer, renal dysfunction, diabetes insipidus, voluminous watery diarrhea, or severe burns.

This recommendation was based on clear evidence of reduced risk of hyponatremia and no evidence for increased risk of potential harms (i.e., hypernatremia, metabolic acidosis, fluid overload, hypertension, or acute renal injury).

COMMENT

For decades, inpatient fluid management was informed by theory and tradition rather than clinical studies. The arrival of this clinical practice guideline, based on a rigorous review of high-quality evidence, will reassure clinicians already using isotonic maintenance IVFs and should prompt those

Pediatrics
December 2018, VOLUME 142 / ISSUE 6
From the American Academy of Pediatrics
Clinical Practice Guideline

Clinical Practice Guideline: Maintenance Intravenous Fluids in Children

Leonard G. Feld, Daniel R. Neuspiel, Byron A. Foster, Michael G. Leu, Matthew D. Garber, Kelly Austin, Rajit K. Basu, Edward E. Conway Jr, James J. Fehr, Clare Hawkins, Ron L. Kaplan, Echo V. Rowe, Muhammad Waseem, Michael L. Moritz, SUBCOMMITTEE ON FLUID AND ELECTROLYTE THERAPY

The evidence-based guide recommends…….

- IV fluids (IVF) are **used to provide critical support** to children **who are seriously ill.**
- That can not be provided by the use of enteral administration for reasons such as **gastrointestinal disease, respiratory compromise, neurological disturbance, a perioperative state, or being moribund from an acute or chronic disease.**
- **Administration and control of electrolytes.**

The evidence-based guide recommends…….

- ✓ The administration of **hypotonic IVFs has been the standard in pediatrics**.
- ✓ This approach results in a **high incidence of hyponatremia ………..**

The evidence-based guide recommends…….

- **Isotonic solutions** for children who need IV fluids **could prevent the development of hyponatremia**

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The Key Action Statement of the subcommittee is:

1A: Quality of evidence. Strong Recomendation

The American Academy of Pediatrics recommends that patients 28 days to 18 years of age requiring IVF should receive **isotonic solutions with appropriate potassium chloride and dextrose because they significantly reduce the risk of developing hyponatremia.**

Personalised fluid resuscitation

Requires careful attention to the mnemonic CIT TAIT:

- **Context**
- **Indication**
- **Targets**

- **Timing,**
- **Amount of fluid,**
- **Infusion strategy**
- **Type of fluid.**

Background

- Although there is no universally accepted definition, personalised medicine has been described as

“A medical model using characterization of individuals”

phenotypes and genotypes (e.g. molecular profiling, medical imaging, lifestyle data)

Background

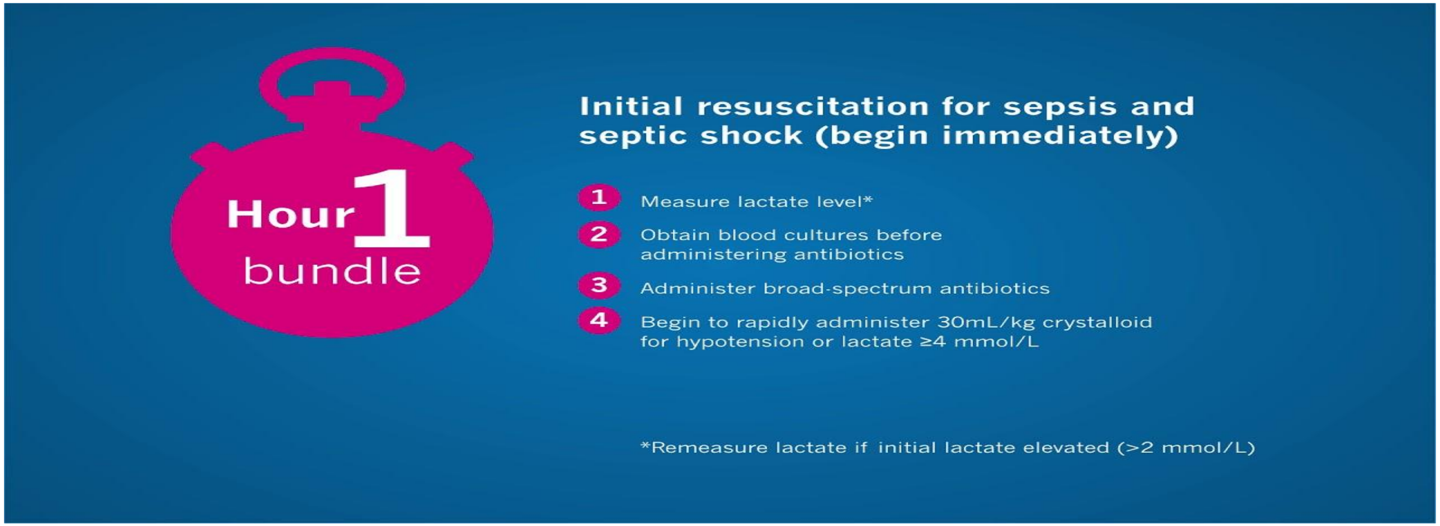
- **For tailoring the right therapeutic strategy for the right person at the right time, and/or to determine the predisposition to disease and/or to deliver timely and targeted prevention"**.
- This definition was used by EU Health Ministers in their Council conclusions on personalised medicine for patients, **published in 2015.**

- Because of the way ER “Shock units” have developed over the years, **one could argue that they perhaps offer the ultimate environment for real-time personalised medicine.**

- **EM patients are significantly heterogeneous, underlining the need for personalised medicine** principles.

intravenous fluids

- **In the case of sepsis**, the bench-to-bedside evidence supporting fluid resuscitation as a **treatment remains remarkably weak and highly conflicting.**
- Our current practice seems mainly to be based on historical beliefs and an incomplete or incorrect understanding of the pathophysiology of sepsis



Sepsis

- **Diagnosing sepsis requires interpreting non-specific signs and can therefore be subjective and variable**.
- In a recent survey, researchers presented case vignettes of patients with suspected or confirmed infection and organ dysfunction.

Context, Indication, and Targets

- It is important to differentiate between fluid substitution and volume substitution in EM

- In addition, and **again touching on patient heterogeneity, an intervention may be beneficial in one group of patients and harmful in another.**

Future Directions

In the Future, we need to focus on several important issues.

First, we need to educate clinicians about the risks of fluid loading patients who are not fluid responsive.

The potential of harm caused by fluid bolus therapy should more clearly feature in guidelines

Future Directions

- Implementation of a physiologic, haemodynamically guided conservative approach to fluid therapy in patients with sepsis would possibly reduce the morbidity and improve the outcome.

Future Directions

- **Second**, we urgently need to go back to the drawing board to design rigorous research to re-examine fluid therapy.
- **The effects of fluid infusion on the immune system, on endothelial function, and on the integrity of the glycocalyx remain poorly understood.**
- **Degradation of the glycocalyx on the vascular luminal cell membrane has been identified to be an early step in septic vascular endothelial cell disorder.**

Future Directions

- **Second**, **Fluid therapy has the potential to further damage the glycocalyx, especially when rapid infusions are used and when fluid infusion results in hyperkalemia**.
- we also require experimental studies that accurately reflect the presentation of human septic shock and clinical studies testing either lower volumes of fluid resuscitation or supportive care without fluid resuscitation.
- **Alternatives to fluid bolus therapy for the treatment of shock, such as the early use of vasoactive drugs**, need to be further assessed in prospective randomised studies

- **Third**, the concept of small-volume resuscitation using hypertonic fluids in sepsis deserves additional investigation.

- **Hypertonic resuscitation may provide effective and rapid intravascular volume resuscitation**.

- **In addition, some preliminary data suggest that hypertonic fluid administration in sepsis may have beneficial effects on the global circulation and the cardiac function that exceed simple intravascular volume expansion**

Conclusions

- **There is no ideal solution that guarantees a correlation with electrolyte abnormalities.**

- **It is important to individualize the liquid measures according to: physiology and pathology of the patient.**

- The surveillance of the monitoring, the adjustment in the composition and the volume of liquids according to the therapeutic objectives are essential for the safety of the patients.

XII Conference, London 2013

Proposes to define

1. Fluid Therapy Goals
2. Monitoring Methods
3. Different Clinical Contexts

Conclusions

- **Fluid resuscitation has long been one of the cornerstones of EM treatment**, albeit with a limited evidence base in terms of its effects on outcome.
- **An increasing body of literature suggests that fluid bolus therapy may contribute to fluid overload and cause harm,** partly because clinicians do not routinely test for fluid responsiveness and rarely apply safety limits.
- **The effects of fluid boluses on physiological parameters are not well studied, and seem small and short-lived at best.**

Conclusions

- Personalised fluid administration requires clinicians to integrate abnormal physiological parameters into a clinical decision-making.
- Personalised fluid resuscitation therefore requires careful attention to the mnemonic CIT TAIT: context, indication, targets, timing, amount of fluid, infusion strategy, and type of fluid.

Conclusions

- **Much of the progress that has been made in emergency medicine is the result of identifying and abandoning potentially harmful interventions and treatments.**
- Perhaps it is now time to add the indiscriminate use of fluid therapy to that list.

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