cause, followed by intrinsic AKI from nephrotoxic medications and ischemic ATN.

DIAGNOSTIC EVALUATION

History and Physical Examination

Evaluation of the patient with AKI should be methodical and systematic to ensure that potentially reversible causes are diagnosed and treated expeditiously to preserve kidney function and limit development of permanent kidney injury, as depicted in Table 31-2. Part of the difficulty in arriving at a correct diagnosis is that several potential causes of AKI often coexist. Emphasis is placed on thorough analysis of available data and examination of the sequence of deterioration in kidney function and urine volume in relation to the chronologies of the potential causes of AKI.

Knowledge of the natural history of the various causes of AKI also is critical. The evaluation should include a thorough patient history and chart review to identify risk factors for prerenal AKI (e.g., vomiting, diuretics, diarrhea, heart failure, cirrhosis); potential nephrotoxic drugs (prescribed or over-the-counter); risk factors for prostate disease, cervical cancer, or bladder cancer; and symptoms of urinary tract obstruction (e.g., prostatism, overflow incontinence, anuria). Some of the important chart review data are presented in E-Table 31-2 . The urine volume is less than 400 mL/day with oliguric AKI, less than 100 mL/day with oligoanuric AKI, and less than 50 mL/day with anuric AKI. Normal urine output does not exclude the diagnosis of AKI: Nonoliguric AKI (>400 mL/day) can be associated with nephrotoxic AKI and partial urinary obstruction. Wide variation in daily urine output also suggests AKI due to partial urinary tract obstruction. Anuria has a limited differential diagnosis, suggesting complete urinary obstruction, a vascular catastrophe, or severe cortical necrosis.

The physical examination should focus on volume status to allow initial classification into one of the broad categories of AKI. Reduced body weight, hypotension, an orthostatic fall in blood pressure (BP), or flat neck veins may be present in patients with prerenal AKI (ischemic AKI) caused by true volume depletion. The presence of edema, pulmonary rales, or an S_3 gallop signals effective volume depletion due to cardiac dysfunction, whereas edema, ascites, and asterixis suggest liver dysfunction or cirrhosis. If the intravascular volume status is uncertain, measurement of cardiac filling pressures with an indwelling catheter may be useful, but this technique is not commonly used. More often, central venous pressure is measured. Although central venous pressure measurement has limitations, even in monitoring of trends and response to fluid administration or removal, it remains an important tool to guide fluid management. New, noninvasive monitoring tools that more accurately measure volume status are under investigation.

Evidence of systemic disease also should be sought. Findings may include signs of pulmonary hemorrhage indicative of a vasculitis or Goodpasture's disease, skin rash as a manifestation of systemic lupus erythematosus, atheroemboli, vasculitis, cryoglobulins, or AIN, as well as joint disease making lupus or rheumatoid arthritis a consideration.

TABLE 31-2 DIAGNOSTIC APPROACH TO THE PATIENT WITH ACUTE KIDNEY INJURY

1. Record review (see E-Table 31-2); special attention to evidence of recent reduction in glomerular filtration rate and sequence of events leading to deterioration of kidney function to determine possible causative factors
2. Physical examination, including evaluation of hemodynamic status
3. Urinalysis and urine microscopy with thorough sediment examination
4. Determination of urinary indices, including fractional excretion of sodium and urine output
5. Catheterization and measurement of postvoid residual urine volume if outlet obstruction is suspected
6. Fluid challenge in cases of suspected prerenal AKI
7. Radiologic studies, particular as dictated by the clinical setting (e.g., ultrasonography to look for obstruction)
8. Kidney biopsy

AKI, Acute kidney injury.

Basic Laboratory Tests

Laboratory tests are directed by the differential diagnosis that is postulated after a complete history, chart review, and physical examination have been performed. Basic tests include a complete blood count to assess for anemia (microangiopathic or immune-mediated) and thrombocytopenia (thrombotic thrombocytic purpura [TTP], hemolytic-uremic syndrome [HUS], and disseminated intravascular coagulation [DIC]). Other tests to evaluate the cause of AKI include various serologic measurements (antinuclear antibody [ANA], antineutrophil cytoplasmic antibodies [ANCA], anti–glomerular basement membrane antibody [anti-GBM], anti–double-stranded DNA antibodies [anti-dsDNA], and hepatitis B and C viral serologies), complement levels, cryoglobulin levels, blood cultures, serum lactate dehydrogenase (LDH) and haptoglobin measurements, serum and urine immunoelectrophoresis, and serum free light chain assay.

Urinalysis and Urine Microscopy

Urinalysis is a key component of the diagnostic evaluation of AKI, as summarized in Table 31-3. It is important to evaluate urine specific gravity (SG), as well as the presence of blood (or heme), protein, or leukocyte esterase.

A very high urine SG typically suggests prerenal AKI, whereas isosthenuria (SG = 1.010) indicates intrinsic AKI (e.g., ATN). A thorough microscopic examination of the spun urine sediment, with quantification of the urinary elements, adds essential information to the case. Bland urine with no blood or protein and few to no cells or casts favors a diagnosis of prerenal AKI. Vascular causes of AKI have a variable urine tonicity and sometimes hematuria (isomorphic or dysmorphic red blood cells [RBCs]) and granular casts. GN exhibits variable urine tonicity, positive blood and protein on the dipstick, RBCs, and RBC casts. ATN shows isotonic urine with variable protein and variable heme on urine dipstick (heme is positive with rhabdomyolysis and hemolysis), Renal tubular epithelial cells (RTECs), RTEC casts, and fine or coarse pigmented granular casts (sometime muddy brown E-Fig. 31-1) may be present on the sediment examination.

Urine in patients with postrenal AKI is typically isotonic and bland unless there is associated infection (pyuria), nephrolithiasis (hematuria), or concomitant ATN (RTECs, RTEC casts, granular casts).