1. SIGNIFICANCE

Acute renal failure (ARF) is a clinical syndrome in which a sudden deterioration in renal function results in the inability of the kidneys to maintain fluid and electrolyte homeostasis. ARF occurs in 2–3% of children admitted to pediatric tertiary care centers and in as many as 8% of infants in the neonatal intensive care unit.

In children, chronic renal failure (CRF) may be the result of congenital, acquired, inherited, or metabolic renal disease, and the underlying cause correlates closely with the age of the patient at the time when the CRF is first detected. CRF in children younger than 5 yr is most commonly a result of congenital abnormalities such as renal hypoplasia, dysplasia, and/or obstructive uropathy. Additional causes include congenital nephrotic syndrome, cortical necrosis, focal segmental glomerulosclerosis, polycystic kidney disease, renal vein thrombosis, and hemolytic uremic syndrome.

After 5 yr of age, acquired diseases (various forms of glomerulonephritis including lupus nephritis) and inherited disorders (familial juvenile nephronophthisis, Alport syndrome) predominate. CRF related to metabolic disorders (cystinosis, hyperoxaluria) and certain inherited disorders (polycystic kidney disease) may present throughout the childhood years.

All the listed clinical entities should be recognized by a student and adequate management plan should be developed.

2. PREREQUISITES

The skills listed below will not be taught in this lesson but are necessary to perform physical examination of the patient in the nephrology department and intensive care unit during practical training. Therefore, before beginning this lesson, student should demonstrate ability to:

- Perform physical examination relevant to urinary system including:
  - Weight the child;
  - Inspect the skin for edema on the legs, periorbital region;
  - Grossly inspect the urine specimen;
  - Measure blood pressure;
  - Inspect the abdominal cavity for masses;
  - Elicit Pasternatskyi sign;
  - Read biochemistry for electrolyte disturbances and acid-base imbalance.

- The student should know indications for renal transplantation.

3. EDUCATIONAL OBJECTIVES

Student should know:

Student should be able:
- to identify the child with renal failure, make correct decisions during physical examination of the patient with listed conditions, take appropriate actions based on those decisions, demonstrate skills to develop treatment plan and follow-up.
4. INTERDISCIPLINARY INTEGRATION

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<td>Normal anatomy, Physiology</td>
<td>Anatomic and physiologic features of the urinary system in children of different age groups</td>
<td>Use knowledge of anatomic and physiologic features of urinary system in children for evaluation of clinical findings</td>
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<td>Biochemistry</td>
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<td>Pathology</td>
<td>Histologic and histochemical presentation of glomerular disease in children</td>
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<td>Pathologic physiology</td>
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<td>Propedeutics of pediatric diseases</td>
<td>Physical examination of urinary system in children.</td>
<td>Perform physical examination of the urinary system (gross inspection, palpation, percussion), assess the results of urinary tests</td>
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<td>Imaging studies</td>
<td>Indications and methods of imaging studies in glomerulonephritis</td>
<td>Assess ultrasound examination of kidney</td>
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<td>Intensive care</td>
<td>Symptoms and signs of renal failure of different stages, its etiology, and principles of intensive care</td>
<td>Recognize renal failure, assess its severity, provide emergency care</td>
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5. ABSTRACT FOR PRE-WORKSHOP SELF-EDUCATION

1. Acute and chronic renal failure (ARF).
   Etiology.
   Prerenal azotemia. Decreased perfusion of the kidney secondary to:
   - Decreased intravascular volume
   - Diminished cardiac output
   Postrenal (obstructive) renal failure:
     In newborns
     - Posterior urethral valves
     - Single kidney.
   Intrinsic renal disease:
   - Acute tubular necrosis (after hypoxic or nephrotoxic injury);
   - Glomerulonephritis (postinfectious acute glomerulonephritis);
   - Hemolytic uremic syndrome
   - Renal venous thrombosis
• Acute interstitial nephritis (idiopathic or secondary to medications nonsteroidal anti-inflammatory drugs, penicillin).

Epidemiology.
The most common form: prerenal azotemia.

Acute tubular necrosis is commonly encountered in intensive care units (ischemia plus nephrotoxic agents such as aminoglycosides, amphotericin B, contrast or chemotherapeutic agents).

Diagnosis.
Rapidly progressive, and potentially reversible, cessation of renal function that results in the inability of the kidney to control body homeostasis manifested by the retention of nitrogenous waste products and fluid and electrolyte imbalance.

Symptoms & signs.
• Lethargy, anorexia, nausea, vomiting.
• Abdominal pain (obstructive uropathy).
• Bloody diarrhea: (hemolytic uremic syndrome).
• Oliguria, edema, hematuria;
• In acute interstitial nephritis, polyuria and nocturia may present;
• Congestive heart failure
• Abdominal mass: in cases of obstructive uropathy
• Pallor, jaundice, petechia in hemolytic uremic syndrome.
• Fever, rash: in acute interstitial nephritis.

Investigations.
• Differential diagnosis with urinalysis:
  • Erythrocyte casts and proteinuria in cases of acute glomerulonephritis;
  • Pyuria with eosinophils in acute interstitial nephritis;
• The specific gravity is low in obstructive uropathy, acute interstitial nephritis, and acute tubular necrosis;
• The specific gravity is elevated in hemolytic uremic syndrome, acute glomerulonephritis, in prerenal azotemia.

Serum chemistries:
• Hyponatremia, hyperkalemia;
• Metabolic acidosis, hypocalcemia;
• Hyperphosphatemia, and azotemia.

Complete blood count:
• Normocytic anemia (except hemolytic uremic syndrome with microangiopathic hemolytic uremia and thrombocytopenia).

Renal ultrasound.
Electrocardiogram.
Echocardiography.
The immunologic studies:
• C3 (decreased in acute glomerulonephritis and SLE);
• Antinuclear antibodies (SLE);
• Antineutrophil cytoplasmic antibodies (Wegener’s granulomatosis).

The fractional excretion of sodium: \( \frac{C_{Na}}{C_{cr}} \times 100 \):
• <1 in prerenal azotemia
• >2 in acute tubular necrosis.

Renal biopsy: in patients with prolonged or unexplained acute renal failure.

Complications.
• Congestive heart failure: secondary to fluid overload or anemia. Hypertension: secondary to fluid overload.
- Cardiac dysfunction: secondary to hyperkalemia.
- Uremia: manifest by pericarditis, increased risk of bleeding, infection. Severe metabolic acidosis.
- Tetany: secondary to hypocalcemia.
- Malnutrition: secondary to decreased appetite and dietary restrictions.

Differential diagnosis.
- Chronic renal failure is insidious, poor growth, polyuria, anemia.
- Elevated BUN: upper gastrointestinal bleeding, malnutrition
- An elevated creatinine can be caused by trimethoprim+sulfamethoxazole, cimetidine.

2. Treatment in acute renal failure.
- Hospitalization for water electrolytic balance
- Fluid intake should not exceed insensible fluid losses plus urine output if the patient is euvolemic.
- A “renal diet” (low protein, potassium, sodium, and phosphorous, high carbohydrate) should be instituted.

Pharmacologic treatment.
preventive treatment.
Mannitol or furosemide to prevent acute renal failure is controversial. It can be used prior to the initiation of known nephrotoxic agents such as amphotericin B, cisplatin or contrast as prophylaxis in cases of acute tubular necrosis secondary to myoglobinuria as a method to augment urine flow. The conversion from an oliguric state (>0.5 mL/kg/h) to a nonoliguric state may improve the prognosis.

Supportive therapy.
- Support effective circulatory volume (normal saline, lactated Ringer’s solution)
- Patients with fluid overload may respond to fluid restriction and diuretic therapy (furosemide 1–4 mg/kg/dose, depending on renal function) to manage congestive heart failure.
- Monitor serum potassium levels frequently.
- Calcium gluconate (0.5–1 mL/kg over 2–10 min), glucose (0.5 g/kg), and insulin (0.1 U/kg), sodium bicarbonate (1–2 mEq/kg over 10–30 min) and Kayexolate (1 g/kg p.o. or p.r.) are effective therapy for hyperkalemia.
- Severe acidosis (pH <7.2) may require therapy with sodium bicarbonate. However, this may precipitate symptomatic hypocalcemia and cause hyponatremia and fluid overload.
- Hypertension may require aggressive treatment if encephalopathy is present. Administer ulcer prophylaxis.
- Adjust drugs according to renal failure.

Specific therapy.
In some forms of glomerulonephritis, corticosteroid and cytotoxic therapy may be indicated. Acute interstitial nephritis is managed by removing the offending agent and possibly corticosteroids. Surgery may be indicated in obstructive causes of renal failure; A postobstructive diuresis may develop after relief of the obstruction.
- Dialysis is indicated in cases of fluid overload refractory to diuretic therapy, severe hyperkalemia, refractory metabolic acidosis, and uremia;
- Conventional dialysis (peritoneal or hemodialysis) as well as continuous arteriovenous hemodiafiltration or pump-assisted continuous venovenous hemodiafiltration can be considered.

Prognosis.
- Many children with isolated acute renal failure have a good prognosis with return of renal function. Children with multiorgan failure have a high mortality rate despite good supportive care. Nonoliguric renal failure is associated with a lower mortality rate than oliguric renal failure.
- Follow-up and management.
Patients with prolonged anuria should be followed for associated sequelae including hypertension, proteinuria, and chronic renal failure.

3. Treatment in chronic renal failure.

Diet and lifestyle
- Influence as little as possible on lifestyle.
- Salt supplementation if salt-losing nephropathy.
- Salt restriction if edematous, hypertensive.
- Hyperkalemia: potassium restriction, Kayexalate, may be indication for chronic dialysis.
- Protein and phosphate restriction: difficult in growing children. Supplement calorie intake.

Pharmacologic treatment.
- Anemia: erythropoietin, folate, iron.
- Osteoporosis: calcitriol, monitor serum PTH, phosphate binders (calcium citrate preferred).
- Metabolic acidosis: sodium bicarbonate.
- Hypertension: calcium channel blockers; angiotensin-converting enzyme (ACE) inhibitors also useful but monitor serum creatinine and potassium.
- Growth below fifth centile: growth hormone.

Nonpharmacologic treatment.
- Educate child and family.
- Psychosocial support for psychosocial problems.
- Surgical treatment of obstructive uropathy.
- Peritoneal dialysis, hemodialysis if symptoms.
- Preemptive renal transplantation preferred.
- Chronic dialysis and/or transplantation in neonates, infants with multiorgan failure.
- Serum creatine level for dialysis or transplanting.


Prognosis. Depends on underlying cause.

Follow-up and management.
- Regular serum creatinine, electrolytes, calcium, phosphate
- Hemoglobin
- Height, weight, blood pressure.
- Support: by telephone, social worker, psychologist. Regular evaluation of nutrition, medication compliance.

6. MATERIALS FOR METHODOLOGICAL BACKGROUND OF THE WORKSHOP

6.1. Quiz
1. What is the prevalence of ARF in children admitted to the tertiary hospital?
2. What is the prevalence of ARF in newborns?
3. What is the etiology of chronic renal failure in children younger than 5 years old?
4. What is the etiology of chronic renal failure in children older than 5 years?
5. What are the causes of pre-renal azotemia?
6. What are the causes of renal azotemia?
7. What are the causes of post-renal azotemia?
8. What is the most common form of azotemia?
9. What is the major cause of ARF in intensive care unit?
10. What are the differential symptoms and signs of ARF?
11. How urinalysis may help you in differentiating the causes of ARF?
12. What are the serum chemistries for ARF?
13. What are the instrumental laboratory tests necessary for examination of a patient with renal failure?
14. What are the immunologic studies for ARF?
15. How one calculates fractional excretion of sodium?
16. What is use of fractional excretion of sodium in differential diagnosis of renal failure?
17. What are complications of ARF in children?
18. What is the differential diagnosis of chronic renal failure in children?
19. What are the treatment options for the acute renal failure?
20. What is the preventive treatment for ARF?
21. What are the medications that can cause ARF?

6.2. Multiple-choice question
A 12 year old boy suffers from chronic renal failure developed after the incidence of hemolytic uremic syndrome 3 years ago. On visit, mother points at decreasing of growth of the child. Blood calcium concentration was 1,9 mmol/l while phosphates 0,7 mmol/l. Radiologic examination of the lower extremity bones revealed decreased density of osseous tissue. What of the drugs below will be helpful in controlling these metabolic changes?
A. Furosemide
B. Calcitriol*
C. Mannitol
D. Anion exchange resin
E. Folate

6.3. Sample case report
A 16 year old boy was admitted to the hospital because of the car accident. He was in very bad condition, because of extensive burn injuries involving 35% of total body surface and massive blood loss. Twenty four hours following admission, he had developed oliguria. Laboratory studies showed leukocytosis, elevated blood urea nitrogen and serum creatinine, with a BUN: creatinine ratio of 30. Urine osmolality was 800 mOsmol/kg H2O, and fractional excretion of sodium at the level of 0,5%. What is your diagnosis in this particular case?
1. What is the preliminary diagnosis?
2. What is differential diagnosis?
3. What is treatment?

Suggested reading

Additional reading