PEDIATRICS

L.1

Dr.Ghada Mansoor

Acute Gastroenteritis in Children

K: 1,2,4,5,7,11,22 .S:1,3,4,7,13,17,18,21,23,24. AB: 1,3,4,5

Objectives:

1. Definition of diarrhea, Types, and mech. of diarrhea.
2. To know the causative agents of Acute GE.
3. Complications, Diagnosis & investigations.

Definitions

Diarrhea: it is passage of 3 or more abnormally loose or liquid stools per day.

Acute diarrhea: is sudden onset of excessively loose stools of >10 mL/kg/day in infants and >200 g/24 hr in older children, which lasts <14 days. When the episode lasts longer than 14 days, it is called **chronic or persistent diarrhea**.

Prolonged (lasting 7-13 days).

Dysentery: small-volume, frequent bloody stools with mucus, often accompanied by fever, tenesmus, and abdominal pain (symptom of colitis).

Mechanisms of Diarrhea

PRIMARY MECHANISM	DEFECT	STOOL EXAMINATION	EXAMPLES	COMMENT
Secretory	Decreased absorption, Increased secretion of fluid and electrolytes	Watery, normal osmolality	Cholera (the enterotoxin of vibrio cholerae causes increased levels of CAMP within enterocytes, leading to secretion of water and electrolytes into the small bowel lumen).	Persists during fasting, no stool leukocytes.
Osmotic	occurs after ingestion of a poorly absorbed solute	Watery, acidic, with reducing substances; Increased osmolality	Lactase deficiency, glucose galactose malabsorption, lactulose, sorbitol	Stops with fasting; no stool leukocytes
Increased motility	Decreased transit time	Loose to normal appearing stool, stimulated by gastrocolic reflex	Irritable bowel syndrome, thyrotoxicosis	
Decreased motility	Stasis (bacterial overgrowth)	Loose to normal appearing stool	Pseudo-obstruction	
Decreased	Decreased functional	Watery	Celiac disease, rotavirus	

surface area (osmotic,motility)	capacity		enteritis	
Mucosal invasion	Inflammation, decreased colonic reabsorption	Bloody diarrhea	*Salmonella, Shigella,* amebiasis; *Yersinia,*	Dysentery with blood, mucus, and WBCs in stool

Acute Gastroenteritis: It is inflammation of the gastrointestinal tract, most commonly the result of infections with bacterial, viral, or parasitic pathogens. The most common manifestations are diarrhea and vomiting, which can also be associated with systemic features such as abdominal pain and fever.

Epidemiology

Diarrheal diseases are one of the leading causes of morbidity and mortality in children worldwide, account for 8.6% of all childhood deaths.

Etiology

Viral > Bacterial > Parasites.

- Viruses:

- Rotavirus is the most common cause of AGE among children throughout the world.
- Less frequently, Caliciviruses (Norovirus and sapovirus), adenovirus, Astroviruses.

Rotavirus and norovirus peak in cool seasons (winter), whereas adenovirus infections increase in summer.

- Bacteria:

- *Salmonella (nontyphoidal)*
- *Shigella*
- *Campylobacter jejuni*
- *Yersinia Enterocolitica*
- *Escherichia coli* (Enteropathogenic (EPEC), Enterotoxigenic (ETEC) (Traveler's Diarrhea), Enteroinvasive (EIEC), Enterohemorrhagic (EHEC) (*Shiga*-Toxin producing EC, includes O157:H7 ……. Causing HUS hemolytic uremic syndrome)
- *Vibrio cholerae*
- *Clostridium difficile.*

- Bacteria that produce preformed toxins *(Staphylococcus aureus, Bacillus cereus).*

➢ Parasites:

- *Giardia intestinalis (lamblia)*
- *Entamoeba histolytica*
- *Cryptosporidium Parvum .*

Transmission

The major mechanisms of transmission for diarrheal pathogens are person to person through the fecal-oral route or by ingestion of contaminated food or water.

Risk factors for gastroenteritis

- young age
- immune deficiency
- Measles
- Malnutrition with micronutrient deficiency as vitamin A deficiency and Zinc deficiency.
- travel to an endemic area
- lack of exclusive breast-feeding
- exposure to unsanitary conditions
- ingestion of contaminated food or water
- attendance at a childcare center.

Clinical Manifestation

❖ **Viral Diarrhea**

Rotavirus AGE: After 2-4 days incubation period, symptoms begin with vomiting, followed by watery non-bloody diarrhea, low-grade fever. No fecal leukocytes. Recovery occurs within 7 days.

❖ **Bacterial Diarrhea**

*The most common presentation is acute diarrhea with fever, abdominal pain, and vomiting.

*Bloody diarrhea or dysentery is classically caused by *Shigella (**Bacillary dysentery**)*.
Salmonella, Campylobacter jejuni, Yersinia enterocolitica, enteroinvasive or hemorrhagic (Shigatoxin-producing) *E. coli, also* produce diarrhea that can contain blood, fecal leukocytes with abdominal cramps, tenesmus, and fever (**bacterial dysentery**).
Vibrio cholerae cause profuse watery diarrhea and vomiting, lead to severe dehydration and death within hours.
*Rapid onset of nausea and vomiting within 6 hr, with possible fever, abdominal cramps, and diarrhea within 8-72 hr. is associated with ingestion of preformed toxins (e.g., those of *S. aureus*).

- ❖ **Parasitic Gastroenteritis**

It is suspected when there is a prolonged diarrhea characterized by gradual onset of abdominal cramps, nausea, watery diarrhea, with bloating, flatulence, malabsorption,
and weight loss.

- E. histolytica also present as **Amebic dysentery** (bloody or mucoid diarrhea).

Organisms associated with dysentery or bloody diarrhea can also cause watery diarrhea alone without fever.

Complications of GE

- Dehydration, metabolic acidosis, shock and acute renal shutdown.
- Electrolyte disturbance (hypokalemia (abdominal distention), hypernatremia & hyponatremia).
- Malnutrition and micronutrient deficiency
- Bacteremia with systemic spread e.g., meningitis, pneumonia.
- Local spread (e.g., vulvovaginitis and urinary tract infection)

Other extraintestinal complications:

- Reactive arthritis.
- Guillain-Barré syndrome→ *Campylobacter.*
- Hemolytic uremic syndrome→ *Shigella dysenteriae* 1, *Escherichia coli* 0157: H7.
- Glomerulonephritis
- Intussusception→ Viral AGE

Diagnosis

- **Clinical Evaluation of Diarrhea**

1. Assessing the degree of dehydration and acidosis and provide rapid resuscitation and rehydration with oral or intravenous fluids as required
2. Obtaining appropriate history include information on exposure to contacts with similar symptoms, intake of contaminated foods or water, child-care center attendance, recent travel to a diarrhea-endemic area.

- **Laboratory evaluation**

1.Stool Examination:

- ❖ Stool specimens should be examined **microscopically** for:
- ➢ mucus, blood, and leukocytes, or fecal lactoferrin. Fecal leukocytes indicate

bacterial invasion of colonic mucosa such as *Shigella, Salmonella, C. jejuni,* invasive *E. coli.*

- ➢ look for trophozoites and/or cysts of *E. Histolytica* or *Giardia* (may need at least 3 samples).
- ❖ Rapid antigen detection of rotavirus in stool specimens by enzyme immunoassays (EIAs). RT-PCR on stool sample for norovirus.
- ❖ Enzyme immunoassays are also available for *Giardia, Entamoeba, and Cryptosporidium.*

- **Stool cultures** are recommended for:

*Bloody diarrhea
*Moderate or severe disease,
*Immunosuppressed children
*If hemolytic-uremic syndrome (HUS) is suspected

2. serum electrolyte measurements.
3. complete blood count and renal function tests if suspected HUS.
4. **Urinalysis** for specific gravity as an indicator of hydration. The urine specific gravity is usually elevated. If **UTI** is suspected, **urine** should be send for **C&S test**.

5. Blood culture → if suspect systemic bacterial infection.

PEDIATRICS

L.2

K:1,5,6,11. S:1,3,4,7,13,17,18,21,23,24.AB:1,3,4,5. **Dr.Ghada Mansoor**

Objectives:

1.To know the main Principles of acute GE management.
2. Fluid and Nutritional Management of Diarrhea according to WHO.
3. To know what is Oral rehydration salt (ORS) solution (compositions, types, preparation, and How does ORS works?)
4. To know the indications of antibiotics therapy in Infectious Diarrhea.
5. To know How calculate deficit and maintenance fluid volume.

Treatment of acute GE

Most cases of diarrhea in children are self-limited. Management of viral and most bacterial causes of diarrhea is primarily supportive.
The principles of management of acute gastroenteritis in children include:

- Hydration
- Enteral feeding and diet selection.
- Zinc supplementation, and additional therapies

❖ Hydration

1. Correction of dehydration (rehydration).
2. Prevent dehydration by giving maintenance ORS plus replacement of continued losses in diarrheal stools and vomitus after rehydration.

So, the first step is → *Assess the degree of dehydration and rehydration with oral or intravenous fluids as required according to the degree of dehydration.*

Oral rehydration salt (ORS) solution It is a solution recommended by WHO and UNICEF to prevent or correct dehydration from diarrhea, irrespective of the cause of diarrhea or age group affected.

Fluid and Nutritional Management of Diarrhea according to degree of dehydration

Degree of dehydration	Rehydration therapy	Replacement of loss during maintenance
Minimal or no dehydration	Not applicable	Infants and children: <10 kg body weight: 50-100 mL (¼ to ½ large cup) ORS for each diarrheal stool or vomiting episode. >10 kg body weight: 100- 200 mL (½ to 1 cup) ORS for each diarrheal stool or vomiting episode.
Some dehydration (mild & moderate)	**ORS, 50-100 mL/kg over 3-4 hr.** Continue breast feeding. After 4 hr, give food every 3-4 hr. for children who normally receive solid foods	<10 kg body weight: **50- 100 mL ORS** for each diarrheal stool or vomiting episode, >10 kg body weight: **100- 200 mL ORS** for each diarrheal stool or vomiting episode;
Severe dehydration	Infants (<12 months) without malnutrition: Give **20-30 mL/kg** boluses of iv isotonic solution (0.9% NS or LR) over **1 hr.** (repeated as need). Then give **70 mL/kg over 5 hr.** Children (12 mo. - 5 yr.): Give **20-30 mL/kg** boluses of iv isotonic solution **over 30 min.** Then give **70 mL/kg over 2.5 hr.** Reassess the infant frequently. When perfusion is adequate, mental status is normal, and the child can drink, switch to ORS, breast milk, and feed as described for some dehydration. Malnourished infants may benefit from smaller-volume, frequent boluses of 10 mL/kg body weight.	<10 kg body weight: 50-100 mL ORS for each diarrheal stool or vomiting episode. >10 kg body weight: 100-200 mL ORS for each diarrheal stool or vomiting episode. If unable to drink, administer through nasogastric tube or give 5% dextrose 0.25 NS solution with 20mEq/L potassium chloride intravenously.

*After rehydration is complete, maintenance fluids should be resumed along with an age-appropriate normal diet offered every 3-4 hr.

*Breastfed infants should continue nursing throughout the illness.

When there is emesis, small volumes of ORS (5 mL) can be given initially by a dropper, teaspoon, or syringe slowly. The volume is increased as tolerated.

Types & Composition of Oral Rehydration Solutions (ORS)

Solution	Carbohydrate (g/L)	Sodium (mmol/l)	potassium (mmol/l)	Chloride (mmol/l)	Base (mmol/l)	Osmolarity (mosm/l)
(WHO) (Low-osmolality ORS) [2005]	13.5	75	20	65	10	245
WHO (Standard ORS) [1975]	20	90	20	80	30	311

Compared with standard ORS, low-osmolality ORS:

- Reduces stool output
- Associated with less vomiting
- Reduce the need for intravenous fluids without substantially increasing the risk of hyponatremia.

The low-osmolality (WHO) ORS is now the global standard of care and more effective than home fluids.

Composition of low-osmolality Oral Rehydration Salts, each sachet contains:

• sodium chloride ⟶ 2.6 g
•potassium chloride ⟶ 1.5 g
•sodium citrate⟶2.9 g
•Glucose⟶ 13.5 g

Concentration of oral rehydration solution (ORS) in mmol/Liter

• Sodium → 75
•Chloride → 65
•potassium→ 20
•Citrate →10
•Glucose → 75
•total Osmolality-----245 mOsm/L

Preparation of ORS: Dissolve entire contents of sachet in 1 Liter of drinking water, and should be given slowly by spoon or syringe (but not by feeding

bottles). Should kept refrigerated and the remining solution should not be used 24hr after preparation.

How does ORS works?

Sodium is absorbed from the intestinal lumen by several mechanisms, most prominently by cotransport with glucose and amino acids, and by Na+/H+ exchange, both of which move sodium from the lumen into the enterocyte. Therefore, glucose in ORS enhance absorption of sodium from intestinal lumen through the cotransport coupling mechanism (so that glucose accelerates absorption of solute and water).

Limitations to ORS use include: Shock, decreased level of consciousness, an ileus, intussusception, carbohydrate intolerance (rare), severe emesis, and high stool output (>10 mL/kg/hr).

Cereal-based oral rehydration fluids can also be advantageous in malnourished children and can be prepared at home. Popular beverages that should not be used for rehydration or maintenance therapy include commercial soft drinks, apple juices, and tea, because they have inappropriately high glucose and osmolality with low sodium concentrations.

2.Enteral Feeding and Diet Selection

*Breastfeeding should continue even during acute rehydration.
*Infant formula if used, **it should not be diluted**, or changed to a lactose-free formulations unless lactose malabsorption is evident.
* Once rehydration is complete, age-appropriate diet should be reintroduced while ORS is given to replace ongoing losses from emesis or stools and for maintenance. Foods with complex carbohydrates (rice, wheat, potatoes, bread, and cereals), fresh fruits, lean meats, yogurt, and vegetables all are recommended.

*Fatty foods or foods high in simple sugars (juices, carbonated sodas) should be avoided.

3. Zinc Supplementation

Zinc supplementation in children with diarrhea in developing countries result in:

- Reduced duration and severity of diarrhea.
- Administration of zinc in community settings leads to increased use of ORS and reduction in the inappropriate use of antimicrobials.

Dose of oral zinc: 10 mg/day for infants <6 mo. of age and 20 mg/day for those older than 6 mo. for 10-14 days during and continued after diarrhea.

4. Additional Therapies

*Probiotic nonpathogenic bacteria *(Lactobacillus, Bifidobacterium).*
*Antiemetic therapy: Oral Ondansetron may be given because persistent vomiting can limit oral rehydration therapy.

* Antimotility agents (loperamide) are contraindicated in children with dysentery and have no role in the management of acute watery diarrhea.

5. Antibiotic Therapy

Most episodes of AGE are self-limited among otherwise healthy children.

Indications of antibiotics therapy in Infectious Diarrhea

1. Dysentery or bloody diarrhea (*Shigella, Campylobacter, EIEC* dysentery*).*
2. Shigellosis (in moderate to severe disease).
3. Immunocompromised patients.
4. Infants younger than 3 mo., and patients with chronic GI disease infected with nontyphoidal *Salmonella.*
5. Bacteremia, disseminated invasive infections, and focal invasive infections.
6. Traveler's diarrhea (ETEC).
7. Pseudomembranous colitis *(Clostridium difficile).*
8. Amebiasis (*Entamoeba histolytica).*
9. Giardiasis *(Giardia intestinalis).*

10. Cholera (*Vibrio cholerae):* AB given only in patients with moderate to severe dehydration).
11. Malnutrition.

- Stool culture should be done prior to treatment if possible.

Organism	**Drug of choice**
Shigella	First line: Ciprofloxacin, Ceftriaxone, Azithromycin. Second line: Cefixime, Trimethoprim-sulfamethoxazole (TMP-SMX).
EPEC, ETEC, EIEC	TMP-SMX or ciprofloxacin
ETEC (Traveler's diarrhea)	Azithromycin, Ciprofloxacin
*Salmonella (*non-typhoidal)	Same as *Shigella*
Campylobacter	Erythromycin or azithromycin
Clostridium difficile	Metronidazole, Vancomycin
Amebiasis	Metronidazole followed by iodoquinol or paromomycin
Giardiasis	Tinidazole, Metronidazole, Nitazoxanide

Note: Avoid antimicrobials and anti-motility drug in **STEC (Shiga toxin–producing Escherichia coli)** infection due to antibiotic therapy increases the risk of Hemolytic uremic syndrome.

Prevention

1. Promotion of Exclusive Breastfeeding (administration of no other fluids or foods for the 1st 6 mo. of life).
2. Improved Complementary Feeding Practices:
   - Complementary foods should be introduced at 6 mo. of age.
   - breastfeeding should continue for up to 2 yr.
   - Vitamin A supplementation.
3. Rotavirus Immunization(vaccines).
4. Improved Water and Sanitary Facilities and Promotion of Personal and Domestic Hygiene.

IV Fluid Management of Dehydration

***Maintenance fluid therapy:** replaces the normal daily ongoing losses of water and electrolytes and used in a child who cannot be fed enterally.

*** Replacement fluids:** replaces the continued excessive losses of water and electrolytes as occur with diarrhea or polyurea.

*** Deficit fluid:** fluid needs to correct dehydration.

Fluid Management of severe Dehydration:

- To restore intravascular volume, the child is given a **fluid bolus**:

Isotonic fluid [Normal saline (NS) or Ringer lactate (LR)]: **20 mL/kg over 20 min** (Repeat as needed)

- Calculate 24 hr fluid needs: **maintenance + deficit volume.**
- Subtract the fluid bolus already administered from 24 hr fluid needs.
- Administer remaining volume over 24 hr (half the calculated fluid during the first 8 hr and the remainder over the next 16 hr), using 5% dextrose NS (D5 NS) + 20mEq/L KCl.

Calculate deficit volume:

Deficit (mL) = body weight (kg) x % dehydration x 10

e.g. Weight 10 kg and is 10% dehydrated has a fluid deficit of 1000mL.

Calculating Daily Maintenance Fluid Volume

Body wt.	Fluid per day
0-10 kg	100 mL/kg
11-20 kg	50 mL for each kg >10 kg
>20 kg	20 mL for each kg >20 kg

- Replace ongoing losses as they occur.

Potassium is not usually included in the IV fluids until the patient voids and normal renal function is documented by measurement of BUN and creatinine.

Treatment of Hyponatremic Dehydration

1. Correction of intravascular volume depletion with isotonic fluid as above. The entire fluid deficit is corrected over 24 hr.
2. Avoid “overly rapid” correction of serum sodium concentration by >12 mEq/L/24hr due to risk of central pontine myelinolysis.

3. Seizures as a result of hyponatremia treated by acute infusion of 4-6 mL/kg of hypertonic (3%) saline.

Treatment of Hypernatremic Dehydration

1. Correction of intravascular volume depletion (fluid bolus) with **0.9%NS**. **LR** should not be used because it is more hypotonic than NS.
2. The total fluid deficit is corrected slowly over 48hr, and the serum sodium concentration should not decrease by >10 mEq/L/24 hr to avoid cerebral edema during correction of hypernatremic dehydration.
3. Typical fluid: 5% dextrose + half-normal saline (D5 ½ normal saline) (with 20 mEq/L KCl).

Patient monitoring

- Vital signs: Pulse, Blood pressure.
- Intake and output: Fluid balance, Urine output.
- Physical examination: Weight, Clinical signs of depletion or overload.
- Measurement of serum electrolyte levels.

Composition of commonly used I.V. fluid solutions (mmol/L)

Fluid	Na+	Cl−	K+	Ca2+	Lactate−	Glucose g/L
Ringer lactate	130	109	4	3	28	
Normal saline (0.9% NaCl)	154	154				
½ normal saline (0.45% NaCl)	77	77				
1/4 normal saline (0.2% NaCl)	34	34				
3% normal saline	513	513				
D5 NS (5% dextrose + 0.9%NaCl)	154	154				50
D5 ½NS (5% dextrose+0.45% NaCl)	77	77				50
D5 0.2NS (5% dextrose+0.2% NaCl)	34	34				50
D4 1/5NS (4% dextrose +0.18% NaCl)	30	30				40
5% dextrose (D_5W)						50
10% dextrose ($D_{10}W$)						100

PEDIATRICS

L.3 Dr.Ghada Mansoor

K: 1,4,5,11.S:1,3,4,7,13,17,18,21,23,24 .AB: 1,3,4.

Objectives:

1.In this lecture we discuss the total body water and electrolytes.
2. Causes of dehydration.
3. How Assess the degree of dehydration?
4. Types of dehydration and Laboratory Findings in each type.

Dehydration

Total body water (TBW)

In newborns and infants → 75-70% of body weight.

Adult male and female→ 60-50% of body wt. (**~ 42 liters**)

TBW is divided between 2 main compartments:

1-Intracellularfluid (ICF): 2/3 (30–40 % of body weight)

2-Extracellularfluid (ECF): 1/3 (20–25% of body weight)

a) Interstitial fluid →15 % of body weight
b) Plasma water →5 % of body weight

❖ **Sources of normal water loss**

. Urine: 60%
- Insensible losses: ≈35% (skin and lungs)
- Stool: 5%

Dehydration

It is a common problem in children, most often caused by gastroenteritis.

Causes of dehydration

1. **Excessive fluid loss**
    - Diarrhea (infectious, noninfectious)
    - Vomiting (GE, Pyloric stenosis)
    - Excessive sweeting (fever, hot climate, cystic fibrosis)
    - Polyurea (diabetes mellitus, diabetes insipidus)
    - Fluid loss (burn)
2. **Inadequate intake of fluid**
    - **Poor feeding**
    - **Inability to drink**

➢ Assessment of degree of dehydration:

The degree of dehydration dictates both the urgency of the situation and the volume of fluid needed for rehydration.

Clinical Signs Associated with Dehydration

SYMPTOM	MINIMAL OR NO DEHYDRATION	SOME DEHYDRATION	SEVERE DEHYDRATION
Mental status	Well; alert	Normal, fatigued or restless, irritable	Apathetic, lethargic, unconscious
Thirst	Drinks normally; might refuse liquids	Thirsty; eager to drink	Drinks poorly; unable to drink
Heart rate	Normal	Normal to increased	Tachycardia, with bradycardia in most severe cases
Quality of pulses	Normal	Normal to decreased	Weak, thready, or impalpable
Breathing	Normal	Normal; fast	Deep
Eyes	Normal	Slightly sunken	Deeply sunken
Tears	Present	Decreased	Absent
Mouth and tongue	Moist	Dry	Parched
Skinfold	Instant recoil	Recoil in <2 sec	Recoil in >2 sec
Capillary refill	Normal	Prolonged	Prolonged; minimal
Extremities	Warm	Cool	Cold; mottled; cyanotic
Urine output	Normal to decreased	Decreased	Minimal

- Skin turgor is assessed by pinching and gently twisting a small skin fold on the lateral abdominal wall at the level of the umbilicus. If the fold does not promptly return to normal after release, the recoil time is quantified as delayed slightly or ≥2 sec.

- To measure capillary refill time, press on the palmer surface of child's distal fingertip for 5 seconds using moderate pressure, with the child's arm at heart level. The time elapsed until restoration of normal color after release usually exceeds 2 sec in the presence of dehydration.
- Urine output asses by number of wet diapers per day and time since the last urination.

Other way for 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; depressed consciousness.

Laboratory Findings in dehydration

1. Serum sodium level ⟶ ↑ in Hypernatremic dehydration or ↓ in Hyponatremic dehydration.

2. Serum potassium (K+) level ⟶ Hypokalemia (↓K+) as a result of diarrheal losses. In children with dehydration as a result of emesis, gastric K+ losses, metabolic alkalosis, and urinary K+ losses all contribute to hypokalemia.

Hyperkalemia (↑K+) → occurs due to metabolic acidosis, which causes a shift of K+ out of cells, or due to acute renal failure.

3. Metabolic acidosis may be a result of stool bicarbonate losses in children with diarrhea, secondary renal insufficiency, or lactic acidosis from shock.

4. Metabolic alkalosis ⟶ Emesis or nasogastric losses.

5. Blood urea nitrogen (BUN) and serum creatinine: ↑BUN with normal creatinine ⟶ volume depletion without renal injury. ↑creatinine concentration ⟶ acute renal injury.

6. Thrombocytopenia and hematuria → indicate **Renal vein thrombosis** which is a sequela of severe dehydration in infants.

7. ↑ hematocrit, hemoglobin, and serum proteins⟶ result from Hemoconcentration.

Types of dehydration

1. Isotonic dehydration
2. Hyponatremic dehydration
3. Hypernatremic dehydration

❖ Isotonic dehydration:

it occurs when the net loss of water & sodium is the same proportion to that found in the normal ECF. The serum sodium concentration was normal (135–145 mEq /L) with normal serum osmolality (285–295 mOsm/kg). e.g. GE with diarrhea and vomiting.

❖ Hyponatremic dehydration

It occurs when sodium loss is greater than water loss, resulting in a decrease in serum osmolality. This causes a shift of water from the extracellular space into the brain cells, resulting in brain swelling, cerebral edema, and seizures.
E.g. as occur with:

- renal salt wasting
- in cholera
- in the child with diarrhea who is taking low-salt fluid, such as water or formula.

The serum sodium level <135 mEq/L, with low serum osmolality.

❖ Hypernatremic Dehydration

It is the most dangerous form of dehydration because of complications of hypernatremia itself and of its therapy. It occurs when the water loss exceeds the sodium loss as occur in:

- Child with diarrhea and poor oral intake because of anorexia or emesis.
- Ineffective breast-feeding.
- High insensible water losses in infant placed under a radiant warmer or with the use of phototherapy for hyperbilirubinemia.

- Serum Na^+ >145 mEq/L, with increase serum osmolality.

- The degree of dehydration is underestimated in hypernatremic dehydration because the movement of water from the intracellular space (ICS) to the extracellular space (ECS) helps preserve the intravascular volume.

Clinical manifestations:

- Children are irritable, weak, and lethargic. Some infants have a high-pitched cry and hyperpnea.
- Fever, hypertonicity, and hyperreflexia.
- The pinched abdominal skin has a “doughy” feel.
- Neurologic symptoms like seizure, central nervous system hemorrhages and thrombosis. This damage is secondary to the movement of water from the brain cells into the hypertonic extracellular fluid (ECF), causing brain cell shrinkage and tearing blood vessels within the brain.
- Seizures may also occur due to cerebral edema which result from rapid treatment of hypernatremic dehydration.
- Cerebral edema result from rapid treatment of hypernatremic dehydration.

PEDIATRICS

L.4

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K:1,4,5,6,21. S:1,3,4,7,13,17,18,21,23,24. AB: 1,3,4,5

Objectives:

1.Definition and etiology of chronic diarrhea.

2. Clinical evaluation of patient with chr. diarrhea.

3.The main lines in the treatment.

Chronic Diarrhea

Chronic diarrhea is defined as stool volume of more than 10 g/kg/day in toddlers/infants and greater than 200 g/day in older children that lasts for 14 days or more. In practice, this usually means having loose or watery stools more than 3 times a day for 14 days or more.

Pathophysiology

The mechanisms of diarrhea are divided into secretory, osmotic, motility disorders, inflammation and mucosal invasion.

The main diagnostic points that differentiate osmotic from secretory diarrhea

	OSMOTIC DIARRHEA	SECRETORY DIARRHEA
Volume of stool	<200 mL/24 hr	>200 mL/24 hr
Response to fasting	Diarrhea stops	Diarrhea continues
Stool Na^+	<70 mEq/L	>70 mEq/L
Reducing substances	Positive	Negative

	OSMOTIC DIARRHEA	SECRETORY DIARRHEA
Stool pH	<5	>6

Etiology

1. **Infections**
   - **Enteric infections**: are the most frequent cause of chronic diarrhea.
     - Enteroaggregative *E. coli* (EAEC)*, Enterotoxigenic E. coli (ETEC).*
     - Shigella.
     - *Giardia lamblia* (mainly in developing countries)
     - Rotavirus and Norovirus (mainly in developed countries)
     - Cryptosporidium (in AIDS patients).
     - *Clostridium difficile* (in patients with inflammatory bowel diseases or malignancy).
     - *Amebiasis.*
     - *campylobacter, salmonella* (cause chronic diarrhea in travelers).
     - Tropical sprue.
   - **Small intestinal bacterial overgrowth**.
   - **Postenteritis diarrhea syndrome**: in which small intestinal mucosal damage persists after acute gastroenteritis, may be due to persistent infection or reinfection, secondary
     lactase deficiency, food protein allergy, or antibiotic-associated diarrhea.
2. **Inflammatory/Immunologic:**
   - **Celiac disease**: is a genetically determined permanent gluten intolerance. Gliadin, the major protein of gluten (found in wheat, barley and rye), reacts with the immune system to cause villous atrophy.
   - **Food allergy (mainly cow milk protein allergy).** Present during infancy.

- **Inflammatory bowel diseases (Crohn disease, ulcerative colitis):** The peak incidence occurs in adolescence.
- **Immune deficiency:** as in children with AIDS.
- **Carbohydrate Malabsorption:**
    - **Lactose intolerance:** Result from lactase deficiency caused by intestinal mucosal damage. It is either Congenital or secondary lactose intolerance.

3. **Chronic nonspecific Diarrhea:** is the most benign and common etiology of chronic diarrhea and including:
   - **Toddler's diarrhea (functional diarrhea**): is defined by the daily painless recurrent passage of 4 or more large stools, containing undigested food particles, for 4 wk or more, with onset in in children younger than 4 yr of age (infancy or preschool) years. Nighttime defecation is usually absent. The child appears well, not concerned, there is no evidence of failure to thrive, and the symptoms resolve spontaneously by school age.
   - Diarrhea result from excessive intake of fluid and fruit juice, especially apple juice. Also, excessive intake of nonabsorbable carbohydrate like sorbitol (found in apple, pear, and prune juices), and lactulose, results in osmotic diarrhea.
   - **irritable bowel syndrome:** in children 5 yr of age and older.
4. **Pancreatic insufficiency:**
   - **Cystic fibrosis:** in which pancreatic insufficiency results in fat and protein malabsorption.
5. **Liver and Bile Acids Disorders**
   - **Cholestasis:** in which fat malabsorption causing chronic diarrhea in the form of steatorrhea.
6. **Protein-Losing Enteropathy→ intestinal lymphangiectasia**
7. **Motility Disorders (pseudo-obstruction and in hyperthyroidism).**
8. **Short Bowel Syndrome.**
9. **Congenital Diarrheal Disorders:** Congenital lactase deficiency, Congenital sucrase isomaltase deficiency, Fructose malabsorption,

Congenital chloride diarrhea, and Acrodermatitis enteropathica (defects in the absorption of zinc).

10. **Factitious diarrhea** (laxatives ingestion).

Common Causes of Chronic Diarrhea according to age

INFANCY
Postenteritis syndrome Cow's milk/soy protein intolerance Secondary disaccharidase deficiencies Cystic fibrosis
CHILDHOOD
Chronic nonspecific diarrhea (Toddler's diarrhea) Secondary disaccharidase deficiencies Giardiasis Postenteritis syndrome Celiac disease Cystic fibrosis
ADOLESCENCE
Irritable bowel syndrome Inflammatory bowel disease Giardiasis Lactose intolerance

Evaluation of Patients

1. Clinical history:

- Age at onset⟶ Early onset diarrhea in the neonatal period may suggest a congenital diarrhea, infections, food allergy, or gastrointestinal (GI) malformations.

In later infancy and up to 2 yr of age⟶ suggest infections and allergies.

In older children and adolescents→ may suggest inflammatory diseases.

Celiac disease as well as functional nonspecific diarrhea should be considered

at all ages.

- ❑ Description of stools (frequency, amount, contents) → green stool containing undigested food particles → suggest toddler' diarrhea.
- ❑ Nature of the diarrhea → explosive watery diarrhea suggests carbohydrate malabsorption. Loose, bulky stools→ associated with celiac disease .
- ❑ Associated signs and symptoms such as fever, mucoid or bloody stools, and abdominal pain ⟶ may suggest inflammatory bowel disease (IBD).

- Feeding and dietary history⟶ association of diarrhea with specific foods may indicate allergy or food intolerance, such as cow's-milk protein allergy, lactose or fructose intolerance. Also ask about the amount and type of fluid ingested per day, history of excessive carbonated drink or fruit juice intake, or ingesting nonabsorbable nutrients (sorbitol) with normal growth and height parameters ⟶ **chronic nonspecific diarrhea**.
- Family history and consanguinity⟶ congenital, allergic, or inflammatory etiology.

2. Physical examination:

a) Assessment of nutritional status includes
   - evaluation of the weight and height curves. Normal weight and growth strongly support Toddler's diarrhea.
   - Assessment of body composition by measuring mid-arm circumference and skinfold thickness.
   - Looks for signs of malnutrition (marasmus, or kwashiorkor).

b) Assessment of hydration.

c) Looks for systemic and extraintestinal manifestations e.g ⟶
   - Eczema or asthma is associated with an allergic disorder.
   - Skin lesions of zinc deficiency ⟶ acrodermatitis enteropathica.
   - Finger clubbing⟶ cystic fibrosis, celiac disease, or IBD.

3. Investigations

Stepwise Diagnostic Approach to Children and Infants with Chronic Diarrhea

INITIAL EVALUATION	
Clinical history Physical examination	*Infectious workup: Stool exam for WBC, fat, ova, and parasites. Stool cultures *Allergic workup: Elimination diet trial
↓	
LABORATORY TESTS	
Stool analysis: stool electrolytes and osmolality; pH and reducing substances; steatocrit; fecal leukocytes, calprotectin, lactoferrin; α 1 -antitrypsin.	Blood tests: CBC, Serum electrolytes; lipid profile; albumin; amylase and lipase; inflammatory markers (ESR, C-reactive protein); Celiac serology (anti-TG2 antibody) Sweat test; Breath hydrogen test
↓	
IMAGING	
Abdominal ultrasound: Bowel wall thickening (IBD); liver and bile disorders	X-ray and contrast studies: Congenital malformation; signs of motility disorders
↓	
ENDOSCOPIES AND INTESTINAL HISTOLOGY	
Endoscopic studies Small bowel biopsy Sigmoidoscopy or colonoscopy with biopsies	
↓	
GENETIC INVESTIGATION	
Specific molecular analysis	

*A stool pH <5 (acidic) and fecal-reducing substances → indicates carbohydrate malabsorption (e.g lactose intolerance).
*↑ Fecal calprotectin, lactoferrin, or leukocytes → indicate Intestinal inflammation (colitis).
*Low serum protein levels and elevated fecal α1 -antitrypsin→ Protein-Losing Enteropathy.
*↑ Steatocrit→ Fat malabsorption.
*Amylase, lipase, fecal elastase → Assess Pancreatic function.

Treatment

1. General supportive measures
2. Nutritional rehabilitation when associated with malnutrition.
3. Elimination diet
4. Medications.

- **General supportive measures**→ including treatment of dehydration with replacement of fluid and electrolyte losses.
- **Nutritional rehabilitation:**
  - In moderate to severe malnutrition, caloric intake should be carefully advanced to avoid the development of refeeding syndrome.
  - Micronutrient and vitamin supplementation → zinc, vitamin A, and folate.
  - In children with steatorrhea (fat malabsorption) → use medium-chain triglycerides.

- **Elimination diet**

- A **lactose-free diet** should be started in all children with chronic diarrhea and is recommended by WHO. Lactose is generally replaced by **maltodextrin** or a combination of complex carbohydrates (corn starch).
- A **sucrose-free formula** is indicated in sucrase isomaltase deficiency.
- For cow's-milk protein allergy → use soy- based formula, hydrolyzed formula, or in severely compromised infants can use elemental formula (amino-acid–based formula).

***Toddler's diarrhea**: may benefit from a diet based on the "**4 F**"principles (reduce **F**ructose and **F**luids, increase **F**at and **F**iber).

*If diarrhea result from an **excessive intake of fluid and (**> 150 mL/kg/24 hr), fluid intake should be reduced not to exceed 90 mL/kg/24 hr.
*If the dietary history suggests that the child is ingesting significant amounts of fruit juice, especially apple juice, then the consumption of juice should be decreased.

➢ Medications.

Anti-infectious drugs.

Immune suppression.

Drugs that may inhibit fluid loss and promote cell growth.

Antimicrobial Treatment for Persistent infectious Diarrhea

	Drugs	Indications
Antibiotics	Trimethoprim-sulfamethoxazole	*Salmonella* spp.
	Ciprofloxacin, Ceftriaxone, Azithromycin, TMP-SMX	*Shigella* spp.
	Metronidazole	*Giardia*
	Metronidazole, Paromomycin	*Amebiasis*
	Metronidazole, Vancomycin	*Clostridium difficile*
Antiparasitic	Nitazoxanide	*Amebiasis, Giardiasis Cryptosporidiosis*

***Probiotics**→ as adjunctive therapy in persistent infectious and postinfectious diarrhea.
*Antisecretory agents ⟶ Racecadotril use in secretory diarrhea to reduce ions secretion.
*Adsorbents (Diosmectite)⟶ use in infectious Diarrhea.
*Immune suppression ⟶ use in selected conditions such as inflammatory bowel disease.

When therapeutic attempts and other nutritional support have failed (intestinal failure) ⟶ long-term parenteral nutrition or intestinal transplantation.