1. What is Tamm-Horsfall glycoprotein (THP)?

_______________________________________
_______________________________________
_______________________________________
_______________________________________
_______________________________________
_______________________________________

2. What is a urinary cast?

_______________________________________
_______________________________________
_______________________________________
_______________________________________
_______________________________________
_______________________________________

3. What are the major types of urinary casts?

_______________________________________
_______________________________________
_______________________________________
_______________________________________

Matching (4 – 15): Match the following urinary casts with the descriptions, conditions, or questions presented hereafter:

A. Bacterial casts
B. Crystal casts
C. Epithelial casts
D. Fatty casts
E. Granular casts
F. Hyaline casts
G. Pigment casts
H. Red blood cell casts
I. Waxy casts
J. White blood cell casts

4. These types of casts are by far the most common urinary casts. They are composed of solidified Tamm-Horsfall mucoprotein and secreted from tubular cells under conditions of oliguria, concentrated urine, and acidic urine.

_______________________________________

5. These types of casts are pathognomonic of acute tubular necrosis (ATN) and at times are described as “muddy brown casts”.

_______________________________________

6. A 6-year-old girl is admitted to the emergency department with fever, and puffy face, eyes, and trunk. Blood pressure taken on admission is 180/120. Her mother states that 10 days ago she had a sore throat, and she has voided very little urine within the past 24 hours. Serology of the patient is significant for high antistreptolysin O titers and low Complement C3. Urinalysis of the child is most likely indicative of which type of cast?

_______________________________________

7. Presence of these types of urinary casts is often indicative of tubulointerstitial nephritis.

_______________________________________
8. Distinction of leukocytic casts from epithelial casts is sometimes difficult. What urinary test often helps to confirm presence of leukocytic casts?

9. What urinary test is indicative of bacteriuria?

10. These casts are the second most common casts. The “muddy brown cast” seen in acute tubular necrosis is a type of this cast.

11. These casts are indicative of very low urine flow and they are associated with severe, longstanding kidney disease and renal failure. They are notably larger than hyaline casts.

12. These caricature urinary casts are seen with polarized microscopy of the urine of a patient with nephrotic syndrome.

13. These types of urinary casts are often seen in patients with rhabdomyolysis and conjugated urobinemia.

14. What is the best description for the cast seen in the picture below?

15. What do these two pictures depict and what is wrong with them?

16. What is the description of acute tubular necrosis (ATN)?

17. What is the most common cause of acute renal injury (AKI)?

18. What are the common causes of ATN?
19. What are the key findings in ATN?

20. What is the key pathognomonic cast seen in urinalysis of patients with ATN who present urinary tubular epithelial cells?

21. What is the treatment for ATN?

22. Of the two types of ATN, ischemic and toxic, one of the two causes “skip” lesions at various parts of the nephrons, including proximal and distal tubules. Which type is it?

23. Kidney failure is defined as prerenal, renal, and postrenal. Which of the three types is similar to ATN?

24. Distinguishing prerenal azotemia from acute tubular necrosis is important in clinical settings because fluid resuscitation often alleviates prerenal azotemia but is ineffective for treating ATN. What lab measurement would help to differentiate the two conditions from each other?

25. How do we measure FeNa+?

26. Which of the two improves rapidly in response to administration of large volume of IV fluids; ATN, or prerenal azotemia?

27. What is the difference between blood urea and blood urea nitrogen?
28. What is the source of blood urea?
_______________________________________
_______________________________________
_______________________________________

29. What is the source of blood creatinine?
_______________________________________
_______________________________________

30. What is the physiologic significance of the BUN to creatinine ratio?
_______________________________________
_______________________________________
_______________________________________

31. What is the normal BUN to creatinine ratio?
_______________________________________
_______________________________________

32. What major factors increase or decrease BUN to creatinine ratio?
_______________________________________
_______________________________________
_______________________________________

33. What is the most important clinical value of the BUN to creatinine ratio?
_______________________________________
_______________________________________

BUN to Creatinine Ratios and their Attributes

Greater than 20:1
- Prerenal
- BUN reabsorption is increased.
- BUN is disproportionately elevated relative to creatinine in serum.
- Dehydration is suspected.

Between 10:1 and 20:1
- Normal or postrenal
- Normal range. Can also be postrenal disease.
- BUN reabsorption is within normal limits.

Less than 10:1
- Intrarenal
- Renal damage causes reduced reabsorption of BUN, therefore lowering the BUN:Cr ratio.

34. A 25-year-old African-American medical student plans on visiting Kenya as part of his international medical training program. He received a prescription for chloroquine and was advised to start the medication 10 days prior to his departure. Two days after taking the medication the patient is admitted to the hospital with the complaint of shortness of breath, pallor, jaundice, and low volume and dark urine. Serology of the patient is significant for bilirubinemia and inclusions within the red cells. What is the LEAST LIKELY urinary finding in this patient?

A. Hemoglobinuria
B. Unconjugated bilirubinuria
C. Epithelial casts
D. Muddy brown casts
E. High levels of urinary sodium
35. Why does urinalysis show epithelial and muddy brown casts in ATN?

36. Why, despite death of tubular cells, is the prognosis of ATN very good and kidney function is resumed after removal of the etiological factors?

37. What is the postulated pathophysiology of ATN?

38. Kidney failure is often described as prerenal, renal, and postrenal. Which of the three descriptions is more accurately applicable to ATN and which one is more applicable to glomerulonephritis?

39. In addition to FeNa of more than 2% in ATN and less than 1% in prerenal azotemia, the two conditions are often characterized by their urinary sediments. How are they differentiated by their sediments?

40. What are the three common causes of intrinsic acute renal injury?

41. Damage to what anatomical structures is the common cause of acute intrinsic renal failure?

42. What is the most common cause of acute renal injury?

43. ATN is more common in hospitalized patients. Name the common hospital-related predisposing factors:
44. Why are renal tubules primarily damaged in ATN?

<table>
<thead>
<tr>
<th>Acute Tubular Necrosis</th>
<th>Acute Glomerulonephritis</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Both acutely affect and drop the GFR</td>
<td>Associated with hypertension (remember the “H2O” mnemonic!)</td>
</tr>
<tr>
<td>• Both cause a rapid rise in serum creatinine and BUN</td>
<td></td>
</tr>
<tr>
<td>• Both are associated with change of urine color</td>
<td></td>
</tr>
<tr>
<td>Results from hypotension</td>
<td>Brown urine</td>
</tr>
<tr>
<td>Associated with hypertension</td>
<td>Red urine</td>
</tr>
<tr>
<td>(remember the “H2O” mnemonic!)</td>
<td>Epithelial casts</td>
</tr>
<tr>
<td>Brown urine</td>
<td>Red cell casts</td>
</tr>
<tr>
<td>Epithelial casts</td>
<td>Does not affect glomerulus (mainly tubules)</td>
</tr>
<tr>
<td>Red urine</td>
<td>Affects glomerulus</td>
</tr>
<tr>
<td>Red cell casts</td>
<td>Lack of proteinuria</td>
</tr>
<tr>
<td>Does not affect glomerulus (mainly tubules)</td>
<td>May have pre-nephrotic proteinuria</td>
</tr>
<tr>
<td>Affects glomerulus</td>
<td>Neither has nephrosis or nephritis</td>
</tr>
<tr>
<td>May have pre-nephrotic proteinuria</td>
<td>For the most part has a nephritic pattern</td>
</tr>
<tr>
<td>Neither has nephrosis or nephritis</td>
<td>Does not cause glomerulonephritis</td>
</tr>
<tr>
<td>For the most part has a nephritic pattern</td>
<td>May cause ATN</td>
</tr>
<tr>
<td>Does not cause glomerulonephritis</td>
<td>Etiology is ischemic or toxic</td>
</tr>
<tr>
<td>May cause ATN</td>
<td>Etiology is immune injury</td>
</tr>
<tr>
<td>Etiology is ischemic or toxic</td>
<td>FeNa is greater than 1%</td>
</tr>
<tr>
<td>Etiology is immune injury</td>
<td>FeNa is less than 1%</td>
</tr>
<tr>
<td>FeNa is greater than 1%</td>
<td>Often rapidly progresses to end-stage failure</td>
</tr>
<tr>
<td>FeNa is less than 1%</td>
<td>Often slowly progresses to end-stage failure</td>
</tr>
<tr>
<td>Often rapidly progresses to end-stage failure</td>
<td>Mostly reversible</td>
</tr>
<tr>
<td>Mostly reversible</td>
<td>Mostly irreversible</td>
</tr>
</tbody>
</table>

45. A 75-year-old man is diagnosed with staphylococcal pneumonia. Serology shows bacteremia with non-methicillin resistant staph aureus. The patient is treated with nafcillin. On day 10 post-nafcillin therapy, the patient presents with fever, malaise, erythematosus body rash, edema, dysuria, and lower back pain. Serology of the patient is significant for eosinophilia. What is the most likely diagnosis?
46. Summarize Major Causes of AIN.

47. What are the key cell types (casts) seen in acute glomerulonephritis (AG), acute tubular necrosis (ATN), and acute interstitial nephritis (AIN)?

48. AIN is often described as what type of hypersensitivity reaction?

49. What is the tetrad of AIN?

---

### Acute Interstitial Nephritis (AIN) vs. Acute Tubular Necrosis (ATN)

<table>
<thead>
<tr>
<th>AIN</th>
<th>ATN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both are rapidly developing conditions</td>
<td></td>
</tr>
<tr>
<td>Both may be drug-induced (although drugs differ)</td>
<td></td>
</tr>
<tr>
<td>Less common</td>
<td>More common</td>
</tr>
<tr>
<td>Spaces between tubules are affected</td>
<td>Tubules are affected</td>
</tr>
<tr>
<td>Fever</td>
<td>Often no fever</td>
</tr>
<tr>
<td>Hypertension (mostly)</td>
<td>Hypotension (mostly)</td>
</tr>
<tr>
<td>WBC casts (and sterile pyuria)</td>
<td>Epithelial casts and muddy brown casts</td>
</tr>
<tr>
<td>• Acute pyelonephritis: Direct ascending bacterial invasion of renal medulla (Vesicoureteral Reflux)</td>
<td>• Ischemic or nephrotoxic, caused by: ischemia, nephrotoxins, sepsis</td>
</tr>
<tr>
<td>• Allergic AIN</td>
<td>• Diagnosis of exclusion</td>
</tr>
<tr>
<td>Drugs involved are mostly antibiotics</td>
<td>Drugs are mostly non-antibacterial (Exception: Aminoglycoside)</td>
</tr>
<tr>
<td>Gallium-67 accumulation (uptake)</td>
<td>Lack of Gallium-67 radionuclide accumulation</td>
</tr>
<tr>
<td>• Eosinophilia, eosinophiluria, and interstitial edema</td>
<td>• Anemia</td>
</tr>
<tr>
<td>• Hematuria, sterile pyuria, and hyperkalemia</td>
<td>• Hyperkalemia</td>
</tr>
<tr>
<td>• Slower renal function recovery after stopping the offending medication (several weeks)</td>
<td>• Faster renal function recovery after stopping the offending medication (a few weeks)</td>
</tr>
<tr>
<td>• Prednisone accelerates recovery</td>
<td>• Prednisolone ineffective</td>
</tr>
<tr>
<td>Question</td>
<td>True/False: Hyperkalemia causes interstitial fibrosis</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>50. Why, in contrast to acute tubular necrosis, is AIN presented with Gallium-67 uptake?</td>
<td></td>
</tr>
<tr>
<td>51. True/False: Glomeruli and vessels are spared in AIN</td>
<td></td>
</tr>
<tr>
<td>52. True/False: AIN has an immune-mediated mechanism</td>
<td></td>
</tr>
<tr>
<td>53. True/False: AIN has a cell-mediated mechanism</td>
<td></td>
</tr>
<tr>
<td>54. What are the top two causes of interstitial kidney injury?</td>
<td></td>
</tr>
<tr>
<td>55. True/False: Hyperkalemia causes interstitial fibrosis</td>
<td></td>
</tr>
<tr>
<td>56. What is the likely mechanism for hypokalemic nephropathy?</td>
<td></td>
</tr>
<tr>
<td>57. True/False: Hypercalcemia causes interstitial fibrosis</td>
<td></td>
</tr>
<tr>
<td>58. What is the likely mechanism for hypercalcemic nephropathy?</td>
<td></td>
</tr>
<tr>
<td>59. Acute tubular necrosis (ATN) is not associated with proteinuria. Why?</td>
<td></td>
</tr>
</tbody>
</table>
Answers: Glomerulonephritis ATN and AIN

1. Also known as uromodulin, it is a glycoprotein that is encoded by the uromodulin (UMOD) gene and is the most abundant protein excreted in ordinary urine. It is produced by the cells of the ascending loop and it is the major protein constituent of urinary casts. Note: The other major protein that is seen in urine under pathological conditions is albumin.

2. Cylindrical structures produced by the kidney and present in the urine in certain disease states. They form in the distal convoluted tubule and collecting ducts and then pass into the urine. They form via precipitation of Tamm-Horsfall mucoprotein. In proteinuric conditions the casts, in addition to Tamm-Horsfall mucoprotein, include albumin and other proteins. Cast formation is enhanced with dehydration, low urine flow and pH, and certain disease conditions.

3. Urinary cast are two types: acellular and cellular
   - **Acellular:** Hyaline, granular, waxy, fatty, pigment, and crystal
   - **Cellular:** Red blood cell, white blood cell, bacterial, and epithelial

4. Hyaline cast! They are seen in normal individuals after intensive exercise and dehydration. They are cylindrical and clear with a low refractive index and may be missed under bright-field microscopy. Due to ubiquitous presence of hyaline casts under pathological conditions, other inclusions are formed via adherence to the hyaline cast.

5. Epithelial casts
   Epithelial casts are formed by inclusion or adhesion of desquamated epithelial cells of the tubular lining. They are characterized by large, round nuclei and a lower amount of cytoplasm. Pathogenesis: Ischemia, infarction, or nephrotoxicity. They cause degeneration, necrosis, and sloughing of tubular epithelial cells. The presence of these casts indicates acute tubular injury but does not indicate the extent or reversibility of the injury. Leukocytes can also be incorporated into the casts in cases of tubulo-interstitial inflammation (e.g. pyelonephritis). It is often difficult to distinguish between epithelial casts and leukocytic casts; however, epithelial casts are usually larger than granulocytes (a key distinguishing factor).

   - **“Muddy brown casts”** of epithelial cells are pathognomonic for ATN.

   Management of ATN: Aggressive treatment of the precipitating factors (e.g. hydration and cessation of the offending drug). Note: Tubular cells continually replace themselves, and as such the overall prognosis for ATN is quite good (recovery often happens within 7 to 21 days).

6. RBC Casts
   The child has post-streptococcal glomerulonephritis. History of sore throat, hematuria with red blood cell casts, hypertension, oliguria, and low serum C3 are cardinal findings in this condition. These casts are indicative of glomerular damage and are usually associated with nephritic syndromes. They are seen in various causes of vasculitis such as Goodpasture’s and Wegener’s granulomatosis, and certain types of systemic lupus erythematosus. They may also be associated with renal infarction and subacute bacterial endocarditis.

7. WBC casts
   WBC casts are indicative of inflammation or infection, and their presence strongly suggests pyelonephritis, tubulointerstitial nephritis, direct infection of the kidney, and sometimes glomerulonephritis.
White blood cells can sometimes be difficult to discern from epithelial cells and may require special staining.

8. Leukocytic esterase!
   It is an enzyme present in the white blood cells, and presence of it in the urine indicates the presence of white blood cells (leukocycturia).

9. Leukocytic esterase!
   It is an enzyme present in the white blood cells, and presence of it in the urine indicates the presence of white blood cells (leukocycturia).

10. Granular casts are due to breakdown of cellular casts or the inclusion of aggregates of albumin or immunoglobulin light chains.
   They are often described as fine or coarse; however, this distinction does not have much diagnostic value.
   They are often cylinder-shaped and have a higher refractive index than hyaline casts.
   They are most often indicative of chronic renal disease, and like hyaline casts, they may be seen for a short time after strenuous exercise.
   The “muddy brown casts” seen in acute tubular necrosis are a type of granular cast.

11. Waxy casts suggest extremely low urine flow and are associated with long-lasting and/or severe renal failure.
   Due to urine stasis and dilated kidney tubules, these casts are significantly larger than hyaline casts.
   They are relatively rigid, have a well-defined cylindrical shape, and possess a high refractive index.
   The edges of the cylinders present with characteristic broken-off pieces and sharp indentations.
   They are relatively rigid, have a well-defined cylindrical shape, and possess a high refractive index.
   The edges of the cylinders present with characteristic broken-off pieces and sharp indentations.
   These casts are also known as “broad casts”, and they are indicative of dilated ducts seen in chronic renal failure.

13. Pigment casts are formed by the adhesion of metabolic breakdown products or drug pigments to hyaline matrix, and named due to their discoloration.
   The pigments are commonly derived from hemoglobin in hemolytic anemia, myoglobin in rhabdomyolysis, bilirubin in liver diseases, and drugs (rifampin, sulfas, deferoxamine, and phenazopyridine).
   Hemoglobin casts are yellow-brown. Bilirubinemia produces yellow and golden-brown color casts.
   Note: In acute tubular necrosis, large numbers of pigmented granular casts, a.k.a. “muddy brown casts”, can be considered a pigment cast as well.

14. Epithelial casts are formed by inclusion or adhesion of desquamated epithelial cells of the tubule lining.
   The cells are distinguished by large, round nuclei and a lower amount of cytoplasm.

15. These are crystals casts; however, there is disagreement about whether they are casts or merely crystals adhering to a cast or appearing in the urine.
   Another issue is that they do not appear in cylindrical form.
   The most important factors causing crystallization are increased acidity or alkalinity of the urine, and increased concentration of dissolved substances.
   Crystals are identified by their shape, color, and by the urine pH, and they may be small, sand-like particles with no specific shape (amorphous) or have specific shapes, such as needle-like (e.g. urate crystals).
   Important crystals are uric acid, calcium oxalates, amorphous phosphates, calcium carbonate, and cystine stones.
16. ATN is a kidney disorder that involves damage to and death of the epithelial tubular cells of the kidneys, which can lead to acute kidney failure.

17. Acute tubular necrosis (ATN)

18. Ischemic ATN:
Renal artery stenosis, hypovolemia, and severe hypotension longer than 30 minutes, septic shock, DIC, and impaired renal auto-regulatory responses (COX inhibitors, ACE inhibitors, and angiotensin receptor blockers).

Toxic ATN:
Endogenous toxins: Free hemoglobin and myoglobin, and crystal-induced nephropathy (urate), and multiple myeloma
Exogenous toxins: Drugs (aminoglycoside, amphotericin B, cyclosporine, forscarnet, pentamidine and cisplatin) and toxic substances (ethylene glycol, radiologic contrasts)

19. ATN findings are:
Elevated BUN and creatinine with or without oliguria
Presence of predisposing conditions (hypotension, sepsis, drug therapy, and rhabdomyolysis)
Urinalysis: Granular casts with or without tubular epithelial cells

20. Muddy Brown Urine

21. Treatment of the underlying cause (e.g. sepsis or hypotension)

22. Ischemic ATN
Toxic ATN primarily affects the proximal tubules

23. Ischemic ATN is part of the spectrum of prerenal azotemia, and the two share the same causes and risk factors.

24. Fractional excretion of sodium (FENa*)
In prerenal azotemia low renal perfusion drops the GFR but the kidneys may still perform well and they are able to retain sodium in response to hypoperfusion. This causes a decrease in fractional excretion of sodium (FENa*) to less than 1%
In ATN the tubular epithelial cells that are involved in sodium reabsorption are damaged and the kidneys cannot retain sodium. As a result, FENa can rise to be more than 2%
Note: In severe cases of chronic hypoperfusion there may also be ischemic damage to the tubular epithelium, which is a characteristic of ATN.

25. FENa* = [(U Na / P Na) / (P Cl / P Cl)] x 100
FE Na is useful in the evaluation of acute kidney failure and low urine output.
Low fractional excretion of sodium retention by the kidney suggests a pathophysiology extrinsic to the urinary system, such as volume depletion or decrease in effective circulating volume (e.g. low output heart failure).
Higher values can suggest sodium wasting due to acute tubular necrosis or other causes of intrinsic kidney failure.
FENa may be affected or invalidated by diuretic use, since many diuretics may alter the kidney’s handling of sodium.

26. Prerenal azotemia! In ATN management may include restricting fluid intake to a volume equal to the volume of urine produced.

27. BUN is the nitrogen component of urea
Roughly one-half of blood urea
Both increase and decrease proportionately in the blood

28. Urea is the primary nitrogen-containing metabolite of dietary protein and tissue protein turnover.

29. Creatinine is the product of muscle creatine catabolism

30. Creatinine is the product of muscle creatine catabolism

31. Usually between 10:1 and 20:1
* Values are expressed in mg/dL

32. An increased ratio may be due to a condition that causes a decrease in the flow of blood to the kidneys, such as congestive heart
failure or dehydration. It may also be seen with increased protein, from gastrointestinal bleeding or increased protein in the diet.

The ratio may be decreased with liver disease (due to decrease in the formation of urea) and malnutrition.

33. The ratio is predictive of prerenal injury when BUN:Cr exceeds 20 or when urea:Cr exceeds 100 and urea is greater than 10.

In prerenal injury, urea increases disproportionately to creatinine due to enhanced proximal tubular reabsorption that follows the enhanced transport of sodium and water.

34. [B].

The patient has an acute episode of hemolytic anemia due to G6PD that is induced by the use of the anti-malarial agent chloroquine. The red cell inclusions of the red cells (diagram) are precipitated hemoglobin (Heinz bodies).

Widespread hemolysis causes bilirubinemia, hemoglobinemia, hemoglobinuria, and toxic ATN due to hemoglobin damage to kidneys. Note that only conjugated bilirubin can be eliminated in the urine.

As a result of ATN, the patient presents with epithelial and muddy brown casts in addition to high levels of urinary sodium. Note that tubular cells are responsible for sodium reabsorption.

35. Toxic and ischemic ATN both cause necrosis of the epithelial lining of the tubular cells.

Hemoglobin and myoglobin are shown to have potent inhibitory effects on production of nitric oxide, and this may trigger widespread intrarenal vasoconstriction and ischemia. The other reason is direct tubular toxic effects.

The necrosed sloughed-off epithelial tubular cells are passed into urine and they cause epithelial casts, and assumption of bilirubin and hemoglobin pigments by the casts leads to muddy brown casts.

36. Epithelial kidney cells have a very good regenerative ability

ATN does not damage the tubular basement membrane

After managing the underlying causes (stopping offending medications or correcting ischemia) kidney function is resumed within 1 to 2 weeks.

37. Renal vasoconstriction

Obstruction of tubules by tubular casts

Tubular Back-leak: Filtrate produced by the glomerulus is not restricted to injured tubules and leaks back into the interstitium and is then reabsorbed into the blood vessels.

38. Renal!

Diagnosis of ATN often requires exclusion of postrenal and prerenal causes of renal failure.

39. ATN shows active centrifuged sediments that include muddy brown epithelial casts. Prerenal azotemia causes bland sediments (waxy or granular) without significant cells.

Note: Significant cells are WBC, RBC, and epithelial cells.

40. ATN shows active centrifuged sediments that include muddy brown epithelial casts. Prerenal azotemia causes bland sediments (waxy or granular) without significant cells.

Note: Significant cells are WBC, RBC, and epithelial cells.

41. Blood vessels (e.g. Wegener's granulomatosis)

Glomeruli (e.g. post-streptococcal glomerulonephritis)

Tubules (Acute tubular necrosis)

Interstitium (Acute interstitial nephritis)

42. Acute tubular necrosis (ATN)

Accounts for 45% of cases of acute renal failure

43. Blood transfusion reaction (i.e. iron overload)

Injury or trauma that damages the muscles (i.e. rhabdomyolysis)

Low blood pressure (hypotension) that lasts longer than 30 minutes

Recent major surgery

Septic shock due to severe infection

44. Blood transfusion reaction (i.e. iron overload)

Injury or trauma that damages the muscles (i.e. rhabdomyolysis)

Low blood pressure (hypotension) that lasts longer than 30 minutes

Recent major surgery

Septic shock due to severe infection

45. Acute interstitial nephritis, also known as acute tubulointerstitial nephritis.
Acute interstitial nephritis (AIN) results from allergy to drugs (75%-85% of cases) and non-allergic causes (up to 25% of cases).

The non-drug allergy cases are mainly associated with infections (e.g., acute bacterial pyelonephritis), immune disorders (e.g., Sjögren's syndrome, systemic lupus erythematosus, and Wegener's granulomatosis) or neoplastic disorders (e.g., lymphoproliferative disorders).

Drugs that commonly cause AIN include penicillins (methicillin and nafcillin), cephalosporins, sulfonamides, NSAIDs, and proton pump inhibitors.

Acute allergic interstitial nephritis is by far more common in the elderly.

46. Drugs: Penicillins, cephalosporins, NSAIDs, rifampin, sulfonamides, proton-pump inhibitors and allopurinol
Infections: Pyelonephritis
Systemic Diseases: Sarcoidosis, Sjögren's syndrome, lupus erythematosus, lymphoma, leukemia

47. AG: RBC casts
AIN: WBC casts
ATN: Epithelial (muddy brown casts)

48. AG: RBC casts
AIN: WBC casts
ATN: Epithelial (muddy brown casts)

49.

50. The body handles Ga3+ similar to ferric iron.

Gallium is bound (and concentrated) in areas of inflammation as well as areas of rapid cell division.

It binds to transferrin, leukocytic transferrin-like proteins, bacterial siderosporas (iron chelating sites), inflammatory proteins, and neutro-philic cell membranes.

This relatively nonspecific binding allows for identification of sites with tumor growth, inflammation, and both acute and chronic infection to be imaged by nuclear scanning.

Therefore, AIN has high gallium uptake properties due to increased number of leukocytes, bacterial pyelonephritis, and inflammation.

51. True
52. True
53. True (T-cells)
54. AIN and interstitial fibrosis!

Notorious Drugs: Chinese herbs (aristolochic acid), carmustine, cyclosporine, streptozotocin, and tacrolimus

55. False! Hypokalemia causes tubulointerstitial fibrosis

56. Hypokalemic nephropathy is associated with alterations in intrarenal vasoactive substances, causing vasoconstriction, salt-sensitivity, and progression of interstitial fibrosis.

Hypokalemic nephropathy causes vasoconstriction, reduced medullary blood flow, and intrarenal ischemia in association with intrarenal angiotensin II and endothelin-1 generation.

It is also postulated that generalized renal anoxia causes intrarenal complement activation, and stimulation of growth factors such as IGF-1 and TGF-β. These further contribute to the renal hypertrophic response.

Note: Angiotensin II and endothelin receptor antagonists are currently considered to be the first line management for fibrotic and sclerotic changes of the kidney.

57. True! Hypercalcemia causes tubulointerstitial fibrosis!

58. In hypercalcemic conditions calcium precipitates in the nephrons.

This is also a compounding factor causing AIN in multiple myeloma and in hypercalcemic neoplastic conditions.

59. It does not affect the glomeruli!