Acute Renal Insult (ARI) — Symptoms and Treatment

See online here

Acute renal insult (ARI) is responsible for 5% of emergency hospitalization cases. Acute renal insult is classified into prerenal, intrinsic, or postrenal, depending on etiology. Prerenal ARI is the most common type. Etiology is determined through a systematic approach involving blood tests, urine tests, and abdominal ultrasonography. Treatment focuses on supportive therapy based on fluid and electrolyte replacement to reduce waste accumulation and sustain nutrition.

Definition

The 3 Criteria for Defining Acute Renal Insult (ARI)

According to the Kidney Disease Improving Global Outcomes (KDIGO) guideline, ARI is defined by 1 of the following 3 criteria:
Structure of creatinine

Increase in creatinine serum level of more than 0.3 mg/dl (within 48 hours)

- Increase in creatinine serum level by more than 50% (within the prior 7 days)
- Decrease in urine volume (oliguria) to less than 0.5 ml/kg body weight/hour for 6 hours

Although oliguria or anuria is considered the preeminent symptom of ARI, many patients also present with polyuria or normuria (see below). In these cases, the measurement of creatinine serum levels over the course of the illness may provide the only indication of ARI.

Epidemiology

A Common Disease

Acute renal insult is a relatively common disease, with an incidence of 2,000 to 3,000 per million inhabitants. Older people and toddlers are particularly susceptible, as they can dehydrate quickly when experiencing acute water loss (e.g., due to infections or heavy sweating). Patients in intensive care can also develop the disease, as kidney problems in this unit are frequent; approximately 5% of all intensive care patients suffer from ARI.

Etiology and Pathophysiology

Causes

Because of various pathophysiologic processes, kidney function can diminish rapidly. As a consequence, uremic substances accumulate and alter water, electrolyte, and acid-base balances. Usually, this loss of function is reversible, as long as the underlying cause or structural processes do not become chronic.

Types

Etiologically, ARI can be subdivided into 3 types. Each type encompasses different pathophysiological processes, so understanding the type of ARI presenting in a patient is crucial to identifying the choice of treatment:

- Prerenal ARI
- Intrinsic ARI
- Postrenal ARI

Prerenal ARI (About 60% of all cases)
Prerenal ARI is the result of reduced renal perfusion, with the glomerular and tubular structures initially being completely intact. It may be caused by actual hypovolemia (e.g., due to exsiccosis, diarrhea, or pancreatitis), but also relative hypovolemia stemming from, e.g., cardiac insufficiency, shock, or sepsis. Prerenal ARI may lead to a reduction in renal perfusion. Diseases that cause renal vasoconstriction may also result in prerenal failure. Hepatorenal syndrome is evident.

Through the regulation mechanisms of the kidney, reduced perfusion activates the renin-angiotensin-aldosterone system (RAAS). At the same time, the body experiences a release of catecholamine and ADH. This reaction is vasoconstriction with simultaneous retention of sodium and water in order to compensate for the hypovolemic condition.

In the case of exsiccosis, these reactions are appropriate. However, in the presence of cardiac insufficiency, actual reduced perfusion does not involve a lack of water. Clinically, signs of hyperhydration predominate. The activation of RAAS erroneously increases the intracorporeal water concentration and hyperhydration increases. If diuretics are administered in this situation, renal perfusion will be reduced even more, increasing the risk of ischemia and intrinsic renal failure.

**Intrinsic Renal Insult (About 35% of All Cases)**

Acute damage to the glomeruli or tubular cells leads to structural damage of the kidney itself. Usually, acute tubular necrosis brought about by, e.g., different (micro- and macroangiopathic) ischemic processes such as thromboembolism or thrombotic microangiopathy will occur. Glomerulonephritides may also lead to reduced kidney function.

Toxic damage, especially iatrogenic damages, are frequent. Contrast agents or other medications play an important role here. In addition, myoglobinuria due to rhabdomyolysis, hemoglobinuria due to hemolysis, or uric acid salts due to gout or tumor lysis are potential causes.

A number of frequently administered drugs can also cause damage to the kidneys, including nonsteroidal anti-inflammatory drugs, aminoglycosides, cephalosporin, vancomycin, amphotericin B, cisplatin, methotrexate, cyclosporine, diuretics, X-ray contrast agents, and angiotensin-converting enzyme (ACE) inhibitors.

The renal tubules are responsible for reabsorption. If an intrinsic renal dysfunction affects the tubules, this may cause severe polyuria as part of ARI.

If sodium reabsorption is diminished because of damage to the tubular cells, the tubuloglomerular feedback mechanism causes constriction of the afferent glomerular arteriole. This, in turn, leads to a reduction in the glomerular filtration rate.

**Postrenal Insult (about 5% of All Cases)**

Any disease with the potential to impair the drainage of urine from the kidneys can lead to urinary retention with subsequent postrenal failure. Congenital malformations of the
Clinical Presentation and Symptoms

The clinical manifestations of ARI are very diverse and largely depend on a persistent underlying disease. The clinical course of the disease can be divided into 3 stages:

1. **Initiating stage:** Before ARI manifests, it is mostly asymptomatic. Possible symptoms of an underlying disease predominate.

2. **Oliguric stage:** The preeminent symptom of ARI is oliguria or anuria, which leads to a corporeal hyperhydration with a number of complications, including hypertension, pulmonary edema, pleural effusion, left ventricular heart failure, ascites, cerebral edema, and others. A consequence of urinary retention may be hyperkalemia with acidosis. However, as noted above, there are many normuric or polyuric stages.

3. **Diuretic or polyuric stage:** Usually, the glomeruli recover faster than the tubular system, which means that during recovery, reabsorption may remain disturbed while the filtration capacity of the kidney begins to function again.

Depending on what is causing the ARI, side pain, fever, fatigue, and symptoms relating to complications (see below) may also be present.
Complications

Complications are due to the above-noted pathophysiological processes. Many organ systems may be affected:

- The **lungs** can be affected by hyperhydration, including **edema** and effusion. Acute respiratory distress syndrome may occur.
- Heart failure may develop due to hypertension or hyperhydration, or arrhythmias may develop due to imbalanced electrolyte concentrations.
- If heart failure occurs, there is a risk of congestion in the venous circuit causing gastritis, ulcerations, or gastrointestinal bleeding. The stress-associated release of hormones can increase the likelihood of gastrointestinal bleeding.
- Seizures may occur due to a cerebral edema or electrolyte imbalance. In addition, vigilance can be impaired.

Diagnosis

**Laboratory Diagnosis and Medical History**

Diagnosis of ARI is based on a focused medical history with a corresponding clinical presentation and determination of the diuretic level. Laboratory tests should include urinalysis. Retention parameters can be measured in the blood, especially electrolyte concentrations, which should be checked regularly. Depending on the underlying condition, lab tests can provide valuable information.

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**Index**

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- **Urine color**
- Dark yellow

- **Serum creatinine**
- 200% of baseline

- **Urine specific gravity**
- High (> 1.020)

- **Urine sodium**
- Low (< 10 mmol/L)

- **Urine sediment**
- Normal

- $\text{FE}_{\text{Na}}$
- < 1%

- $\text{FE}_{\text{urea}}$
- < 35%

- **Urine osmolality**
- High (> 500 mOsm/kg H$_2$O)

- **Urine/plasma osmolality**
- > 1.5

- **Urine/plasma creatinine ratio**
- High (> 40)

- **BUN/creatinine ratio**
- High

- **Urine sodium/potassium ratio**
- Low (< 1/4)

- **RFI (Renal failure index)**
- < 1

**Table:** “Laboratory evaluations used to diagnose acute kidney injury” by Rajitbasu. License: CC BY-SA 3.0

**Determining the Fractional Sodium Excretion in ARI**

The determination of fractional sodium excretion is an important finding. Fractional sodium excretion is based on the clearance of sodium in relation to the clearance of creatinine. The results of this test help distinguish between a prerenal and an intrinsic ARI. It is based on the following assumptions:
1. In prerenal ARI, the tubular system is still functioning and hypovolemia is counteracted by increased reabsorption. This results in concentrated urine with low sodium content. Fractional sodium excretion < 1%.

2. In intrinsic ARI with acute tubular necrosis, tubular function is impaired and deficient reabsorption results in diluted urine with high sodium content. Fractional sodium excretion > 1%.

Other Examination Methods for ARI

Imaging techniques can also provide useful additional information or a differential diagnosis. Sonography can be used to detect enlarged kidneys and confirm a diagnosis of ARI; in contrast, small, thin, hyperechoic kidneys may indicate chronic renal failure.

An enlarged renal pelvis may indicate urinary obstruction related to postrenal ARI. Magnetic resonance imaging and computed tomography scans are particularly suited to the more specific assessment of structural lesions (tumors, thrombosis, and perfusion dysfunctions).

For a definitive diagnosis of glomerulonephritis, a percutaneous kidney biopsy is indispensable.

Differential Diagnosis

Differential diagnosis is mostly concerned with diagnosing the type of ARI. Medical history, premedication, and pretreatment are especially useful here. Chronic renal failure needs to be excluded.

An important differential diagnosis is a functional oliguria. This disorder may occur after a long period of time without water and is usually accompanied by a barely increased creatinine level; functional oliguria can eventually lead to ARI.

Treatment

Substitution of Fluids and Electrolytes for ARI of Prerenal Genesis

In prerenal ARI, kidney function can only recover when the underlying pathophysiological mechanism has been eliminated. Nephrotoxic substances should be avoided, and fluid and electrolyte balances must be thoroughly controlled and treated.

The reason for the hypoperfusion must be uncovered and then treated. The administration of fluids and electrolytes is a prudent option. Loop diuretics can also be helpful in maintaining diuresis. (Note that while this medication measurably increases diuresis, it does not increase glomerular filtration or have any impact on the recovery of kidney function.)

Patients with sepsis or severe heart failure often require treatment in the intensive care unit.

Immunosuppressive Therapy and Revascularization for
ARI of Intrinsic Genesis

In intrinsic ARI, it is important to first treat the underlying disease. Immunosuppressive treatment is advisable for glomerulonephritis, and revascularization for ischemia.

For raising diuresis, loop diuretics can be administered; however, the use of diuretics is controversial and therefore not generally recommended. The only absolute indication for the administration of diuretics is hyperhydration.

Treatment of ARI of Postrenal Genesis

In cases of postrenal ARI, it is imperative to remove the urinary obstruction. If this is not immediately possible, the surgical insertion of an artificial excretory opening (percutaneous nephrostomy) is indicated.

Extracorporeal Treatment of ARI

Extracorporeal treatment with hemodialysis or hemofiltration for electrolyte imbalances, water overloads, or acid-base imbalances can also be attempted. This type of renal replacement therapy should be considered only as a temporary measure and limited accordingly. If kidney function cannot be restored sufficiently, permanent dialysis may become necessary.
Prognosis

Despite the progress that has been made in treating ARI in intensive care units, it is a dangerous disease with a high mortality rate, at approximately 60%. This high rate can often be explained by a serious underlying disease or, sometimes, severe and systemic complications.

References


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