Fluids in special situations

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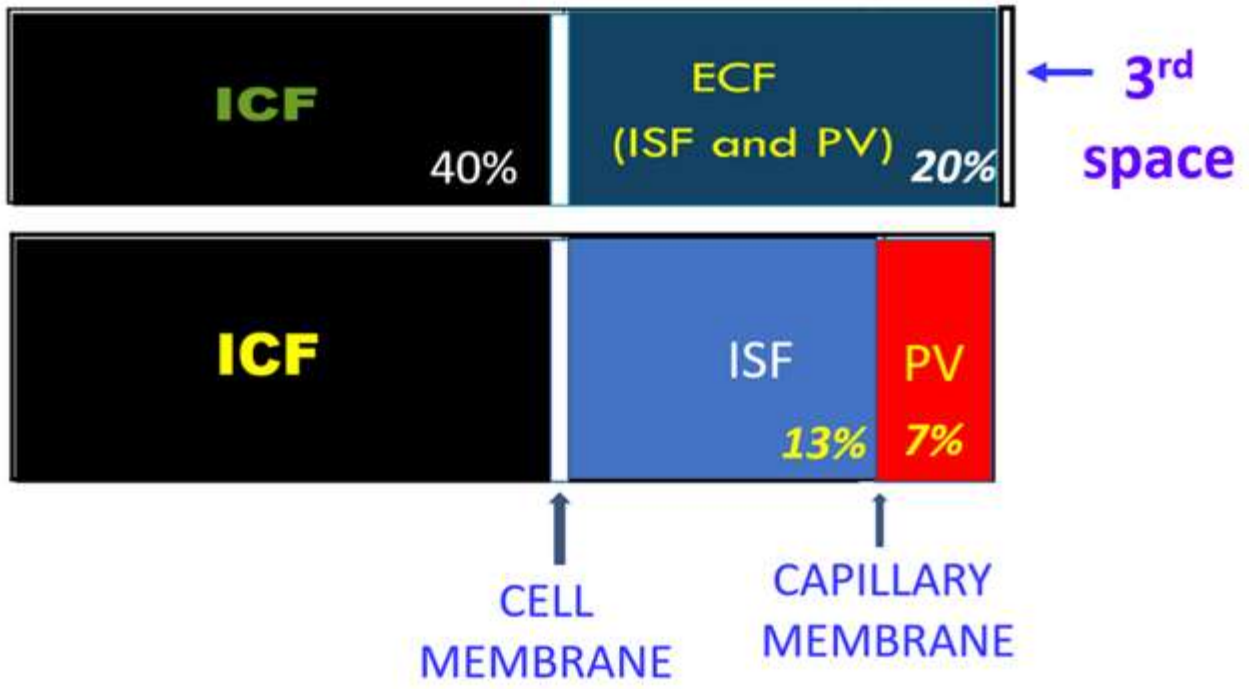
- Principles
- Terminologies
- Evaluation
- Identify -Fluid load
  Fluid deficit
- Comorbids
- Intervene
- Monitoring
- Summary

Principles

- 3 Compartments
- 2 Membranes
- Na travels with water

- Resuscitation
- Routine maintenance
- Replacement
- Redistribution
- Reassessment



Terminologies

- Osmolarity of a solution is the number of osmoles of solute per liter of solution
- Osmolality of a solution is the number of osmoles of solute per kilogram of solution
- Tonicity is the measure of the osmotic pressure gradient between two compartments/ solutions.

E.g Na (ICF/ECF). Effective osmoles will be retained Urea & gluc not included.

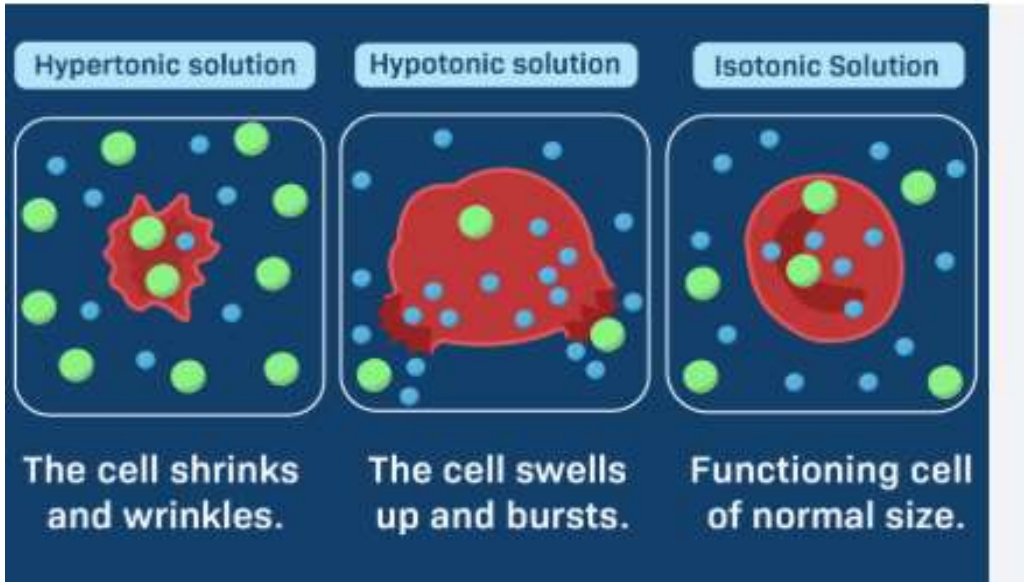
Osmolarity / Osmolality/Tonicity

moles of sugar / liter of coffee

Molarity

Moles of sugar / kg of coffee

Molality



Evaluation /monitoring

- History
- Monitoring of weight
- Clinical Assessment – vitals /fluid status
- Timed Intake output charts
- Lab evaluation of electrolytes
- Point of care ultrasound
- Bioimpedence

Calculation of fluids

- Holliday segar formula
- Fluids based on measured weight
- Use the Gut whenever feasible
- Fluids should include oral/ IV
- Input ----Calculate the infusions /antibiotics /sedation / boluses /blood products /medications /oral fluids/ then decide the IV fluids
- Output -- Urine /NG loss/ diarrhea/ drain/bleeds /ISL

Co-morbids

- Severe acute malnutrition(SAM)
- Anaemia
- Cardiac dysfunction
- Renal dysfunction
- Cerebral edema
- SIADH
- Capillary leak states

Prescription – Fluid is a drug

- What is the fluid status ?
- Why to give ?
- What route to give ?
- How much to give ?
- How long to give ?
- What exact content?
- What to monitor ?
- When to bolus ?
- When to Deescalate/ stop?

ROSE concept

- Resuscitate
- Optimize
- Stabilize
- Evacuate

ROSE concept of fluid management in critically ill children

Fluid loss

$$\frac{\text{Pre illness weight- current weight Kg}}{\text{pre illness weight Kg}} \times 100 = \%\ \text{of dehydration}$$

Or assess based on the clinical features of dehydration

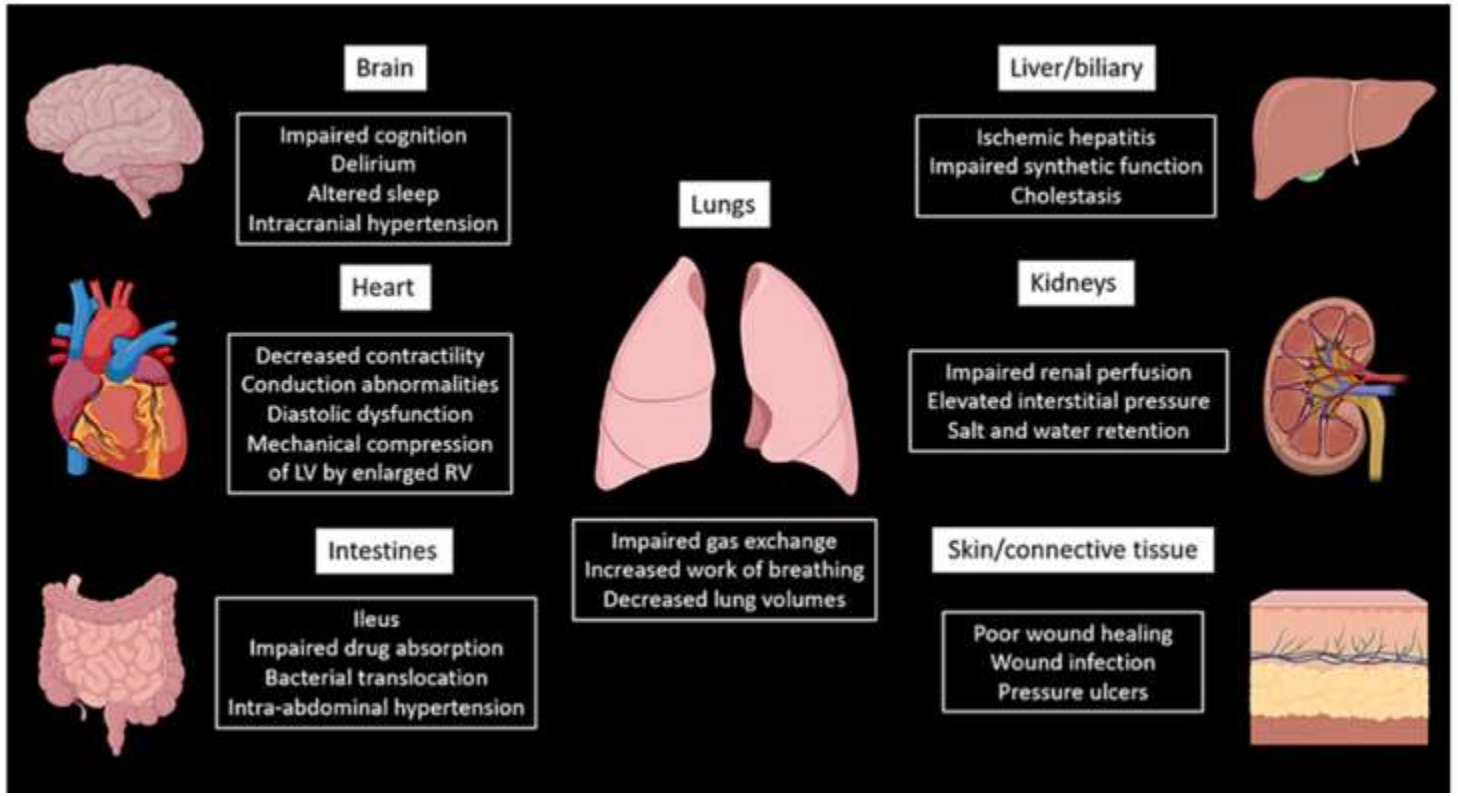
Appearence , eyes , thirst, skin turgor

Fluid Load

- Clinically significant" degree of FO could be below 10%

$$\%FO = \frac{\text{Sum of daily fluid (fluid in} - \text{fluid out)}}{\text{ICU admission weight}} \times 100.$$

Fluid Load – consequences



Fluid loss

Table 75.1	Clinical Evaluation of Dehydration

Mild dehydration (<5% in an infant; <3% in an older child or adult): Normal or increased pulse; decreased urine output; thirsty; normal physical findings

Moderate dehydration (5–10% in an infant; 3–6% in an older child or adult): Tachycardia; little or no urine output; irritable/lethargic; sunken eyes and fontanel; decreased tears; dry mucous membranes; mild delay in elasticity (skin turgor); delayed capillary refill (>1.5 sec); cool and pale

Severe dehydration (>10% in an infant; >6% in an older child or adult): Peripheral pulses either rapid and weak or absent; decreased blood pressure; no urine output; very sunken eyes and fontanel; no tears; parched mucous membranes; delayed elasticity (poor skin turgor); very delayed capillary refill (>3 sec); cold and mottled; limp, depressed consciousness

Nelson text book of pediatrics

Titrate the fluids

Table 74.7	Replacement Fluid for Diarrhea
AVERAGE COMPOSITION OF DIARRHEA	
Sodium: 55 mEq/L	
Potassium: 25 mEq/L	
Bicarbonate: 15 mEq/L	
APPROACH TO REPLACEMENT OF ONGOING LOSSES	
Solution: D5 1/2NS + 30 mEq/L sodium bicarbonate + 20 mEq/L KCl	
Replace stool mL/mL every 1-6 hr	

D5, 5% dextrose; NS, normal saline.

Table 74.8	Replacement Fluid for Emesis or Nasogastric Losses
AVERAGE COMPOSITION OF GASTRIC FLUID	
Sodium: 60 mEq/L	
Potassium: 10 mEq/L	
Chloride: 90 mEq/L	
APPROACH TO REPLACEMENT OF ONGOING LOSSES	
Solution: normal saline + 10 mEq/L KCl	
Replace output mL/mL every 1-6 hr	

Table 74.9	Adjusting Fluid Therapy for Altered Renal Output
OLIGURIA/ANURIA	
Replacement of insensible fluid losses (25–40% of maintenance) with D5 1/2NS	
Replace urine output mL/mL with D5 1/2NS ± KCl	
POLYURIA	
Replacement of insensible fluid losses (25–40% of maintenance) with D5 1/2NS ± KCl	
Measure urine electrolytes	
Replace urine output mL/mL with solution based on measured urine electrolytes	

D5, 5% dextrose; NS, normal saline.

Nelson text book of pediatrics

Monitoring

- History
- Weight
- Intake output chart
- Clinical assessment
- Bedside Ultrasound
- Lab evaluation

IVC

Normal IVC

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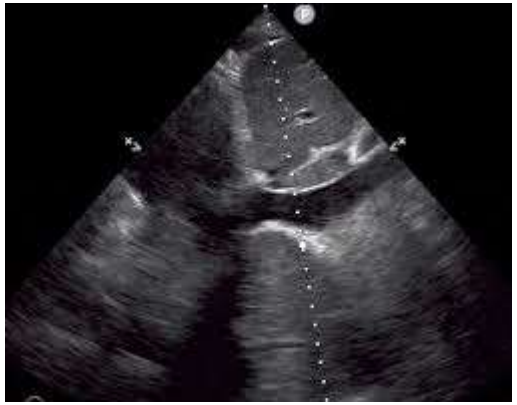
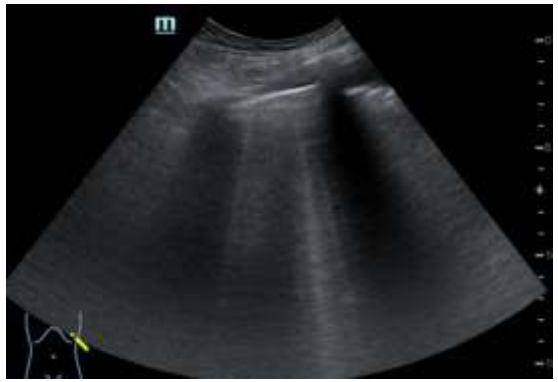
Dilated IVC

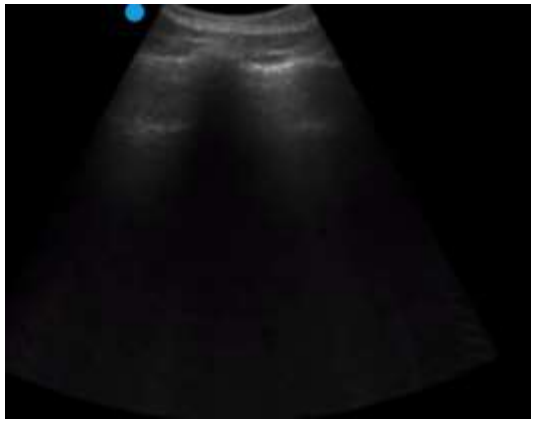


IVC- trends are useful

Lung ultrasound

Normal B lines





Abnormal B lines

summary

Step 1— Evaluate --based on weight/clinical features/IO chart
Step 2 – Dyselectrolytemia -look at sodium, potassium, magnesium
Step 3 – Identify ---Deficit/load
Step 4 –Comorbid states - SAM, organ involvement
Step 5 – Intervene
Step 1

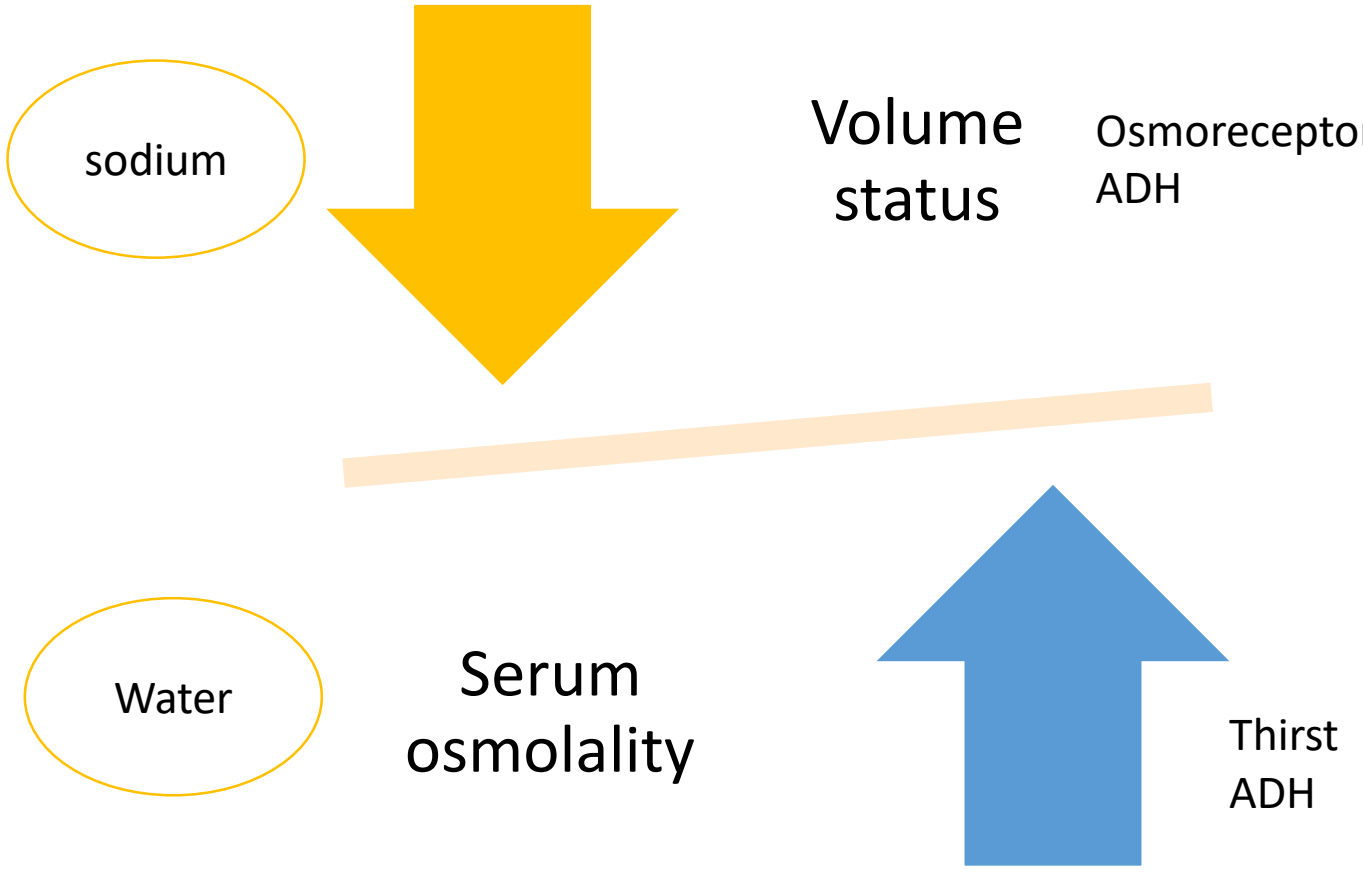
- Remember Evaluate identify intervene

Thank you

Dehydration

Nephkids 2025

Hydration/ water homeostasis



Dehydration

- Loss of normal fluid and electrolyte homeostasis

- Due to rapid and excessive fluid loss gastrointestinal tract (diarrhea and vomiting),
skin (fever, sweat, burns),
urine(glycosuria, diuretic therapy, obstructive uropathies, interstitial disease, neurogenic and nephrogenic diabetes insipidus).

Requirement of fluids

Maintenance fluids

Ongoing losses

Replacement fluids

Dehydration features

Deficit replacement

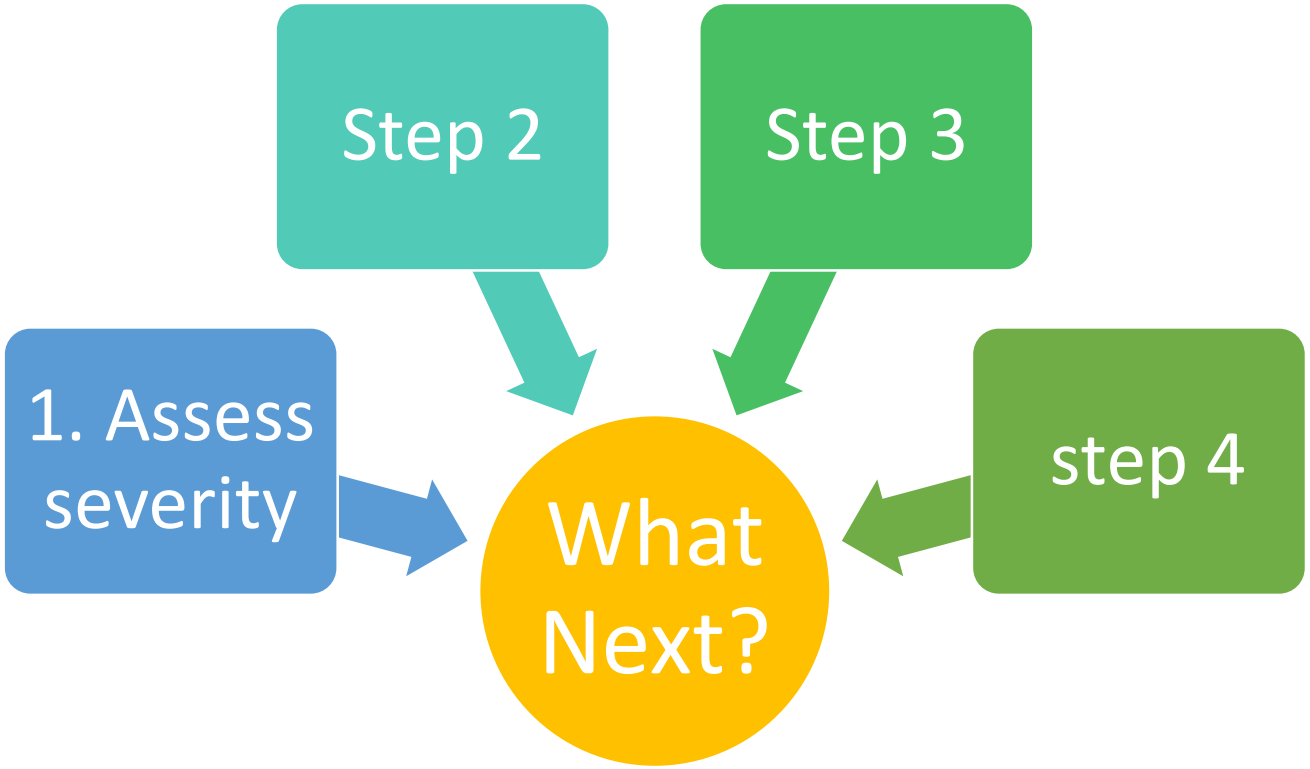
Hemodynamic compromise

Shock correction

Case 1

- 6 years old
- Fever, vomiting 8-10 episodes
- Loose stools watery 5-6 episodes
- Poor oral intake, lethargic

What next?

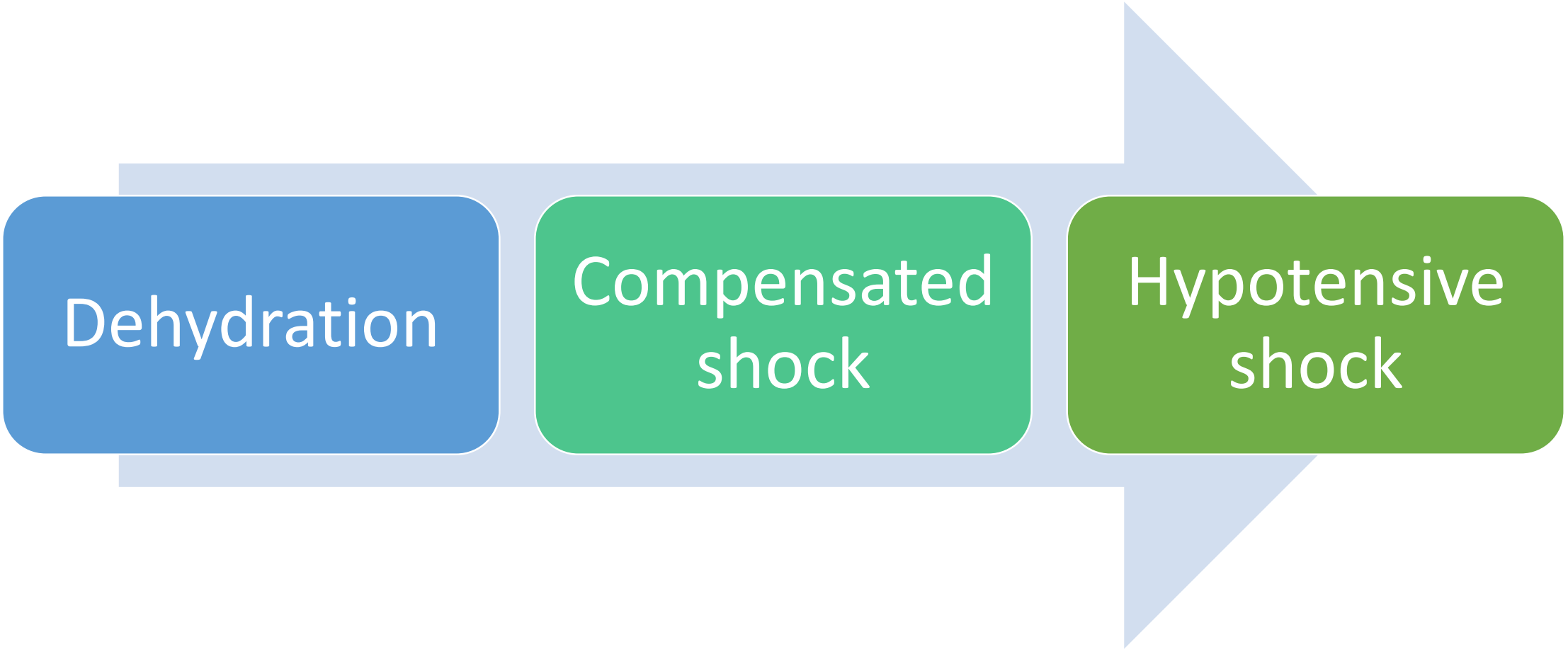


Step 1. Assess severity

Table 1. Degree of Fluid Deficit & Clinical Symptoms Associated with Dehydration

	Mild Dehydration	Moderate Dehydration	Severe Dehydration
Weight Loss Older child Infant	 3% (30 ml/kg) 5% (50 ml/kg)	 6% (60 ml/kg) 10% (100 ml/kg)	 9% (90 ml/kg) 15% (150 ml/kg)
Heart rate	Normal	Mildly increased	Marked tachycardia
Distal pulses	Normal	Slightly diminished	Weak, thready
Capillary refill	Normal	Approx. 2 seconds	>3 seconds
Urine output	Normal	Decreased	Anuria
Fontanelle	Flat	Soft	Sunken
Eyes	Normal	Normal	Sunken
Tearing	Normal	Diminished	Absent
Mucosa	Normal	Dry	Parched

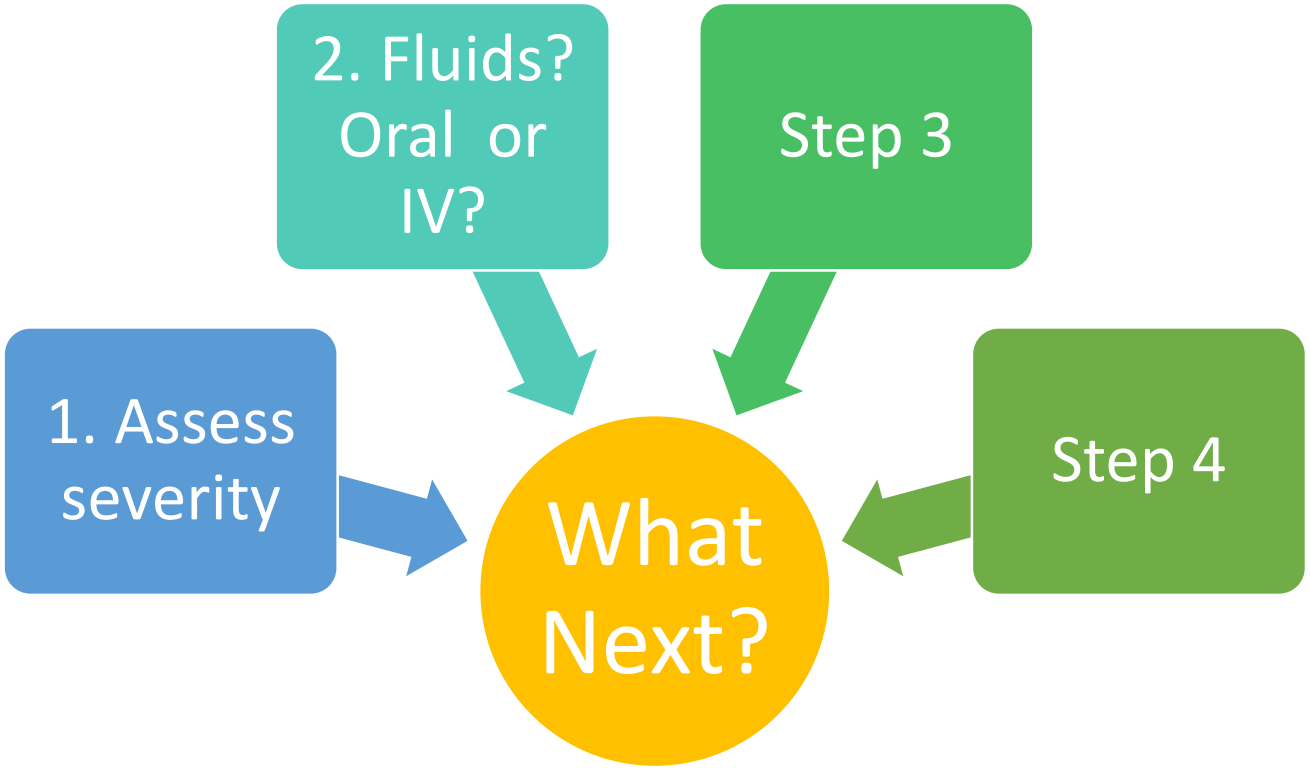
Adapted from Gunn VL, Nechyba C. The Harriet Lane Handbook, 16th edition. 2002.


Dehydration
Compensated shock
Hypotensive shock

The index case

- Airway Stable
- Breathing: Effortless Tachypnea
- Circulation: Tachycardic, perfusion good, Liver span N, BP increased, narrow pulse pressure
- Disability: lethargic
- Dehydrated
- CBG: 62mg/dl
- Temp: 102deg F

What next?



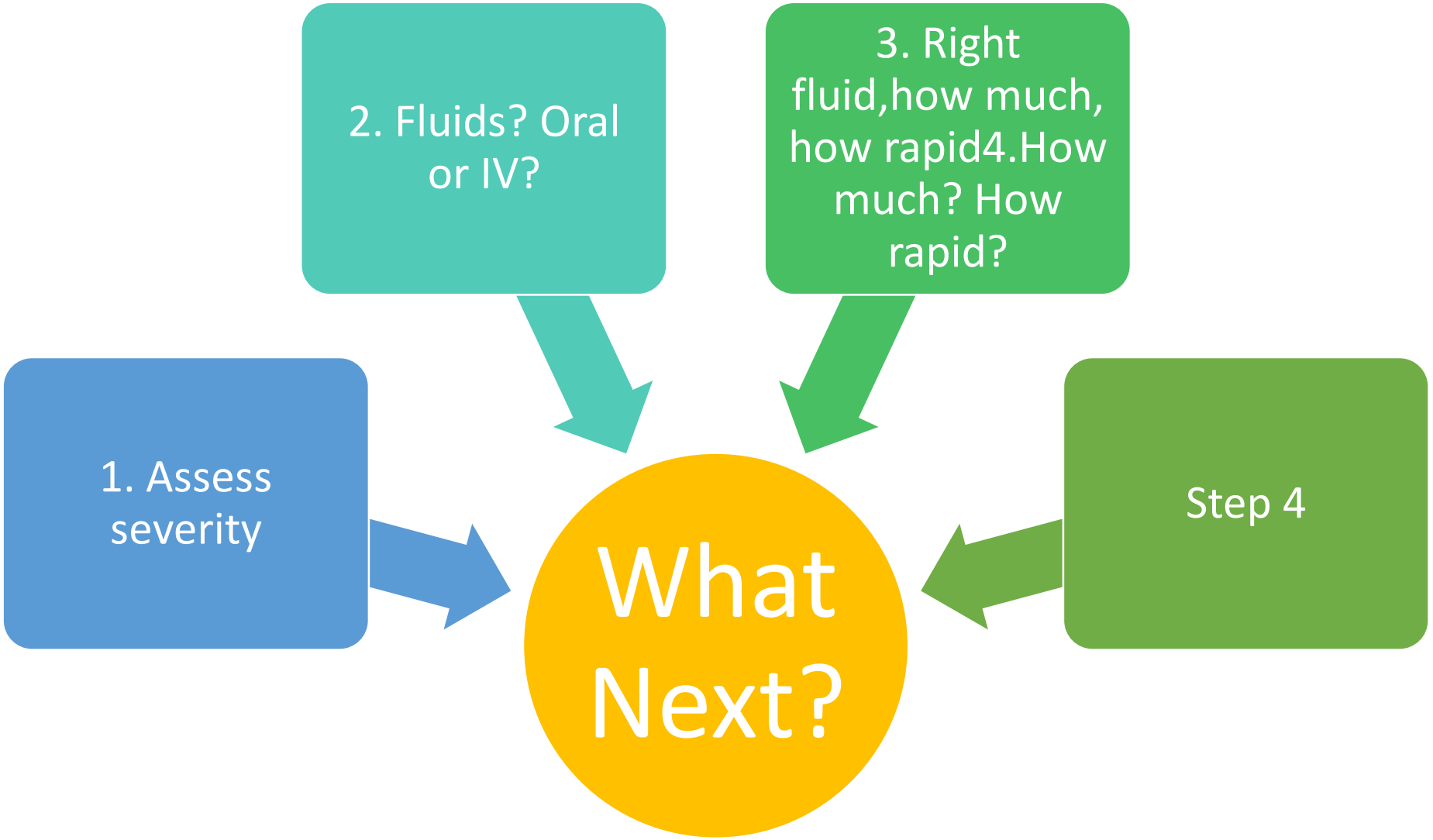
Oral/ Intravenous?

- SHOCK: Isotonic fluid IVF
- MODERATE DEHYDRATION:
  - ORS
  - IVF as second choice.
  - Isotonic fluid throughout
- NO/MILD: ORT
- On admission– Check electrolytes
  - HCO3 < 16, hyponatremia, hypoglycemia
  - In hyperosmolar dehydration (DKA, Hypernatremia) signs of dehydration are absent, because dehydration is intracellular

Oral rehydration for mild dehydration

- Step 1: deficit
  - Mild dehydration: 30-50ml/kg
  - Moderate dehydration: 50-75ml/kg
  - Severe dehydration: 70-100ml/kg
- Step 2: ongoing losses:
- replace one milliliter of fluid for every gram of output, stool, emesis, or urine.
- If measurements are not available, replacing 10 mL/kg body weight for each watery stool or 2 mL/kg body weight for each episode of emesis
- Step 3 maintenance

What next?


2. Fluids? Oral or IV?
3. Right fluid,how much, how rapid4.How much? How rapid?
1. Assess severity
What Next?
Step 4

Types of fluids

Variable	Human Plasma	Colloids									Crystalloids		
		4% Albumin	Hydroxyethyl Starch						4% Succinylated Modified Fluid Gelatin	3.5% Urea-Linked Gelatin	0.9% Saline	Compounded Sodium Lactate	Balanced Salt Solution
			10% (200/0.5)	6% (450/0.7)	6% (130/0.4)		6% (130/0.42)						
Trade name		Albumex	Hemohes	Hextend	Voluven	Volulyte	Venofundin	Tetraspan	Gelofusine	Haemaccel	Normal saline	Hartmann's or Ringer's lactate	PlasmaLyte
Colloid source		Human donor	Potato starch	Maize starch	Maize starch	Maize starch	Potato starch	Potato starch	Bovine gelatin	Bovine gelatin			
Osmolarity (mOsm/liter)	291	250	308	304	308	286	308	296	274	301	308	280.6	294
Sodium (mmol/liter)	135–145	148	154	143	154	137	154	140	154	145	154	131	140
Potassium (mmol/liter)	4.5–5.0			3.0		4.0		4.0		5.1		5.4	5.0
Calcium (mmol/liter)	2.2–2.6			5.0				2.5		6.25		2.0	
Magnesium (mmol/liter)	0.8–1.0			0.9		1.5		1.0					3.0
Chloride (mmol/liter)	94–111	128	154	124	154	110	154	118	120	145	154	111	98
Acetate (mmol/liter)						34		24					27
Lactate (mmol/liter)	1–2			28								29	

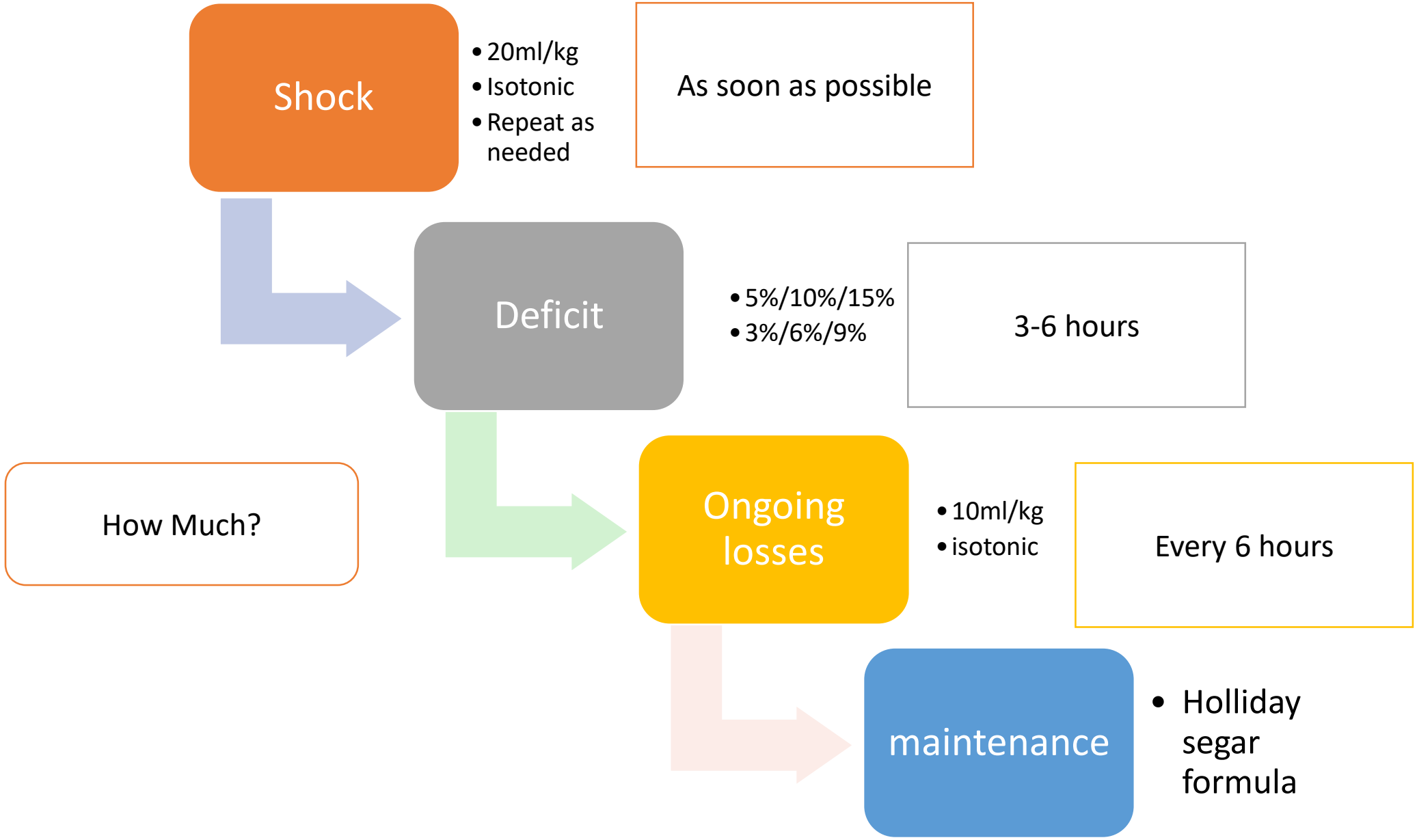
What fluid-RL/NS

- Numerous normal saline fluid boluses may result in a hyperchloremic non-anion gap metabolic acidosis, which may obscure acidosis secondary to poor tissue perfusion.

- Lactated Ringer’s solution has the theoretical benefit of producing bicarbonate from lactate, provided that liver function is normal

How rapid?

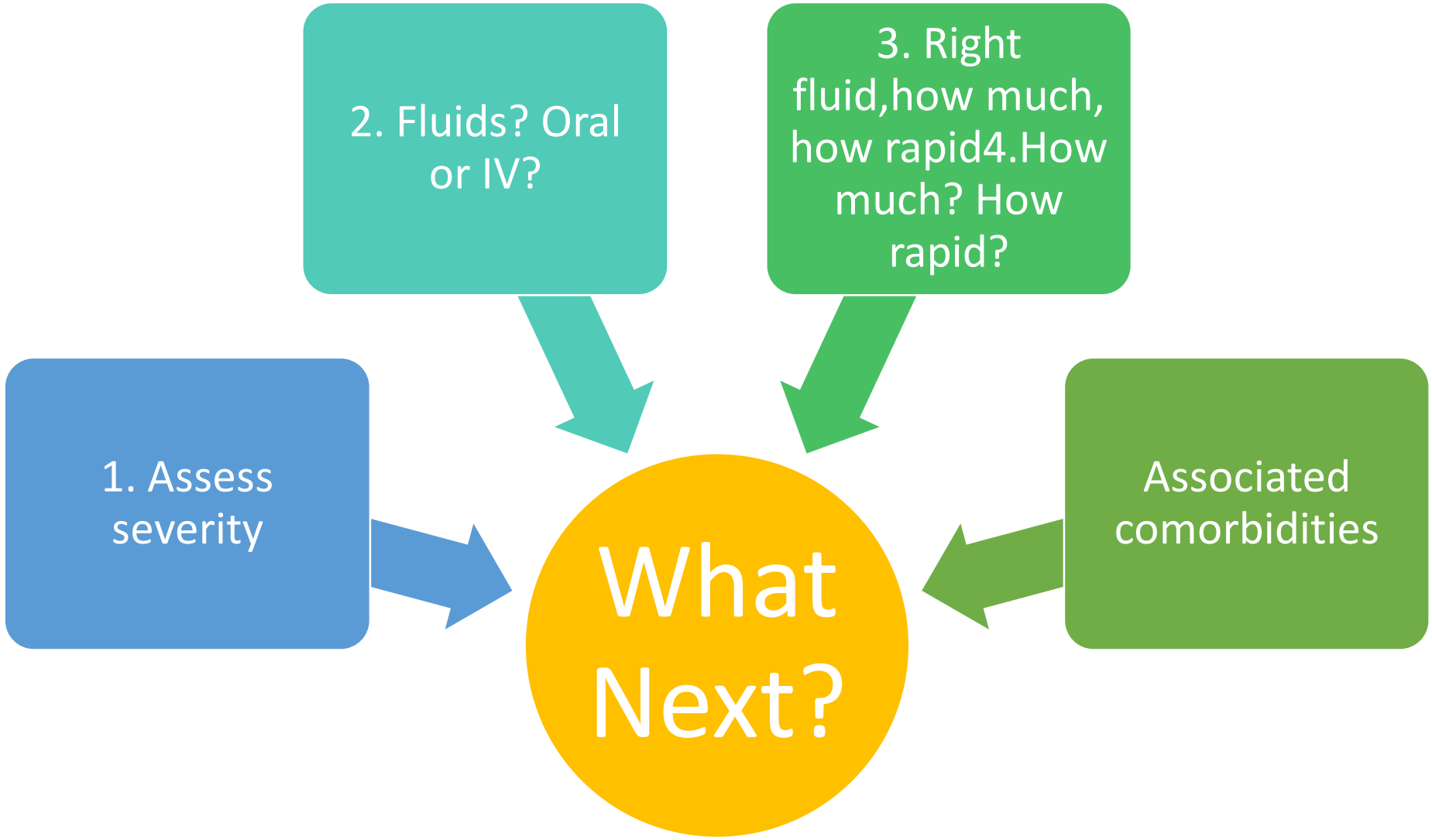
- For the patient in hypotensive shock, rapid isotonic fluid boluses in 20 ml/kg aliquots are provided to restore intravascular volume.
- Compensated shock : 20ml/kg over 20 minutes


Shock
• 20ml/kg
• Isotonic
• Repeat as needed
As soon as possible
Deficit
• 5%/10%/15%
• 3%/6%/9%
3-6 hours
How Much?
Ongoing losses
• 10ml/kg
• isotonic
Every 6 hours
maintenance
• Holliday segar formula

Maintanence fluids

Body weight	Fluid per day
0-10kg	100ml/kg
11-20kg	1000ml+50ml/kg for each kg>10kg
>20kg	1500ml+ 20ml/kg for each kg>20kg

Body weight	Fluid per day
0-10kg	4ml/kg/hr
11-20kg	40ml/hr+2ml/kg/hr x (wt-10 kg)
>20kg	60ml/hr+ 1 ml/kg/hr x (wt-20kg)


2. Fluids? Oral or IV?
3. Right fluid,how much, how rapid4.How much? How rapid?
1. Assess severity
What Next?
Associated comorbidities

- Look for sepsis
- Adequacy of fluids
- Calculative errors

Scenario 2

Dr. Priyavarthini V

Consultant, PICU

Apollo Children’s Hospital

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Scenario..

- 3 years old girl, 12 kg, developmentally normal
- Otherwise previously well
- 3 weeks of polyuria
- 2 days of rapid breathing
- No h/o fever, cough, cold, diarrhea, vomiting, rash, burning micturition
- Presented to ER

O/E

Conscious and oriented
RR 52/min
No retractions
SpO2 96% in room air
HR 140/min, Peripheral pulses weak
CFT 5 secs, extremities cold to touch
BP 80/58 (68)
Sunken eyes, reduced skin turgor

Investigations

- CBG: 528 mg%
- VBG: pH 7.0/ pCO2 20/pO2 48/HCO3 8/ BE -18/Lactate 3.0 mmol/L
- Na 135, K 4.0, Cl 104 mmol/L
- Urine ketones 3+

Clinical diagnosis ?

Severe Diabetic Ketoacidosis

Fluid management

Step 1

Assessment of fluid status

O/E

Conscious and oriented
RR 52/min
No retractions
SpO2 96% in room air
HR 140/min, Peripheral pulses weak
CFT 5 secs, extremities cold to touch
BP 80/58 (68)
Sunken eyes, reduced skin turgor

Step 1: Assessment of fluid status

- Compensated shock
- Dehydration

- Compensated shock – resuscitation – 20 ml/kg crystalloid – 0.9% NS over 20-30 minutes
- Reassess

Step 2

Calculation of deficit – Determines volume of replacement

Step 2: Calculation of deficit – Determines volume of replacement

- In DKA: Clinical estimates of volume deficit based on physical exam and vital signs are inaccurate

- Assume: Mild DKA 5%, moderate DKA 7% and severe DKA 10% dehydration

- ***Our patient – Severe DKA – Hence, 10 % dehydration correction plus maintenance fluids***

Step 3

Identify associated electrolyte disturbance – Determines composition of replacement fluid

Step 3:Identify associated electrolyte disturbance – Determines composition of replacement fluid

- 0.45%–0.9% saline or a balanced salt solution (Ringer's lactate, Plasmalyte)

- Potassium chloride/potassium phosphate to be added – 40 mmol/L as ***children with DKA have total body potassium deficits***

Step 4

Attention to co-morbidity/disease pathology – Determines rate of correction of replacement fluid

Step 4: Attention to co-morbidity/disease pathology – Determines rate of correction of replacement fluid

- In DKA: Replace the estimated fluid deficit *(minus initial fluid bolus amount)* over **24–48 hours** *in addition to providing the usual daily maintenance fluids*

- However, DKA typically resolves before 24 h: remaining fluid deficits are replaced by oral intake after transition to s/c insulin

Step 5

Prescription based on all 3 - volume, composition, rate

Step 5: Prescription based on all 3 - volume, composition, rate

- 12 kg, severe DKA

- Initial prescription?

12 kg child Severe DKA

Volume and rate:

- 10% dehydration correction over 48 hours = 100ml/kg = 1200 ml
- Resuscitation fluid = 240 ml - to be subtracted
- Deficit = 1200 – 240 = 960 ml over 48 hours = 20 ml/hr
- Maintenance fluids = 44 ml/hr
- So total fluids per hour = 20+44 = 64 ml/hr

Type of fluid: 0.9% saline with KCl 40mmol/L

Insulin infusion @ 0.05 -0.1 U/kg/hr (0.6 - 1.2 Units /hr in this child): To be started 1 hr after initiation of IV fluid treatment

Case scenario – Workbook

- A 10-year-old girl weighing 30 kg has been brought to the emergency department with a history of frequent micturition, lassitude, excessive thirst for the past week, vomiting, and fast breathing for one day. There was no fever or burning micturition. She has been previously well and developmentally normal with no other significant personal or family history.

- On examination, she is conscious and oriented with a respiratory rate of 40/min, no retractions, bilateral equal air entry with no adventitious sounds, and SpO2 of 98% in room air. Her heart rate is 120/min, BP 102/70 (82) mm Hg, extremities are warm, distal pulses are felt, and capillary refill time is 2 seconds. She has sunken eyes, dry mucous membranes, and reduced skin turgor. Her capillary blood glucose done on arrival is 470 mg%. Urine ketones were 4+. Arterial blood gas values are as follows: pH 7.15, pCO2 26 mm Hg, PO2 96 mm Hg, HCO3 4 meq/L, BE -20, lactate 2.2 mmol/L, Na 132 meq/L, K 3.5 meq/L, Cl 102 meq/L.

- What is the clinical diagnosis? Assess the fluid status and draft a fluid prescription for this child.

30 kg child: Moderate DKA

Volume and rate:

- 7% dehydration correction over 48 hours = 70ml/kg = 2100 ml
- Resuscitation fluid = Nil
- Deficit = 2100 ml over 48 hours = 44 ml/hr
- Maintenance fluids = 70 ml/hr
- So total fluids per hour = 44 + 70 = 114 ml/hr

Type of fluid: 0.9% saline with KCl 40mmol/L

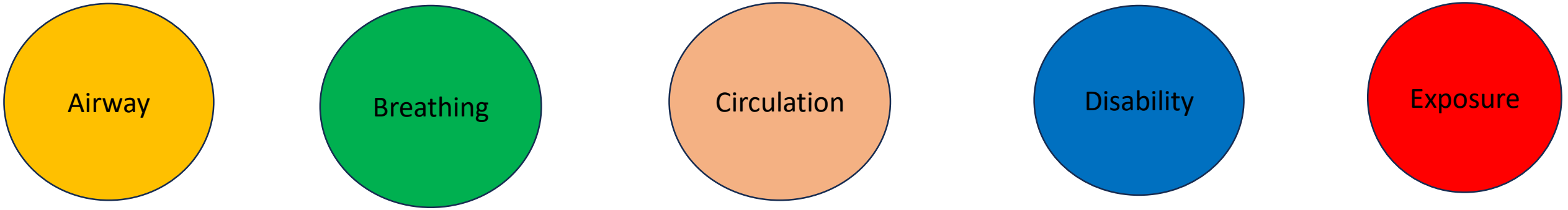
Insulin infusion @ 0.05 -0.1 U/kg/hr (1.5 - 3 Units /hr in this child): To be started 1 hr after initiation of IV fluid treatment

Thank you

Fluids In Special Situations: Case 3

- A 5 yr old child with nephrotic syndrome presented to ER with history of fever for 2 days, abdominal pain, progressively increasing anasarca and oliguria.
- On examination: she had mild pallor, severe oedema (genital and sacral areas), cold peripheries with CRT of 3 to 4 sec. She had tachycardia, BP measured was 70/60 mm Hg, systems examination was normal.
- 1. What is the diagnosis.
- 2 Step wise management in treating her condition.
- 3 Role of diuretics and albumin in treating her.

Primary Assesment



Index case

- Airway: Clear
- Breathing: No tachpynea, labored breathing
- Circulation: Tachycardia

  CRT of 3 to 4 sec

  BP measured was 70/60 mm Hg
- Disability : Conscious and oriented
- Exposure : Cold and pale peripheries.

Major Signs & Symptoms of Intravascular Fluid Loss/Dehydration

	Mild Dehydration	Moderate Dehydration	Severe Dehydration
Heart Rate	Normal	Slight increase	Significant tachycardia
Capillary refill	Normal	Around 2 seconds	>3 seconds
Peripheral pulses	Normal	Slightly decreased	Difficult to palpate
Urine output	Normal	Decreased	Little or none
Fontanelle	Flat	Soft	Sunken
Eyes	Normal	Normal	Sunken
Mucus membranes	Normal	Dry	Extremely dry
Tear production	Normal	Diminished	No tears

Can we use this classification in NS

	Mild Dehydration	Moderate Dehydration	Severe Dehydration
Weight Loss Older child Infant	 3% (30 ml/kg) 5% (50 ml/kg)	 6% (60 ml/kg) 10% (100 ml/kg)	 9% (90 ml/kg) 15% (150 ml/kg)
Heart rate	Normal	Mildly increased	Marked tachycardia
Distal pulses	Normal	Slightly diminished	Weak, thready
Capillary refill	Normal	Approx. 2 seconds	>3 seconds
Urine output	Normal	Decreased	Anuria
Fontanelle	Flat	Soft	Sunken
Eyes	Normal	Normal	Sunken
Tearing	Normal	Diminished	Absent
Mucosa	Normal	Dry	Parched

In ER Diagnosis: Resuscitation

- Clinical : Hypovolemic shock
- Etiological: Nephrotic syndrome in relapse , Probable Subacute bacterial peritonitis.
- Step 1 : Check vitals: Start oxygen by mask if needed
- Step 2 : Start IV Access along with collection of sample
- Step 3 : Start 0.9% NS bolus at 10-20 ml/kg over 10 to 30 min
- Step 4: Administer Antibiotics 1st dose (Golden Hour)
- Step 5: Recheck Vitals and give another bolus if needed (IVC Collapsibility) and if still does not improve consider inotropic support.(Keep checking for HR, RR, SPO2, JVP, Liver)

Optimisation

- The normal minimum dosing is **at least three fluid boluses of 20 ml/kg each**.
- As each 20 ml/kg fluid bolus is given,
- Evaluate → Identify→ Intervene Sequence of the Systematic Approach Algorithm is carried out.
- The child's response to each fluid bolus should dictate the course of further treatment.
- **Each bolus should be given over 10-30 minutes and reevaluation should take place**.

Stabilisation

- Typical signs that would indicate **improvement**

1) decrease in heart rate,

2) improved urine output,

3) decreased respiratory rate,

4) improved level of consciousness.

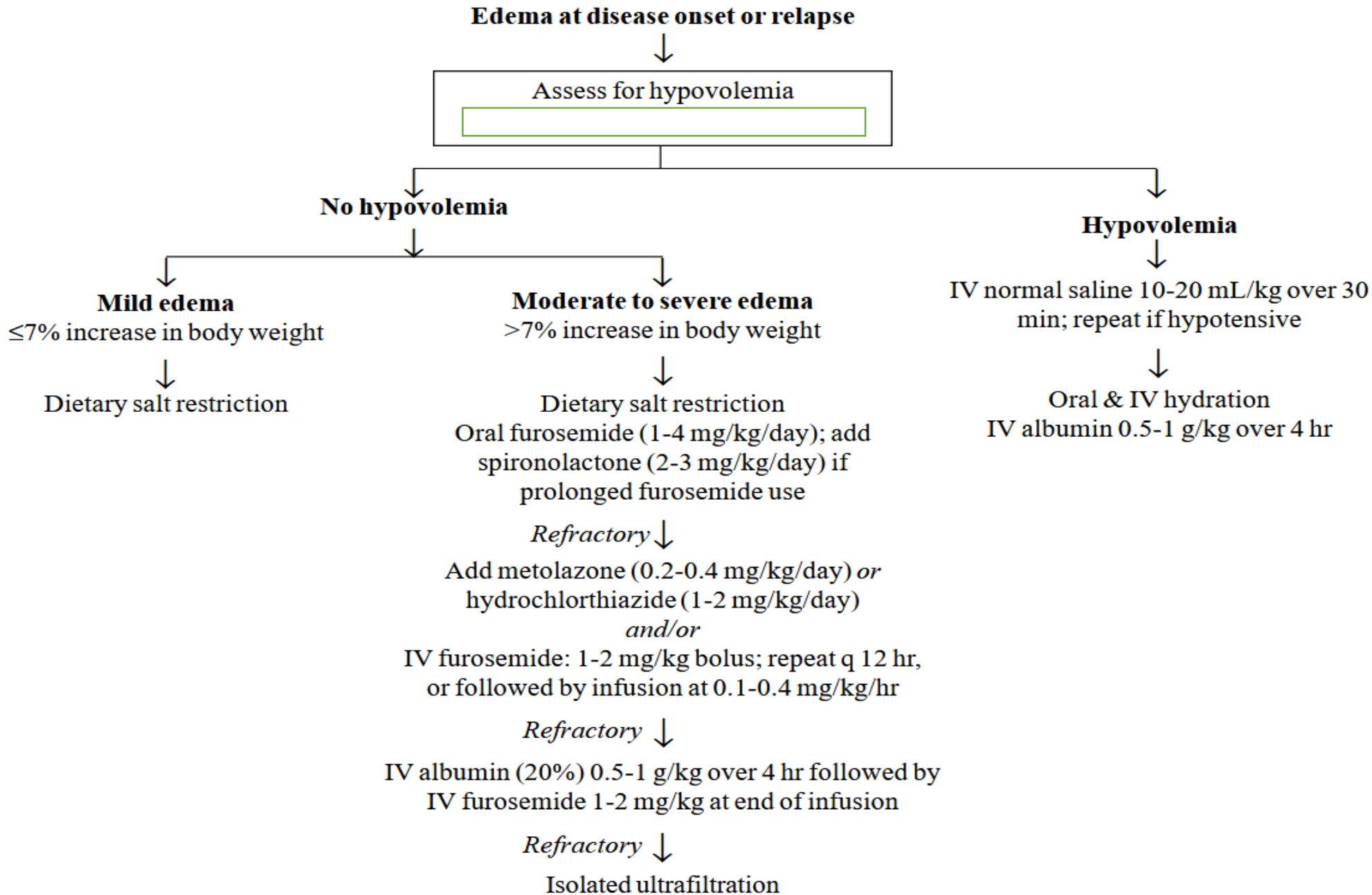
After stabilization:

- Step 1 : Look for urine output and improved hydration and shock.
- Step 2 : Can initiate stress dose of steroids.
- Step 3 : Looking at reports (hematocrit, urea/creat ratio) can decide on dehydrational correction.
- Step 4 : To start on diuretics (Oral Furosemide and look for diuresis)

Diuretics/ Albumin

- In Nephrotic syndrome edema is explained by 2 different theories

Underfill theory.	Over fill theory.
1. Tachycardia 2. Low volume pulses 3. Shock. 4. Prolonged CRT and cold peripheries 5. Increased Hematocrit 6. Blood urea/ creat ratio >100 7. FENa <0.5% 8. Urinary Potassium Index > 0.6 9. Decreased IVC diameter and increased collapsibility 10. ALBUMIN	1. Hypertension 2. Good volume pulses 3. Tachypnea 4. Dyspnea 5. Elevated JVP 6. Enlarged Liver 7. B lines on USG lung 8. Low collapsibility of IVC. 9. DIURETICS


Edema at disease onset or relapse
Assess for hypovolemia
No hypovolemia
Hypovolemia
Mild edema
≤7% increase in body weight
Dietary salt restriction
Moderate to severe edema
>7% increase in body weight
Dietary salt restriction
Oral furosemide (1-4 mg/kg/day); add spironolactone (2-3 mg/kg/day) if prolonged furosemide use
Refractory
Add metolazone (0.2-0.4 mg/kg/day) or hydrochlorthiazide (1-2 mg/kg/day)
and/or
IV furosemide: 1-2 mg/kg bolus; repeat q 12 hr, or followed by infusion at 0.1-0.4 mg/kg/hr
Refractory
IV albumin (20%) 0.5-1 g/kg over 4 hr followed by IV furosemide 1-2 mg/kg at end of infusion
Refractory
Isolated ultrafiltration
IV normal saline 10-20 mL/kg over 30 min; repeat if hypotensive
Oral & IV hydration
IV albumin 0.5-1 g/kg over 4 hr

Thank You