СИНДРОМЫ

- Вторичная АГ (К) → реноваскулярная; → ренопаренхиматозная
- Отеки (К)
- Мочевой синдром(Л)
- Нарушение образования и выделения мочи (Л + К)
- Нефритический синдром (Л + К)
- Нефротический синдром (Л + К)
- Почечная недостаточность

Поражение клубочка

Поражение канальца

Артериальная гипертензия

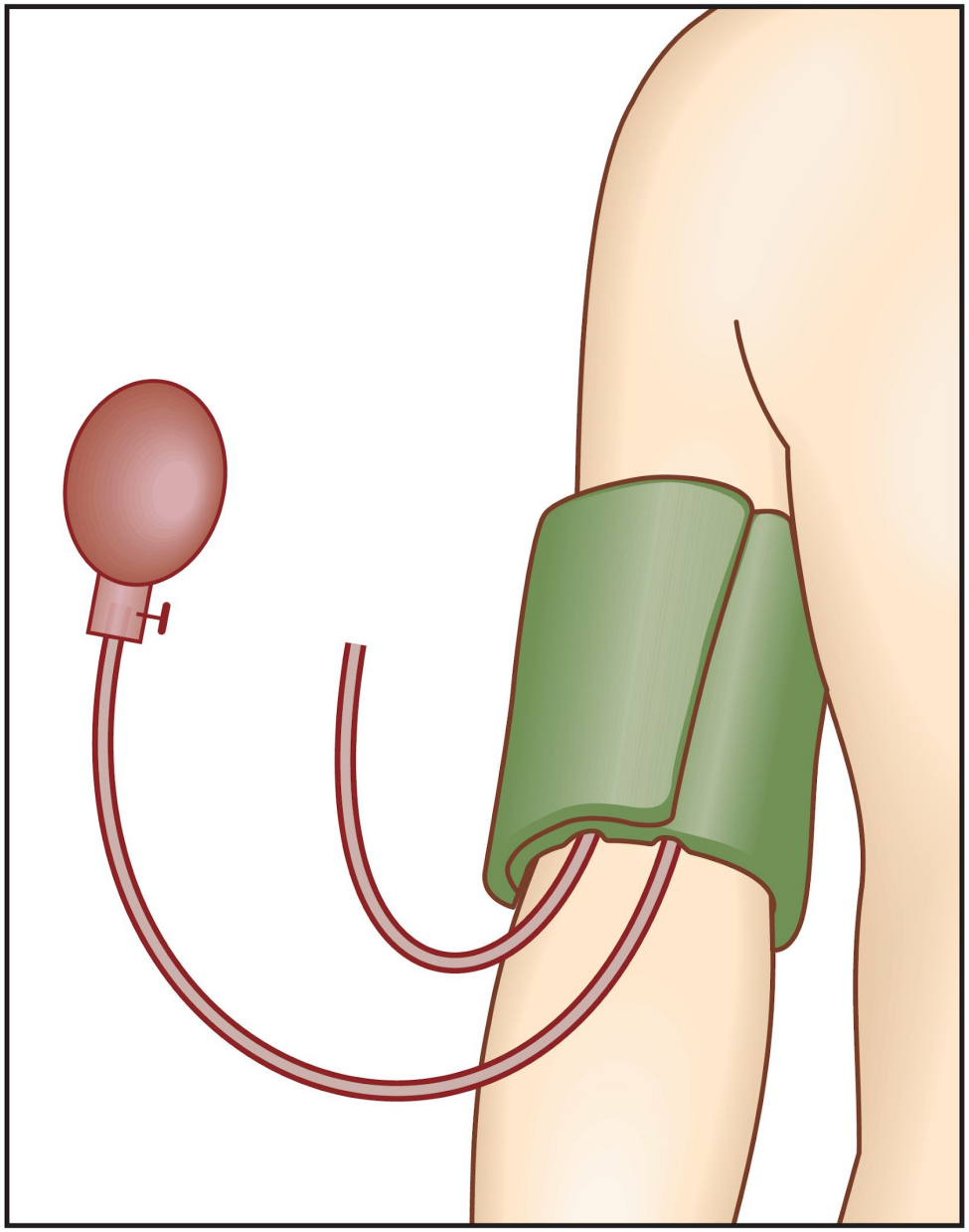
Мочевой синдром

Почечная недостаточность

- Нефр**и**тический синдром
- Нефр**о**тический синдром

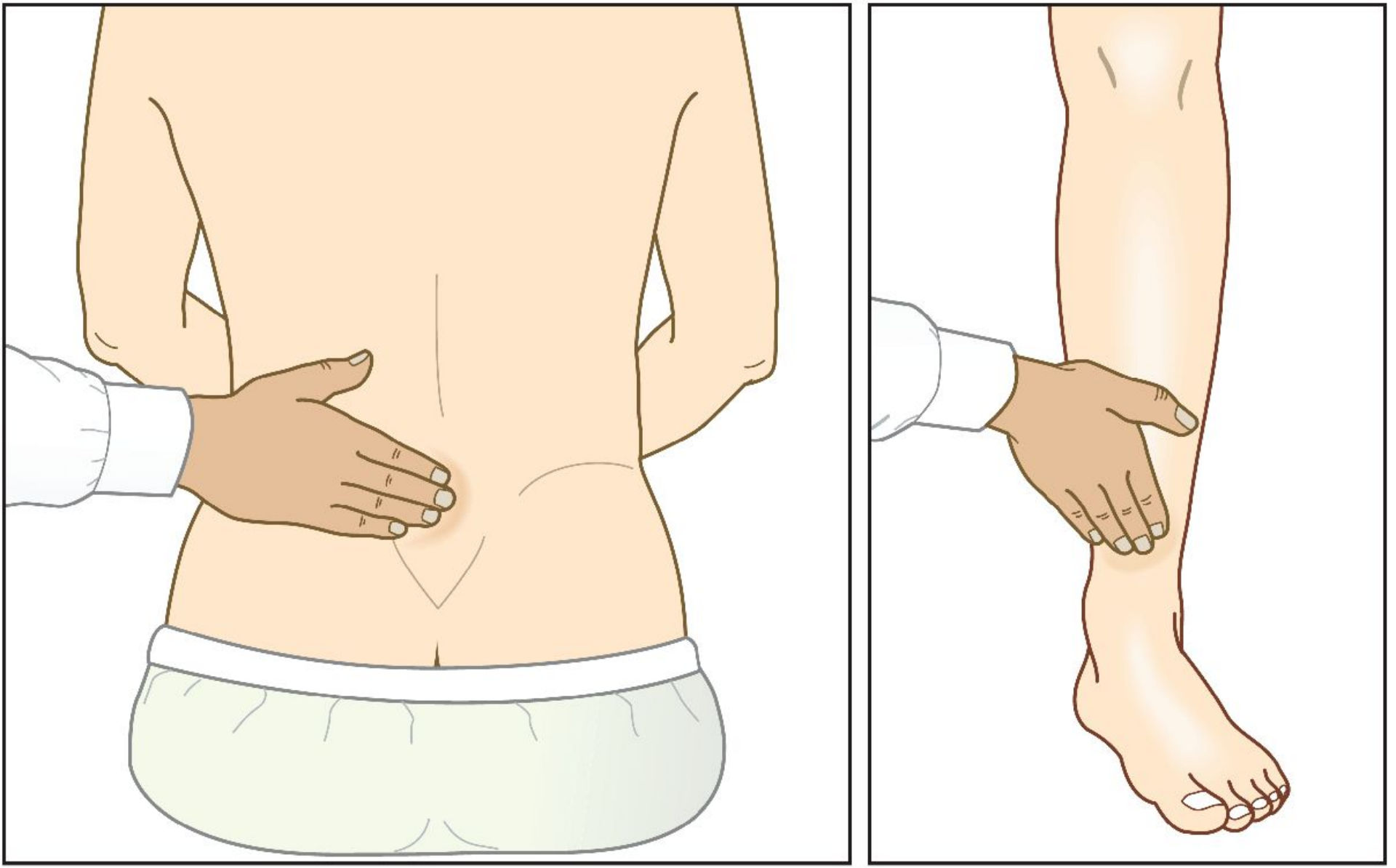
- Нарушения образования и выделения мочи:

  гипо-, изостенурия



Blood pressure measurements

>140/90 мм.рт.ст.



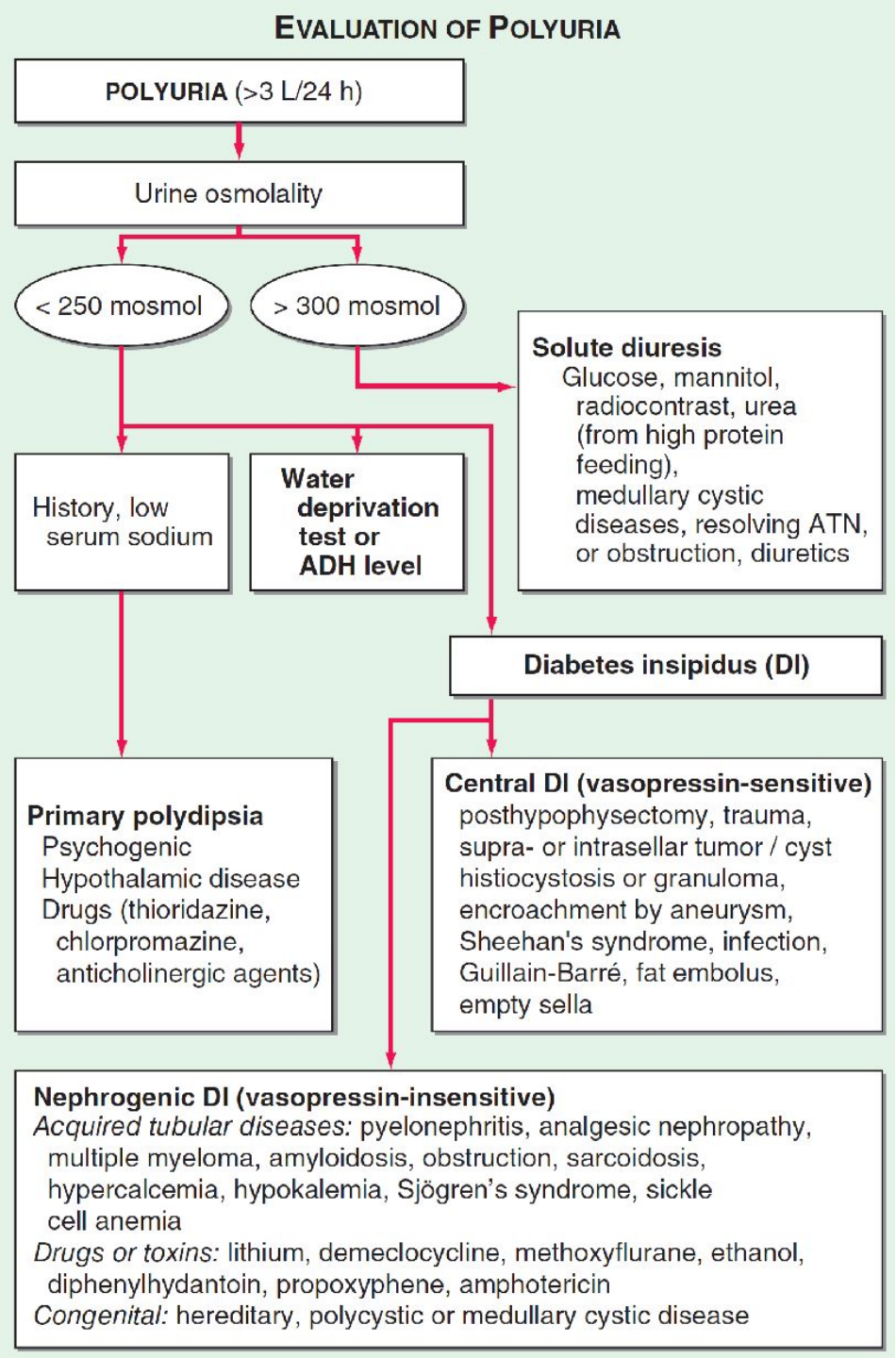
Checking sacrum and ankles for pitting oedema

Нарушение образования и выделения мочи

- Полиурия
- Олигурия, анурия
- Никтурия
- Ишурия
- Поллакиурия
- Дизурия
- Изостенурия
- Гипостенурия

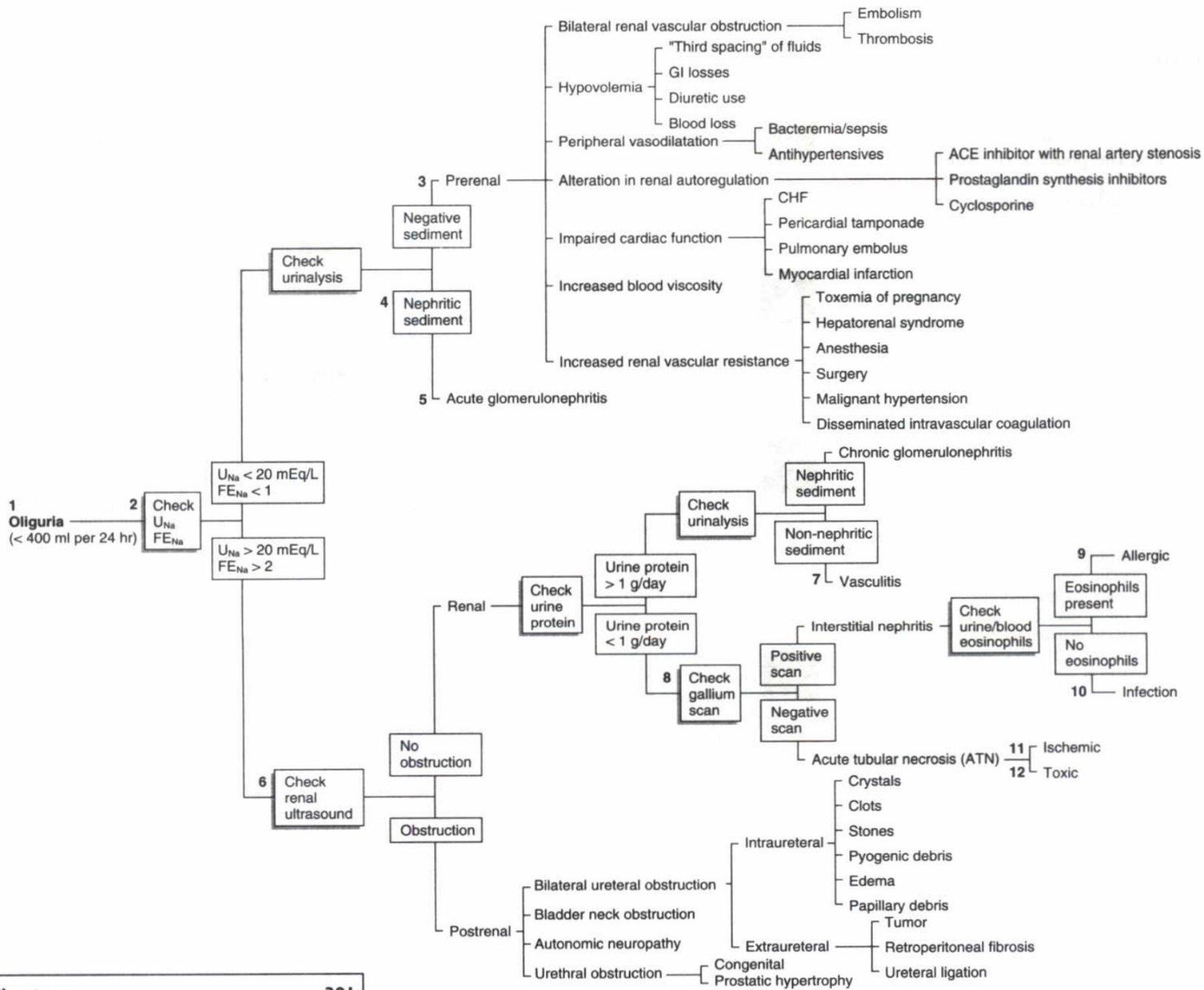
> 3 л / сут

- Чрезмерное потребление жидкости
- ОПН (полиурическая стадия, ОПН при ТИН)
- ХПН кроме заключительных стадий
- Осмотический диурез (гипергликемия, маннитол)
- Диуретики
- Тубулопатии – с. Фанкони, ТИН и др. (+ низкая плотность мочи)
- Несахарный диабет (+ очень низкая плотность мочи):
  а. центральный
  б. нефрогенный


EVALUATION OF POLYURIA
POLYURIA (>3 L/24 h)
Urine osmolality
< 250 mosmol
> 300 mosmol
Solute diuresis
Glucose, mannitol, radiocontrast, urea (from high protein feeding), medullary cystic diseases, resolving ATN, or obstruction, diuretics
History, low serum sodium
Water deprivation test or ADH level
Diabetes insipidus (DI)
Primary polydipsia
Psychogenic
Hypothalamic disease
Drugs (thioridazine, chlorpromazine, anticholinergic agents)
Central DI (vasopressin-sensitive)
posthypophysectomy, trauma, supra- or intrasellar tumor / cyst histiocystosis or granuloma, encroachment by aneurysm, Sheehan's syndrome, infection, Guillain-Barré, fat embolus, empty sella
Nephrogenic DI (vasopressin-insensitive)
Acquired tubular diseases: pyelonephritis, analgesic nephropathy, multiple myeloma, amyloidosis, obstruction, sarcoidosis, hypercalcemia, hypokalemia, Sjögren's syndrome, sickle cell anemia
Drugs or toxins: lithium, demeclocycline, methoxyflurane, ethanol, diphenylhydantoin, propoxyphene, amphotericin
Congenital: hereditary, polycystic or medullary cystic disease

< 400 мл/сут

- ОПП
- ХБП
- …



Cecil Chapter	**391**
Harrison Chapter	**47**

$FENa = [(UNa \times PCr) \div (PNa \times UCr)] \times 100$

Variable	Prerenal	Intrinsic Renal	Postrenal
Urine osmolality (mOsm/kg)	> 500	< 350	< 350
Urine Na^+ (mEq/L)	< 20	> 40	> 40
FENa	< 1%	> 2%	> 1% (mild) > 2% (severe)
Serum BUN/Cr	> 20	< 15	> 15

НИКТУРИЯ

Заболевания почек

+ изостенурия

Соотношение день/ночь - N

ССЗ

Соотношение день/ночь 

ЦВЕТ МОЧИ

- **Темно-желтый:** **прямой билирубин** (механическая - зеленоватая, оливковая желтуха + симптомы холестаза, Щ Ф, ГГТП, 5-НУК), **уробилин** (внесосудистый гемолиз-надпеч. лимонная желтуха, болезни печени – печ. шафранная желтуха, + АСТ, АЛТ, ПВ), **каротиноиды** (псевдожелтуха)
- **Красный/розовый:** макрогематурия, Hb-урия (внутрисосудистый гемолиз, + снижение гаптоглобина опасность ОПН), миоглобинурия (рабдомиолиз, краш-синдр., + КФК, альдолаза,опасность ОПН), порфирия (особенно на солнце или под лампой Вуда), лекарства (рифампицин, феназопиридин и др.)
- **Черная** после экспозиции на свету: алкаптонурия (ауто.-рец., дефицит оксидазы гомогентензиновой кислоты)

ЦВЕТ МОЧИ

Appearance and Color of Urine

Appearance	Cause	Remarks
Colorless	Very dilute urine	Polyuria, diabetes insipidus
Cloudy	Phosphates, carbonates	Soluble in dilute acetic acid
	Urates, uric acid	Dissolve at 60° C and in alkali
	Leukocytes	Insoluble in dilute acetic acid
	Red cells ("smoky")	Lyse in dilute acetic acid
	Bacteria, yeasts	Insoluble in dilute acetic acid
	Spermatozoa Prostatic fluid	Insoluble in dilute acetic acid
	Mucin, mucous threads	May be flocculent
	Calculi, "gravel"	Phosphates, oxalates
	Clumps, pus, tissue	
	Fecal contamination	Rectovesical fistula
	Radiographic dye	In acid urine
Milky	Many neutrophils (pyuria)	Insoluble in dilute acetic acid
	Fat	
	Lipiduria, opalescent	Nephrosis, crush injury—soluble in ether
	Chyluria, milky	Lymphatic obstruction—soluble in ether
	Emulsified paraffin	Vaginal creams
Yellow	Acriflavine	Green fluorescence
Yellow-orange	Concentrated urine	Dehydration, fever
	Urobilin in excess	No yellow foam
	Bilirubin	Yellow foam if sufficient bilirubin
Yellow-green	Bilirubin-biliverdin	Yellow foam
Yellow-brown	Bilirubin-biliverdin	"Beer" brown, yellow foam

Red	Hemoglobin	Positive (Reagent strip for blood)
	Erythrocytes	Positive (Reagent strip for blood)
	Myoglobin	Positive (Reagent strip for blood)
	Porphyrin	May be colorless
	Fuscin, aniline dye	Foods, candy
	Beets	Yellow alkaline, genetic
	Menstrual contamination	Clots, mucus
Red-purple	Porphyrins	May be colorless
Red-brown	Erythrocytes	
	Hemoglobin on standing	
	Methemoglobin	Acid pH
	Myoglobin	Muscle injury
	Bilifuscin (dipyrrole)	Result of unstable hemoglobin
Brown-black	Methemoglobin	Blood, acid pH
	Homogentisic acid	On standing, alkaline; alkaptonuria
	Melanin	On standing, rare
Blue-green	Indicans	Small intestine infections
	Pseudomonas infections	
	Chlorophyll	Mouth deodorants

Porphyria cutanea tarda. Wood light examination of the urine in a patient with porphyria cutanea tarda demonstrating classic coral red fluorescence with normal urine specimen exhibited for comparison

Urine Color Changes with Commonly Used Drugs*

Drug	Color
Alcohol, ethyl	Pale, diuresis
Anthraquinone laxatives (senna, cascara)	Reddish, alkaline; yellow-brown, acid
Chlorzoxazone (Paraflex) (muscle relaxant)	Red
Deferoxamine mesylate (Desferal) (chelates iron)	Red
Ethoxazene (Serenium) (urinary analgesic)	Orange, red
Fluorescein sodium (given IV)	Yellow
Furazolidone (Furoxone) (Tricofuron) (an antibacterial, antiprotozoal nitrofuran)	Brown
Indigo carmine dye (renal function, cytoscopy)	Blue
Iron sorbitol (Jectofer) (possibly other iron compounds forming iron sulfide in urine)	Brown on standing
Levodopa (L-dopa) (for parkinsonism)	Red then brown, alkaline
Mepacrine (Atabrine) (antimalarial) (intestinal worms, *Giardia)*	Yellow
Methocarbamol (Robaxin) (muscle relaxant)	Green-brown
Methyldopa (Aldomet) (antihypertensive)	Darkens; if oxidizing agents present, red to brown
Methylene blue (used to delineate fistulas)	Blue, blue-green
Metronidazole (Flagyl) (for *Trichomonas* infection, amebiasis, *Giardia*)	Darkening, reddish brown
Nitrofurantoin (Furadantin) (antibacterial)	Brown-yellow
Phenazopyridine (Pyridium) (urinary analgesic), also compounded with sulfonamides (Azo Gantrisin, etc.)	Orange-red, acid pH
Phenindione (Hedulin) (anticoagulant) (important to distinguish from hematuria)	Orange, alkaline; color disappears on acidifying
Phenol poisoning	Brown; oxidized to quinones (green)
Phenolphthalein (purgative)	Red-purple, alkaline pH
Phenolsulfonphthalein (also sulfobromophthalein)	Pink-red, alkaline pH
Rifampin (Rifadin, Rimactane) (tuberculosis therapy)	Bright orange-red
Riboflavin (multivitamins)	Bright yellow
Sulfasalazine (Azulfidine) (for ulcerative colitis)	Orange-yellow, alkaline pH

*Other commonly used drugs have been noted to produce color change once or occasionally: amitriptyline (Elavil)—blue-green; phenothiazines—red; triamterene (Dyrenium)—pale blue (blue fluorescence in acid urine). An extensive list may be found in Young et al. Clin Chem 1975;21:379.

Глюкоза в моче

- При отсутствии гипергликемии – доброкачественная глюкозурия (SGLT (*SLC5A2*), беременность
- + гипергликемия - СД

Кетоновые тела

- Нитропруссидный тест – обнаруживает ацетон и ацетоацетат (но не β-ОНБ)
- ДКА, голодный кетоз, алкоголь, кетогеная диета, беременность, отравление изопропиловым спиртом

pH (4,6-8)

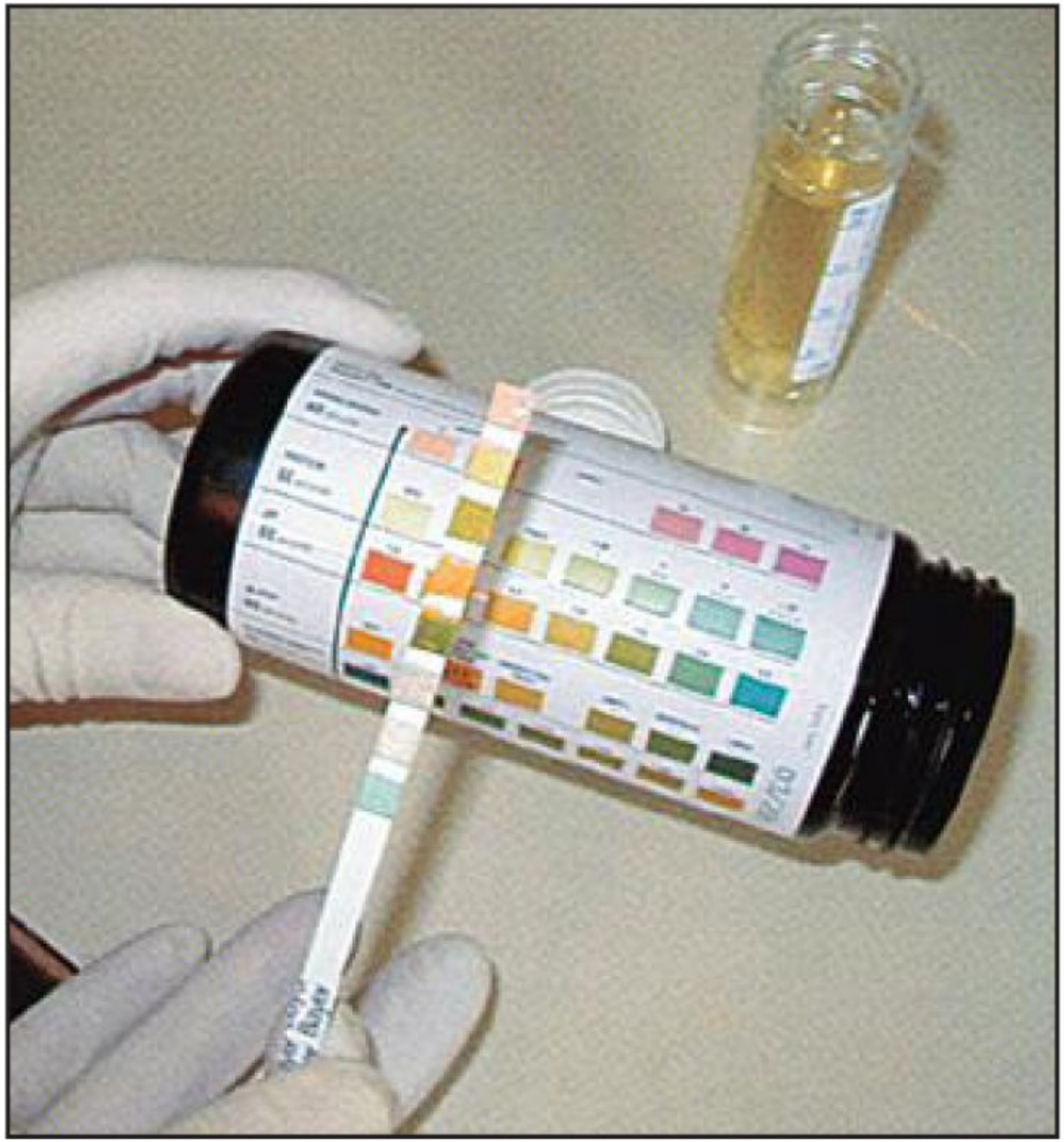
- Понижается при мясной диете
- Повышается при растительной диете (цитрат превращается в бикарбонат), некоторых МПИ (МО с уреазной активностью, напр., **Proteus**)

Относительная плотность

Urea (20%), sodium chloride (25%), sulfate, and phosphate contribute most of the specific gravity of normal urine. Normal adults with adequate fluid intake will produce urine of specific gravity 1.016–1.022 over a 24-hour period; however, normal kidneys have the ability to produce urine with specific gravity that ranges from 1.003–1.035. If a random specimen of urine has a specific gravity of 1.023 or more, concentrating ability can be considered normal. Minimum specific gravity after a standard water load should be less than 1.007.

Мочевой синдром
(= изменения осадка)

- Гематурия
- Протеинурия
- Цилиндрурия
- Лейкоцитурия (пиурия)
- Бактериурия
- Хилурия (*Wuchereria bancrofti, опухоль, увеличение лимф. узлов бр. полости*)
- Телескопический осадок



Dipstick testing for protein, blood, nitrate and leucocytes

ГЕМАТУРИЯ

>2–3 RBCs per HPF

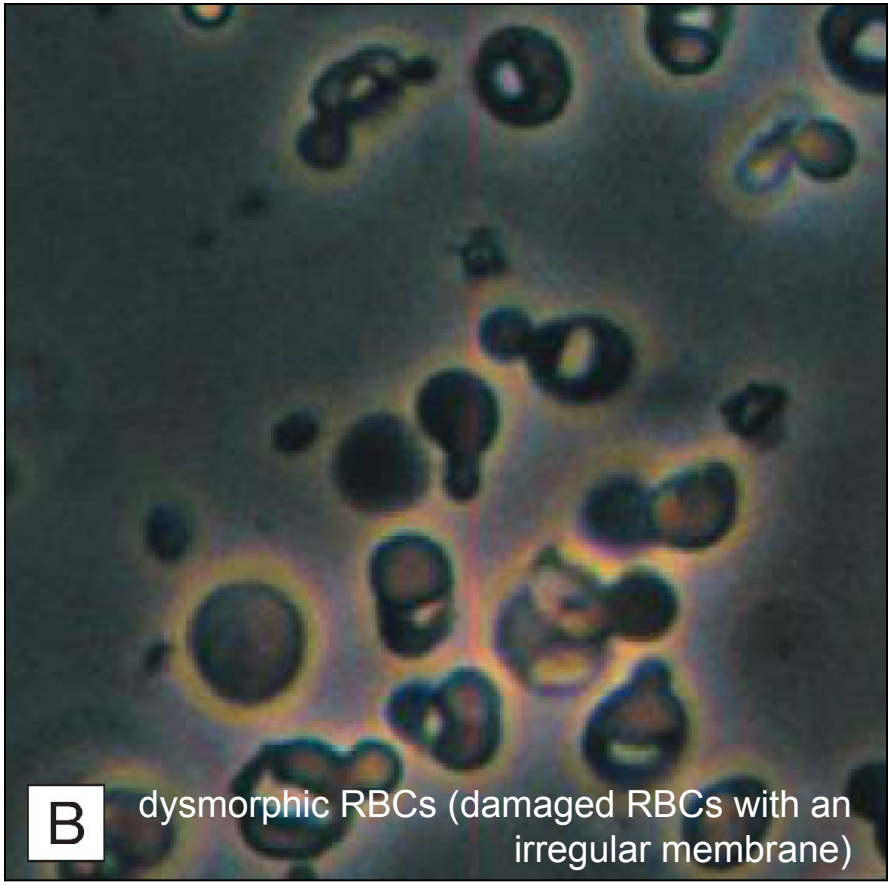
фальсификация

Почечная:

- Гломерулярная (ГН, доброкачественная семейная гематурия)
- Негломерулярная (напр. папиллярный некроз)

Внепочечная:

Опухоль (почечноклеточный рак, опухоль Вильмса, переходноклеточный рак МП)
МКБ
Шистосомы
Гиперплазия ПЖ
ЛС (варфарин, циклофосфамид)
и др.



ниже клубочка

Часто + боль, дизурия

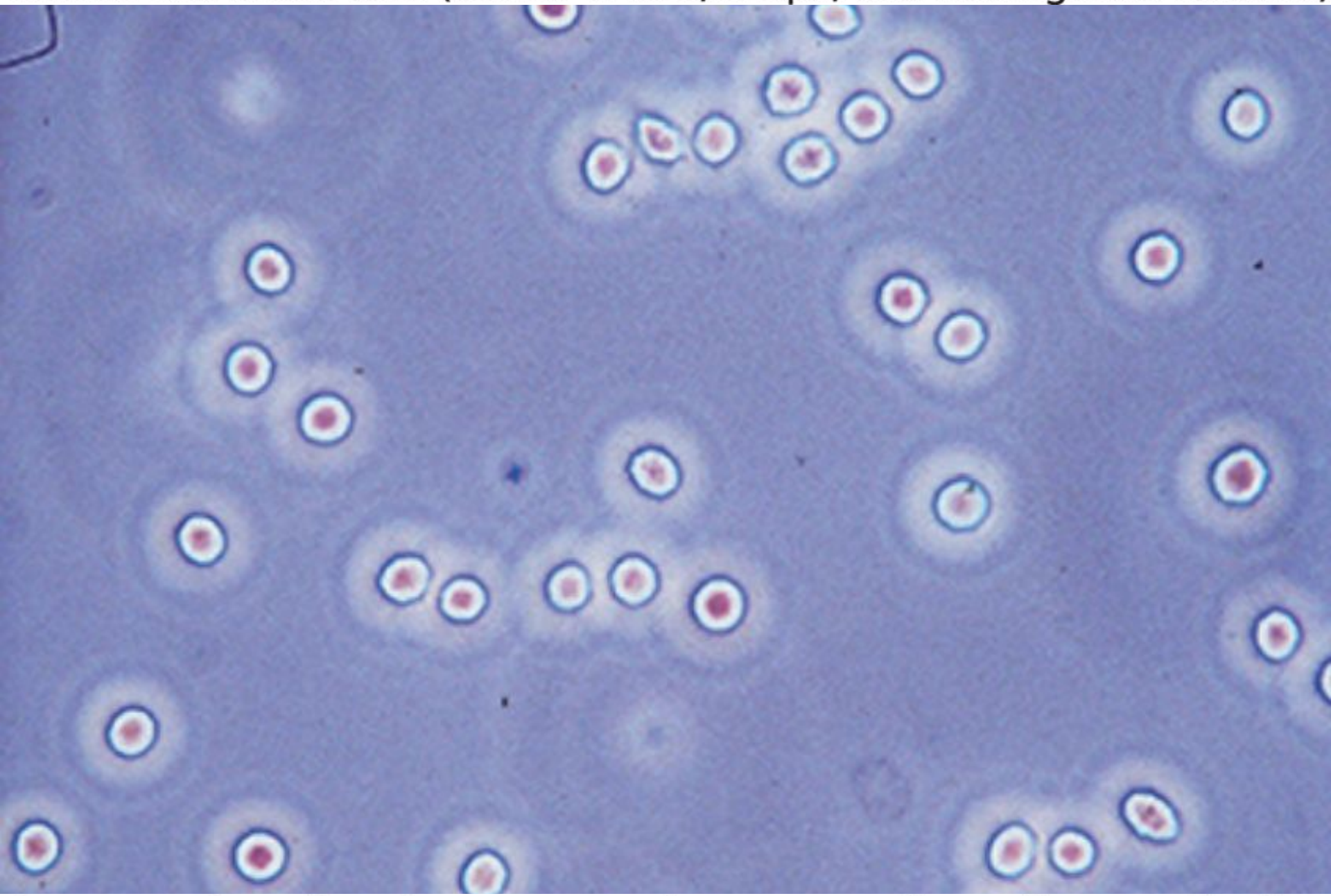
клубочек

Гломерулопатии

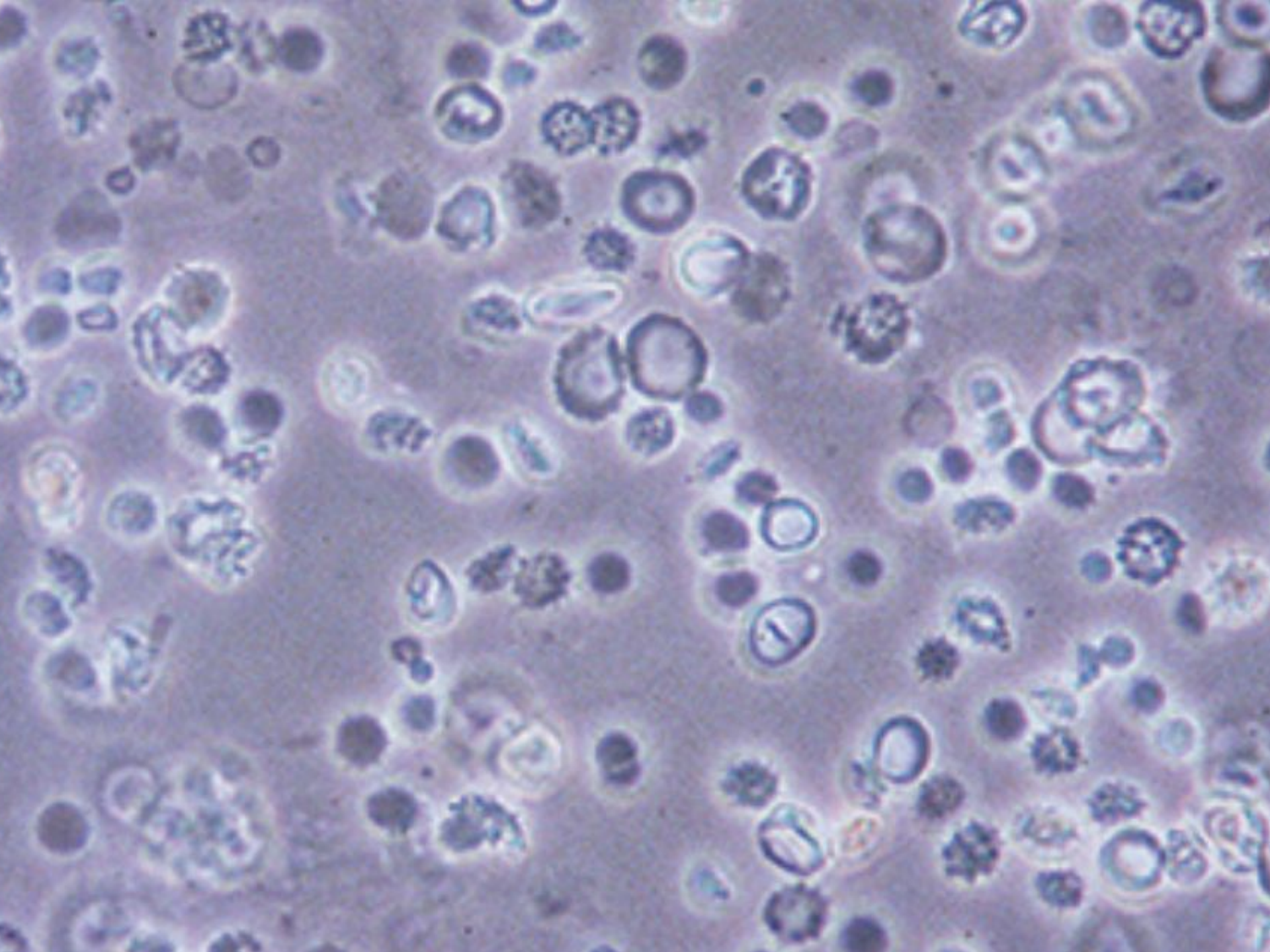
Часто + протеинурия, АГ

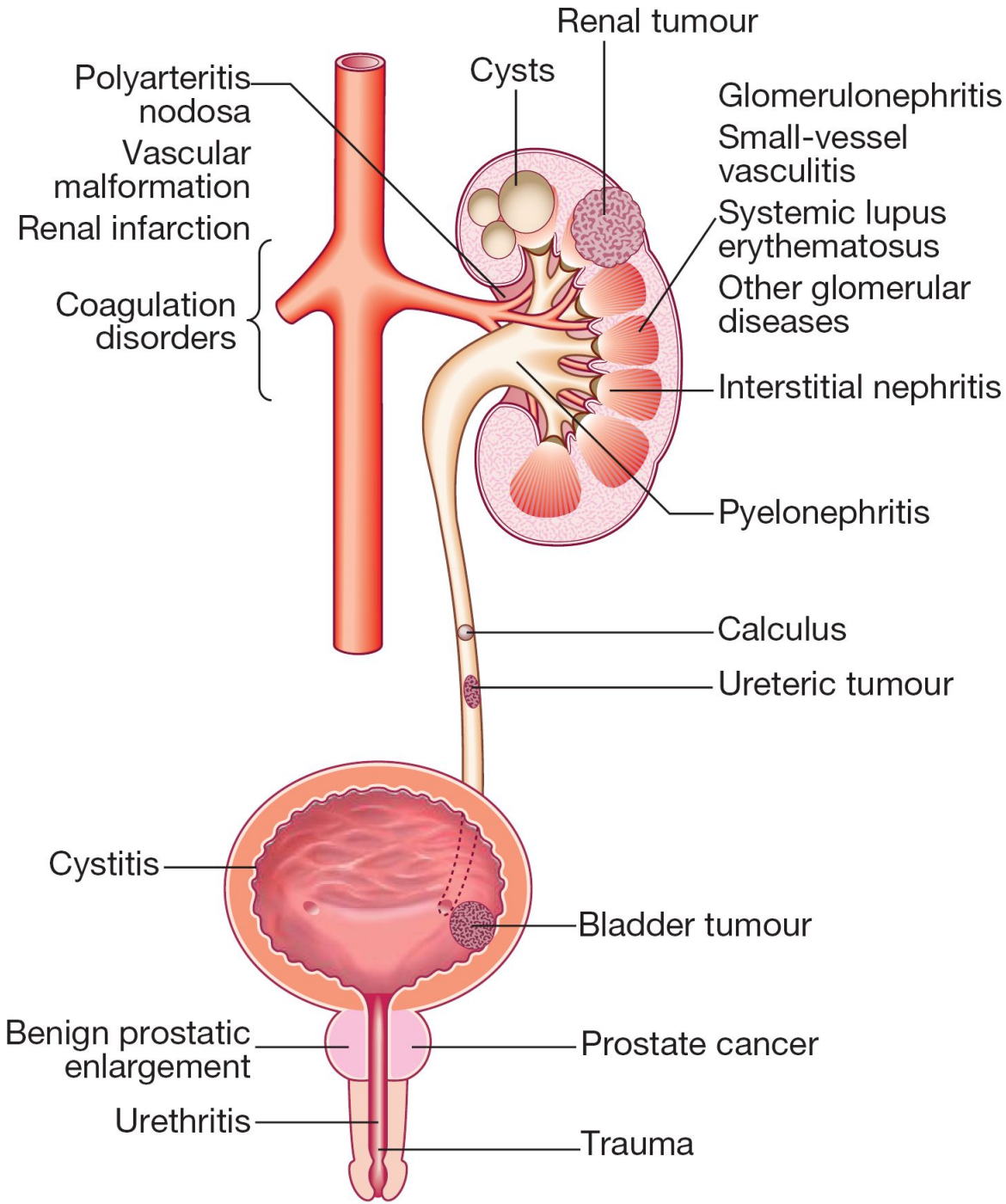
Возможно + респираторная инфекция(ОСГН, болезнь Берже)

normal red blood cells (similar in size, shape, and hemoglobin content)



hematuria is nonglomerular in origin




Renal tumour
Cysts
Polyarteritis nodosa
Vascular malformation
Renal infarction
Coagulation disorders
Glomerulonephritis
Small-vessel vasculitis
Systemic lupus erythematosus
Other glomerular diseases
Interstitial nephritis
Pyelonephritis
Calculus
Ureteric tumour
Cystitis
Bladder tumour
Benign prostatic enlargement
Prostate cancer
Urethritis
Trauma

Hematuria

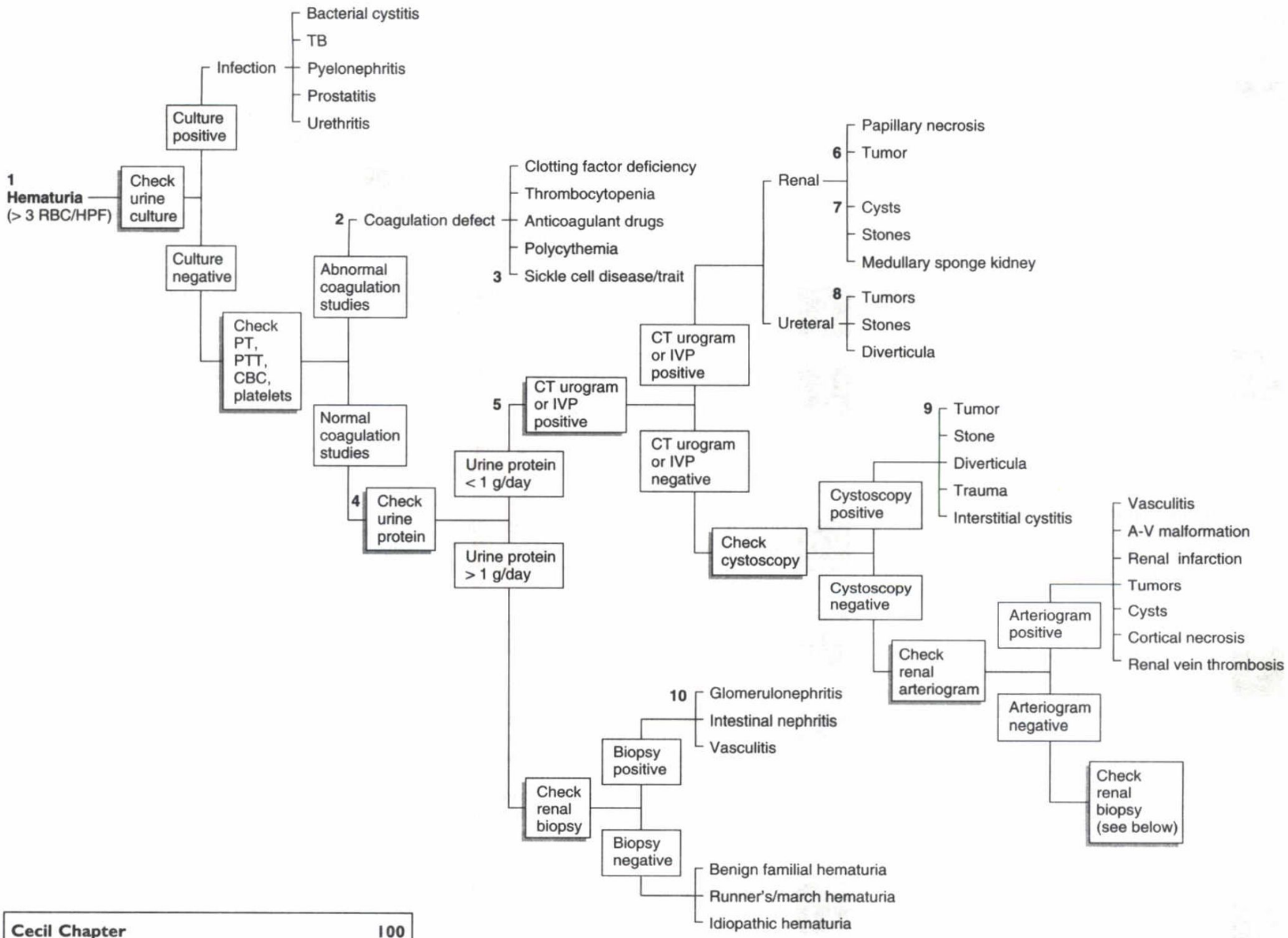
1. Upper urinary tract (UUT; kidneys, ureter) causes of hematuria include:
   a. Renal stone (most common cause)
   b. Glomerulonephritis (GN). Characterized by dysmorphic red blood cells (RBCs) (damaged RBCs with an irregular membrane)
   c. Renal cell carcinoma (RCC) and Wilms tumor
2. Lower urinary tract (LUT; bladder, urethra, prostate) causes of hematuria include:
   a. Infection (most common)
   b. Urothelial carcinoma (old term, *transitional cell carcinoma*): most common noninfectious cause of hematuria
   c. Prostatic hyperplasia: most common cause of microscopic hematuria in men
3. Drugs associated with hematuria
   a. Anticoagulants (warfarin, heparin)
   b. Cyclophosphamide
      (1) Hemorrhagic cystitis
      (2) Risk factor for urothelial carcinoma

‘Macroscopic haematuria has a positive predictive value of 83% for bladder cancer and 22% for all urothelial tumours, rising to 41% in patients over the age of 40.’

- Buntinx F, et al. Fam Pract 1997; 14(1):63–68.

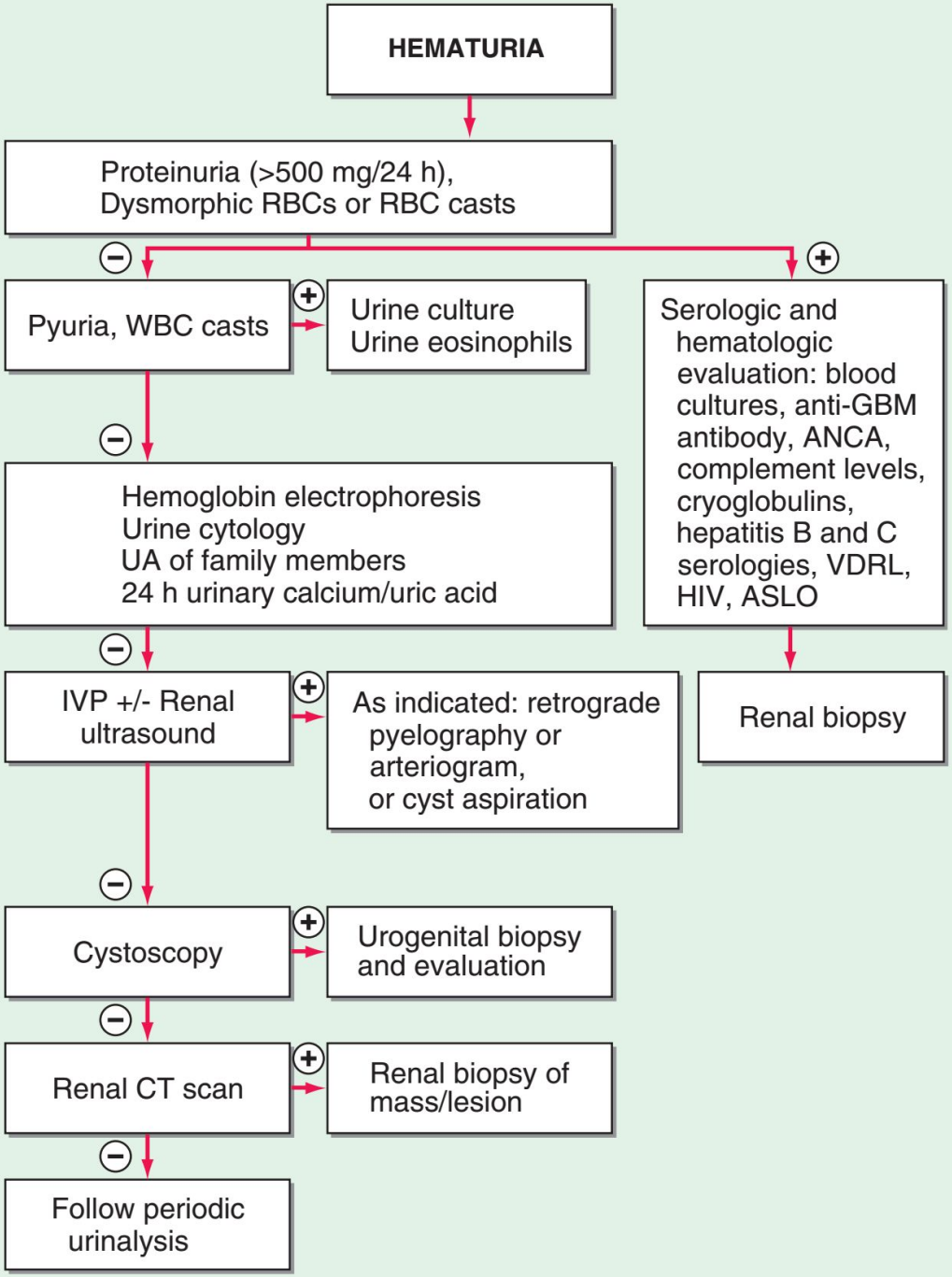
Факторы риска

- >40 лет
- Курение
- Лучевая терапия
- Ароматические амины (анилиновые красители)
- Н-1 блокаторы, фенацетин, клофибрат
- Циклофосфамид



Cecil Chapter	**100**
Harrison Chapter	**47**

Evaluation of Hematuria

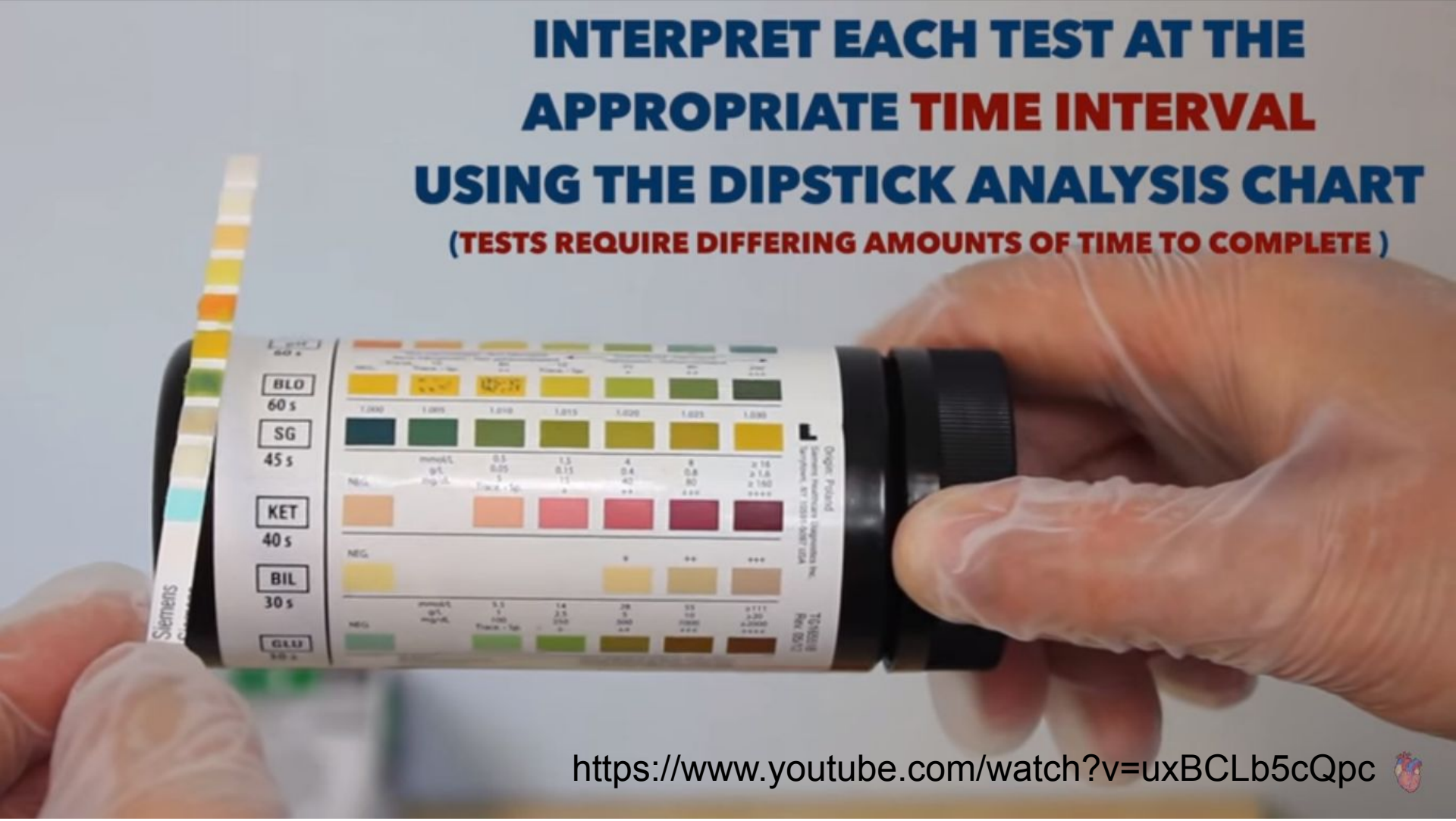


ПРОТЕИНУРИЯ

N < 150 мг/сут

N альбумина
< 30 мг
МАУ
30-300мг/г (ACR)

МАУ- микроальбуминурия



Qualitative tests include dipsticks and sulfosalicylic acid (SSA).
(1) Dipsticks are specific for albumin.
(2) SSA detects albumin and globulins.

What do you know about Tamm–Horsfall protein in the urine?

Normal individuals excrete <150 mg/day protein. Of this, about 5–15 mg is albumin and the remainder consists of different plasma proteins and glycoproteins derived from renal cells. Tamm–Horsfall mucoprotein is the most abundant protein that is not derived from plasma but from the cells of the ascending limb of the loop of Henle; it is excreted at the rate of 50–75 mg/day. Pathological proteinuria occurs when daily excretion exceeds 150 mg protein.

Микро(???)альбуминемия

Стадии ХБП				Альбуминурия*		
				A1	A2	A3
				Оптимальная или незначительно повышенная	Высокая	Очень высокая
				<30 мг/г	30–300 мг/г	>300 мг/г
				<3 мг/ммоль	3–30 мг/ммоль	>30 мг/ммоль
СКФ, мл/мин/1,73м²	C1	Высокая или оптимальная	90	Низкий**	Умеренный	Высокий
	C2	Незначительно снижена	60–89	Низкий**	Умеренный	Высокий
	C3a	Умеренно снижена	45–59	Умеренный	Высокий	Очень высокий
	C3б	Существенно снижена	30–44	Высокий	Очень высокий	Очень высокий
	C4	Резко снижена	15–29	Очень высокий	Очень высокий	Очень высокий
	C5	ТПН	<15	Очень высокий	Очень высокий	Очень высокий

*Альбуминурия определяется как отношение альбумин/креатинин в разовой (предпочтительно утренней) порции мочи; альбуминурия выше 300 мг/г соответствует уровню протеинурии выше 0,5 г/л. СКФ рассчитывается по формуле CKD-EPI;
**низкий риск – т.е. как в общей популяции. При отсутствии признаков повреждения почек категории СКФ C1 или C2 не удовлетворяют критериям ХБП.

«оптимальный» (< 10 мг/г), «высоконормальный» (10-29 мг/г), «высокий» (30-299 мг/г), «очень высокий» (300-1999 мг/г) и «нефротический» (> 2000 мг/г)

протеинурия

Доброкачественная (функциональная):
< 1(-2)г/сут
До 30 лет
При физической нагрузке, лихорадке, ортостазе, после судорог,

патологическая

Table 1 **Common Causes of Functional Proteinuria**

Dehydration
Emotional stress
Fever
Intense physical activity
Most acute illnesses
Orthostatic (postural) disorder

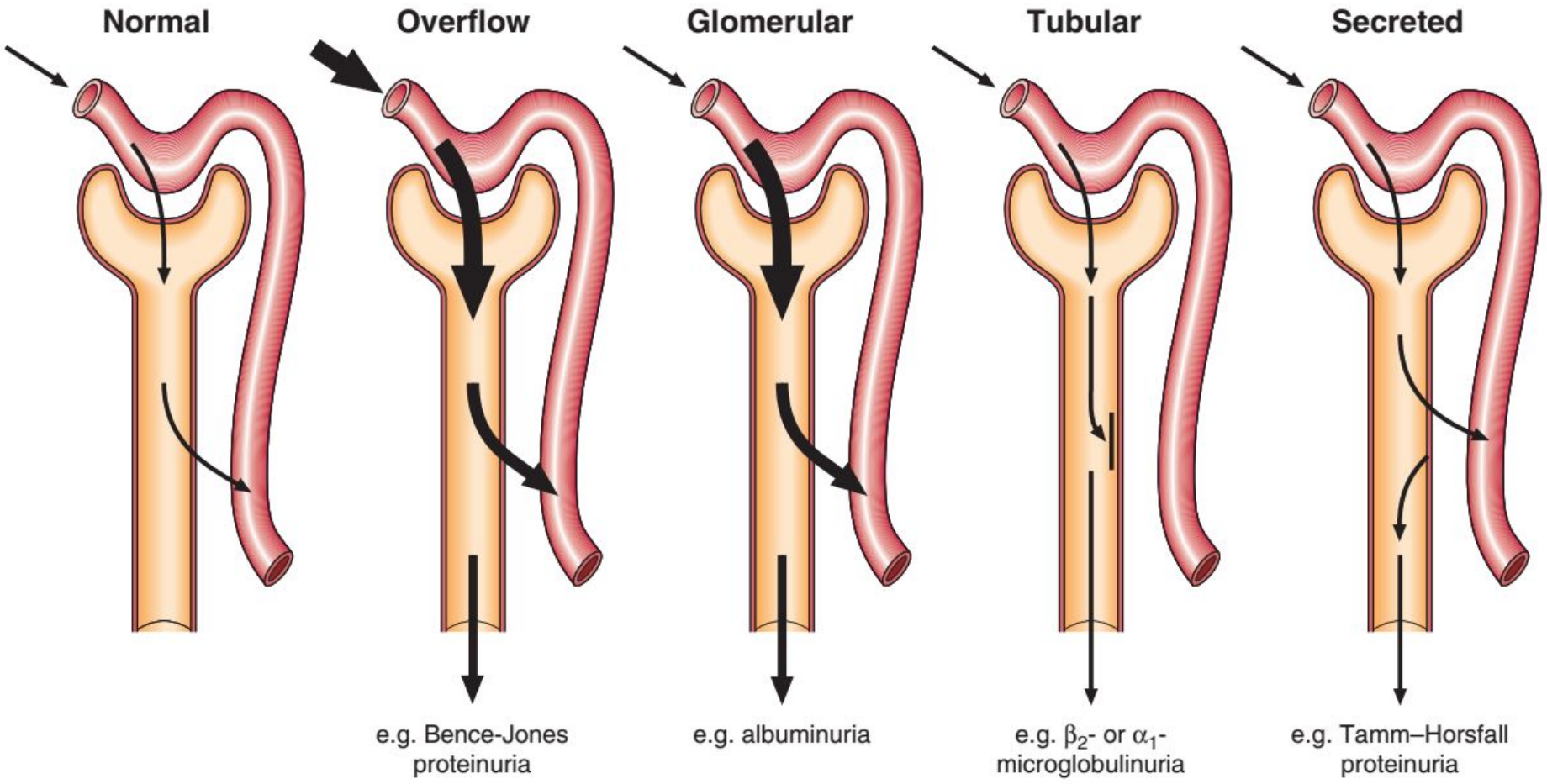
патологическая протеинурия

Клубочковая
нефритический и нефротический синдромы при гломерулопатиях

Канальцевая
тубулопатии
отравление тяжелыми Ме, синдром Фанкони, синдром Хартнупа

Секреторная
опухоль, воспаление мочевых путей

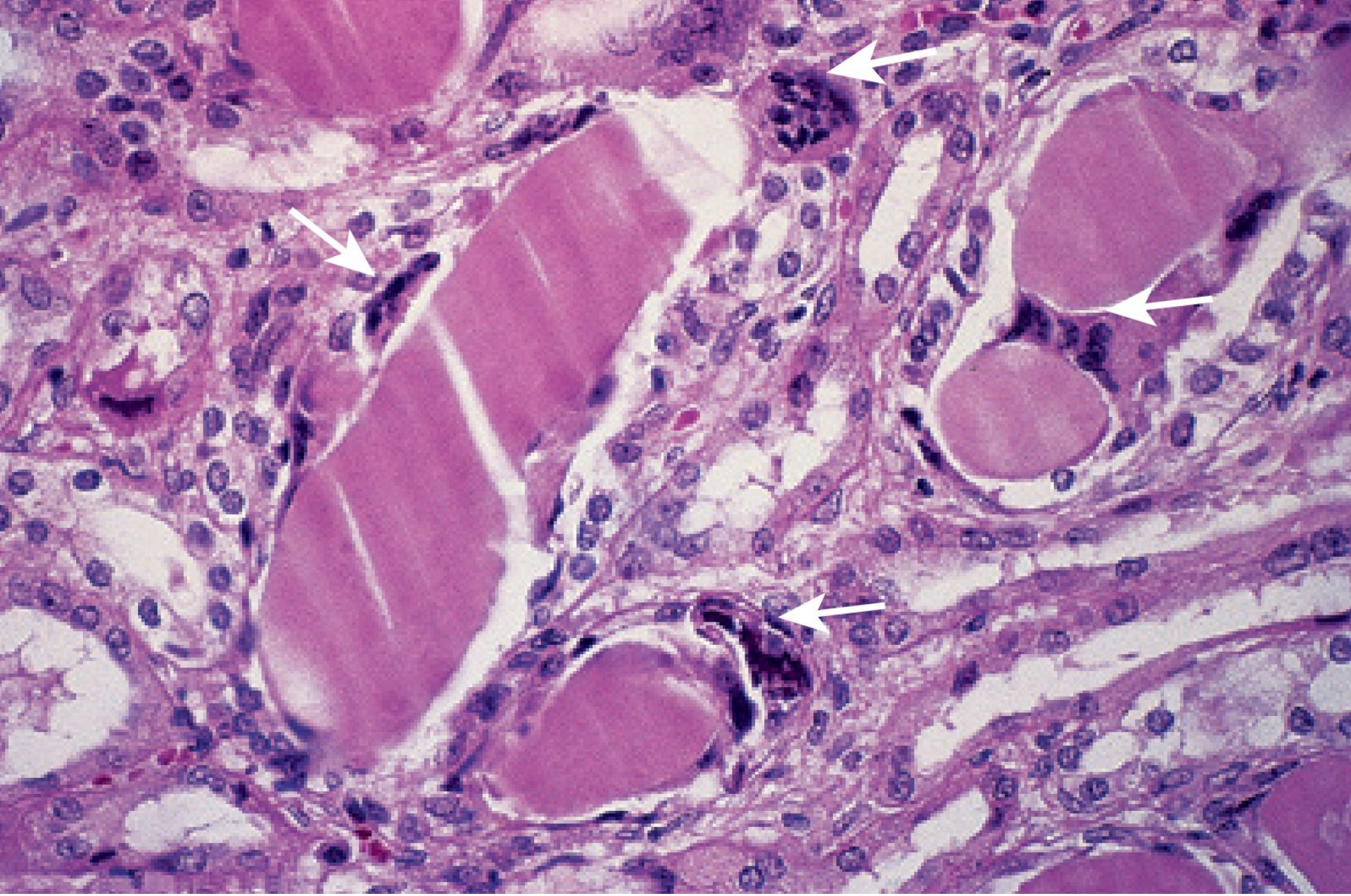
«стоковая»
увеличение фильтрации НМ белков
(белок BJ + при миеломе, миоглобинурия при краш-синдроме и синдроме МакАрдла, Hb-урия при внутрисосудистом гемолизе)



Link 20-7 Mechanisms of proteinuria. See text for discussion. *(From Gaw A, Murphy MJ, Srivastava R, Cowan RA, O'Reilly Denis St J:* Clinical Biochemistry: An Illustrated Colour Text, *5th ed, St. Louis, Churchill Livingstone Elsevier, 2013, p 34, Fig. 17.1.)*

TYPE	DEFINITION	CAUSES
Functional	• Protein <2 g/24 hr • *Not* associated with renal disease	• Fever, exercise, congestive heart failure • Orthostatic (postural): occurs with standing and is absent in the recumbent state. Urine protein is absent in the first morning void. *No* progression to renal disease.
Overflow	• Protein loss is variable • LMW proteinuria • Amount filtered > tubular reabsorption	• Multiple myeloma with BJ proteinuria • Hemoglobinuria: e.g., intravascular hemolysis (e.g., paroxysmal nocturnal hemoglobinuria) • Myoglobinuria: crush injuries, McArdle glycogenosis (deficient muscle phosphorylase). Increase in serum creatinine kinase.
Glomerular	• Nephritic syndrome: protein >150 mg/24 hr but <3.5 g/24 hr • Nephrotic syndrome: protein >3.5 g/24 hr	• Damage of GBM: nonselective proteinuria with loss of albumin and globulins. Example: poststreptococcal glomerulonephritis • Loss of negative charge on GBM: selective proteinuria with loss of albumin and *not* globulins. Example: minimal change disease (lipoid nephrosis)
Tubular	• Protein <2 g/24 hr • Defect in proximal tubule reabsorption of LMW proteins (e.g., amino acids at normal filtered loads)	• Heavy metal poisoning: e.g., lead and mercury poisoning • Fanconi syndrome: inability to reabsorb glucose, amino acids, uric acid, phosphate, and bicarbonate • Hartnup disease: defect in reabsorption of neutral amino acids (e.g., tryptophan) in the GI tract and kidneys

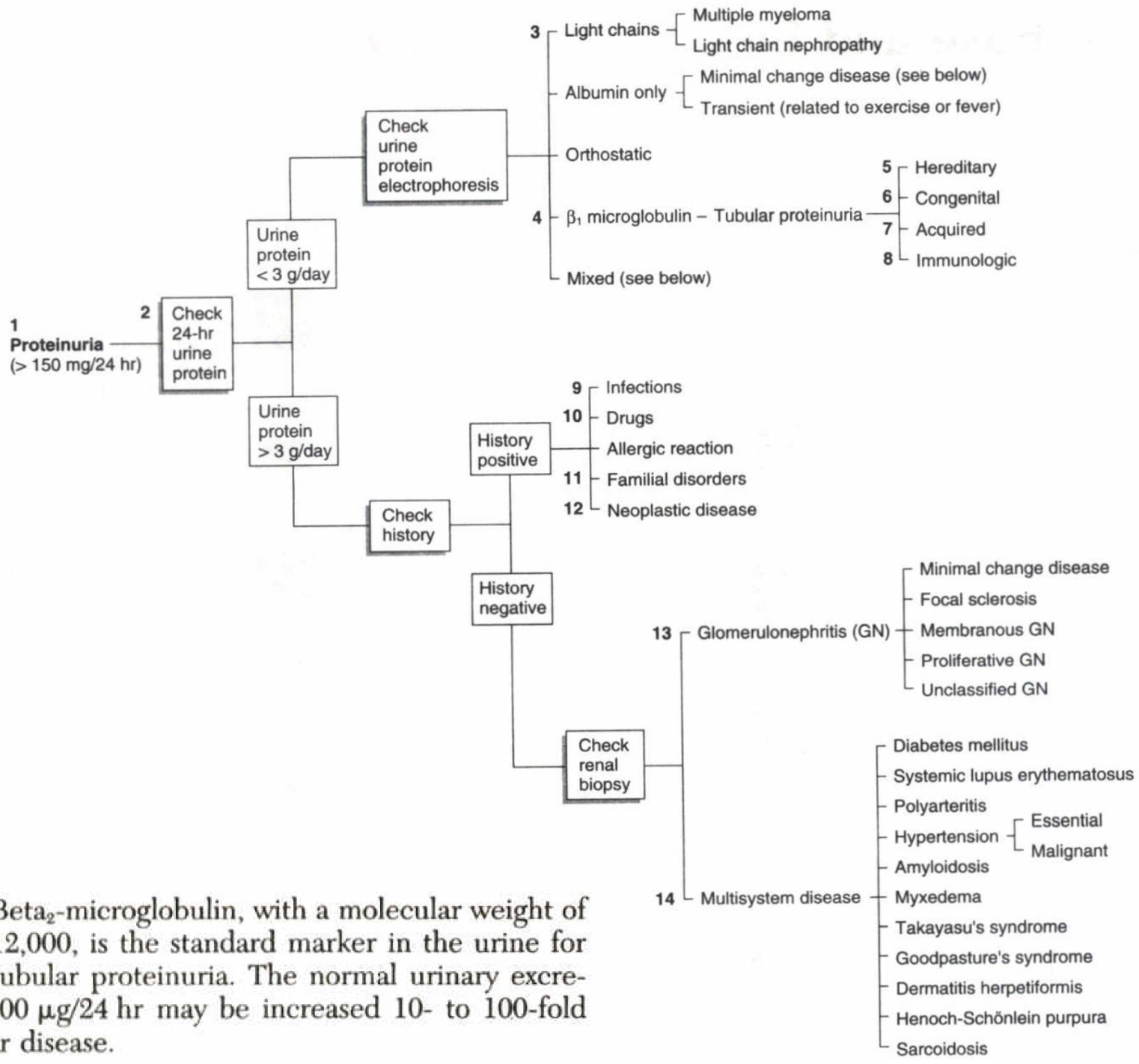
Синдром **Имерслунд-Гресбека**



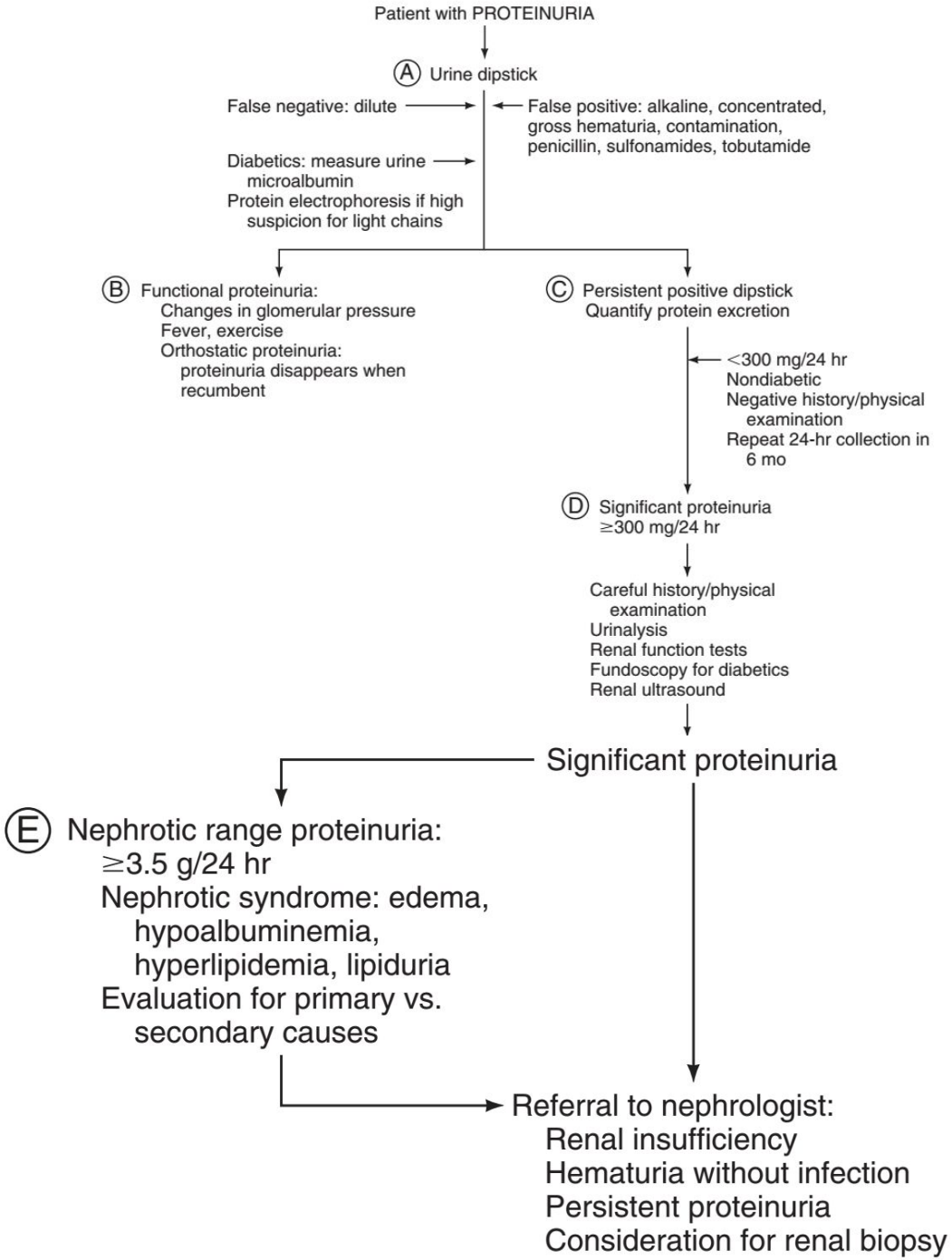
Link 20-58 Light chain nephropathy in multiple myeloma. Note the dilated tubules with eosinophilic casts with Tamm-Horsfall protein trapping light chains. Also note the multinucleated giant cells that "invade" the tubules through breaks in the membrane *(white arrows).* *(From Rosai J:* Rosai and Ackerman's Surgical Pathology, *10th ed, St. Louis, Mosby Elsevier, 2011, p 1165, Fig. 17.87.)*

Селективная протеинурия

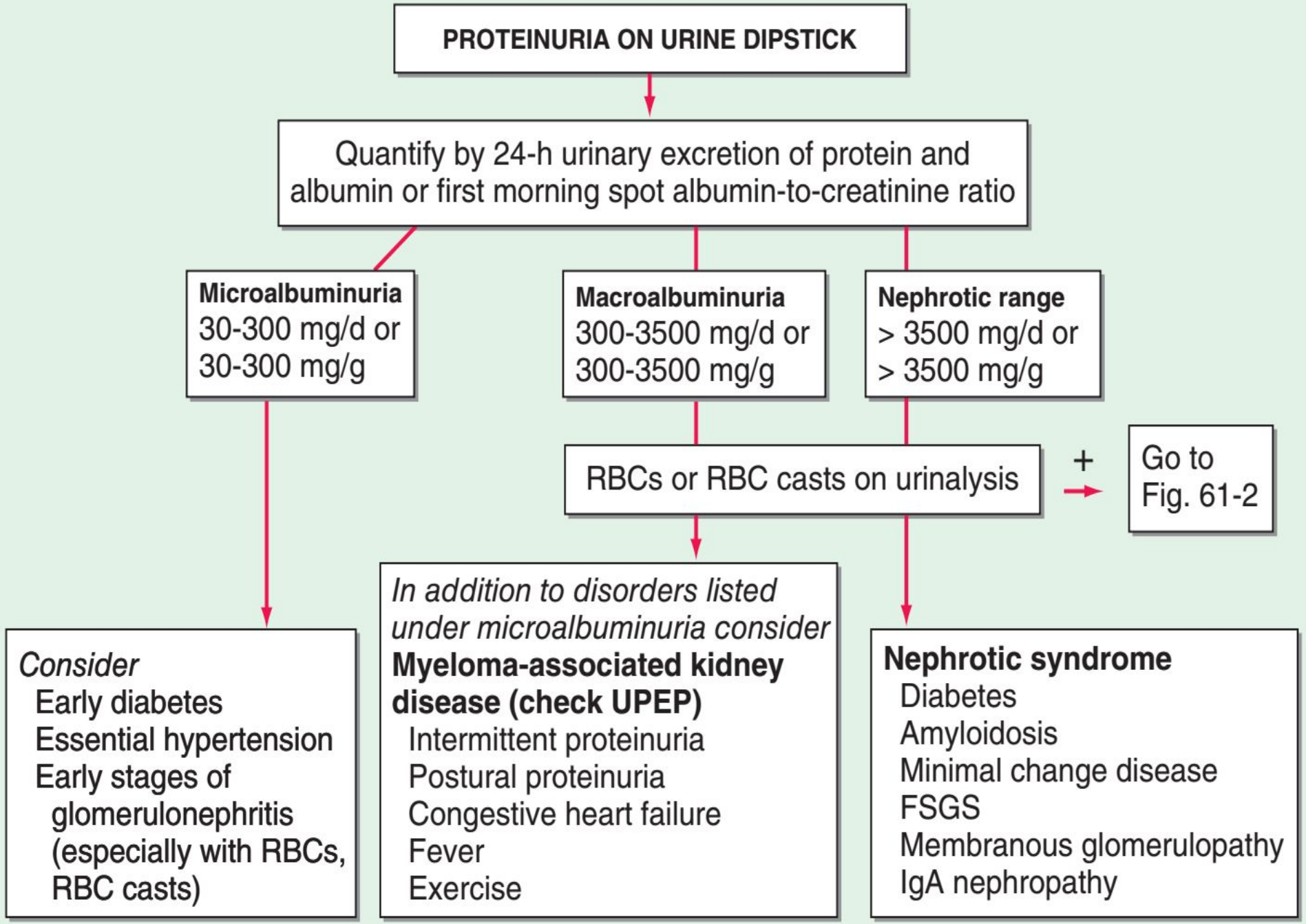
- Потеря заряда БМ
- Например, при болезни минимальных изменений
- Альбуминурия, но нет глобулинурии



4 Beta$_2$-microglobulin, with a molecular weight of 12,000, is the standard marker in the urine for tubular proteinuria. The normal urinary excretion of 100 μg/24 hr may be increased 10- to 100-fold in tubular disease.


Patient with PROTEINURIA
A Urine dipstick
False negative: dilute
False positive: alkaline, concentrated, gross hematuria, contamination, penicillin, sulfonamides, tobutamide
Diabetics: measure urine microalbumin
Protein electrophoresis if high suspicion for light chains
B Functional proteinuria:
Changes in glomerular pressure
Fever, exercise
Orthostatic proteinuria: proteinuria disappears when recumbent
C Persistent positive dipstick
Quantify protein excretion
<300 mg/24 hr
Nondiabetic
Negative history/physical examination
Repeat 24-hr collection in 6 mo
D Significant proteinuria
≥300 mg/24 hr
Careful history/physical examination
Urinalysis
Renal function tests
Fundoscopy for diabetics
Renal ultrasound
Significant proteinuria
E Nephrotic range proteinuria:
≥3.5 g/24 hr
Nephrotic syndrome: edema, hypoalbuminemia, hyperlipidemia, lipiduria
Evaluation for primary vs. secondary causes
Referral to nephrologist:
Renal insufficiency
Hematuria without infection
Persistent proteinuria
Consideration for renal biopsy

Evaluation of Proteinuria



лейкоцитурия

≥10 WBCs/HPF in a
centrifuged specimen or ≥5 WBCs/HPF in an uncentrifuged specimen

+ бактерии:

МПИ

стерильная

Нейтрофилы:

МПИ + Антибиотики
ГН
Папиллярный некроз
Опухоль
Хламидиоз
Туберкулез и др.

стерильная

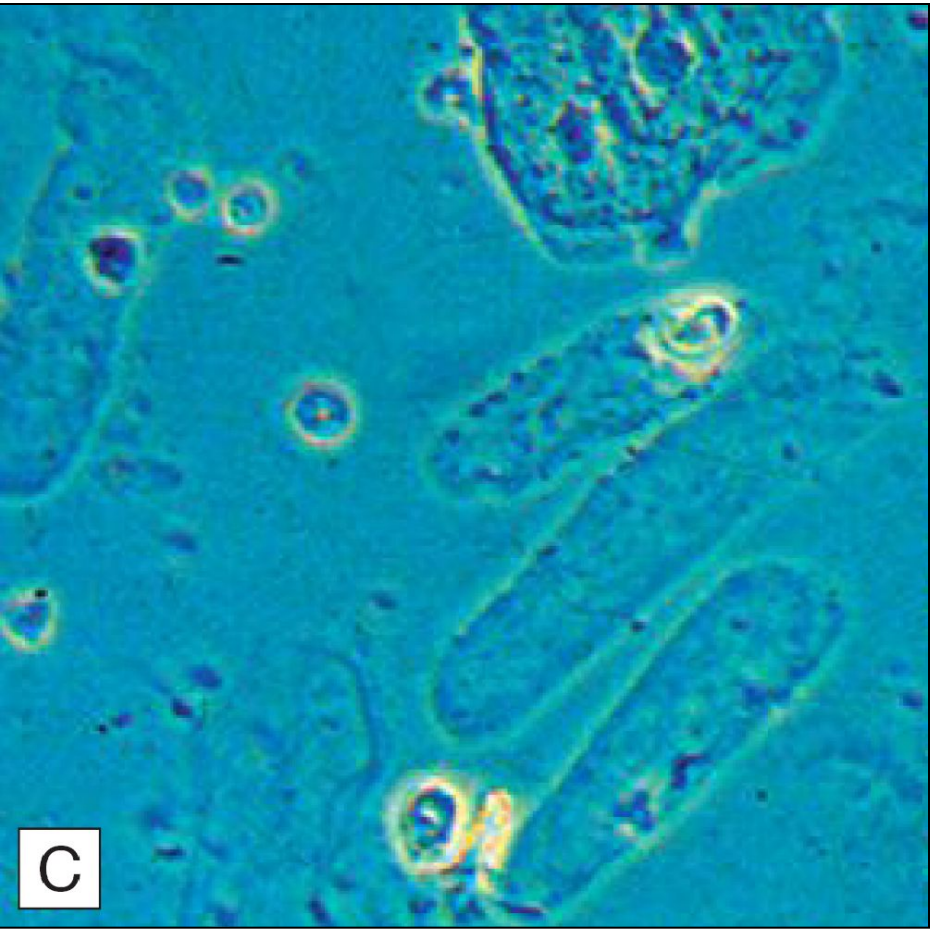
Лимфоциты:

ТИН

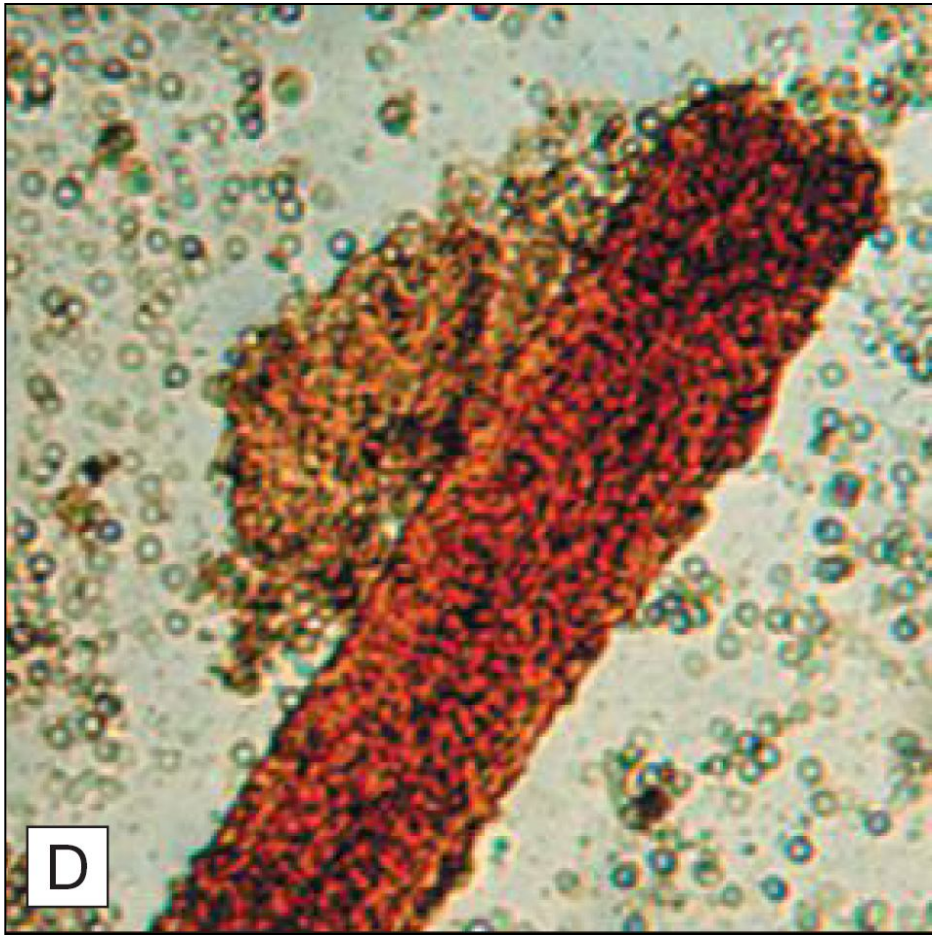
проба Томпсона
Эстераза лейкоцитов – ч. = 80%
Нитриты – обнаружение нитрат восст. бактерий (E.coli), ч.= 30% (особенно при частом мочеиспускании), сп. = 90%

B, Sediment with neutrophils. The *arrow* points to a bilobed neutro-

ЦИЛИНДРЫ

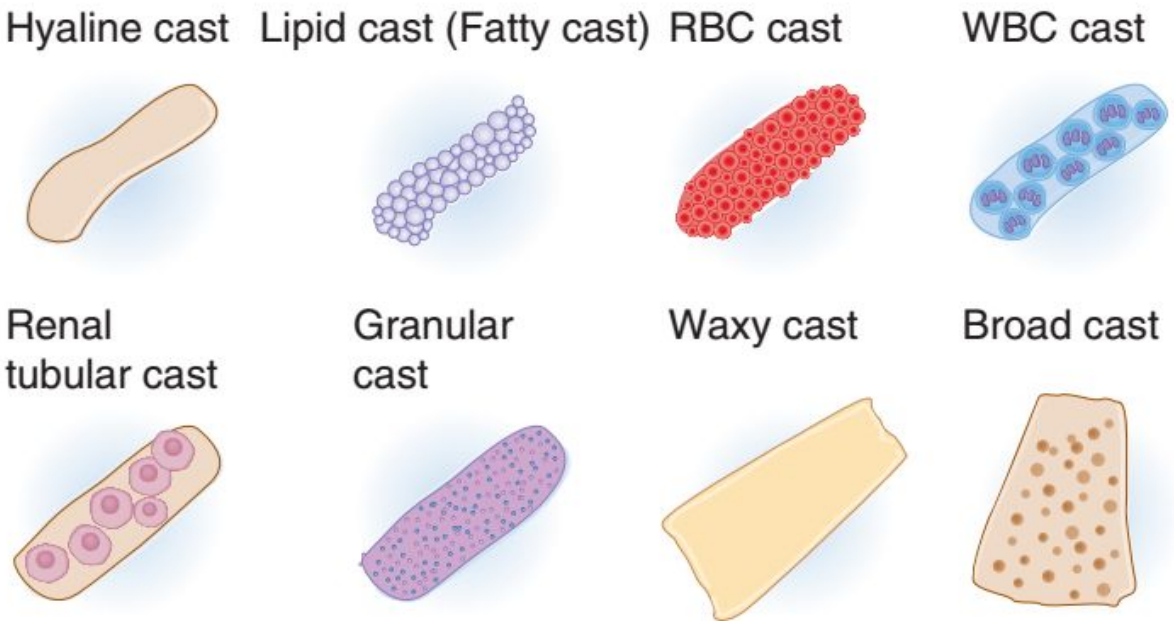


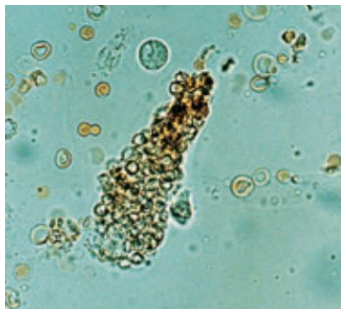
N

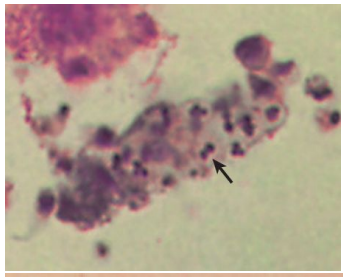


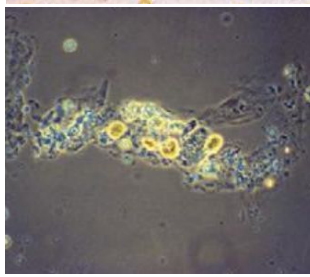
ГН

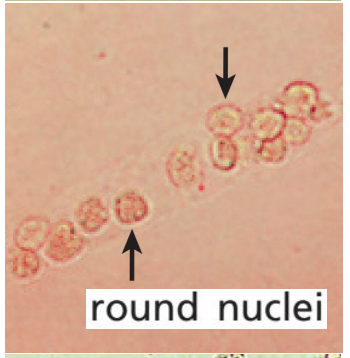
Casts in urine	Presence of casts indicates that hematuria/pyuria is of renal (vs. bladder) origin.	
RBC casts	Glomerulonephritis, ischemia, or malignant hypertension.	Bladder cancer, kidney stones → hematuria, no casts.
WBC casts	Tubulointerstitial inflammation, acute pyelonephritis, transplant rejection.	Acute cystitis → pyuria, no casts.
Fatty casts ("oval fat bodies")	Nephrotic syndrome.	
Granular ("muddy brown") casts	Acute tubular necrosis.	
Waxy casts	Advanced renal disease/chronic renal failure.	
Hyaline casts	Nonspecific, can be a normal finding, often seen in concentrated urine samples.	

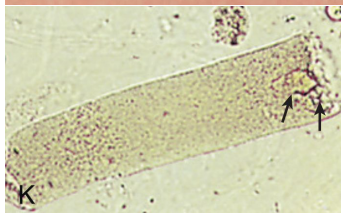


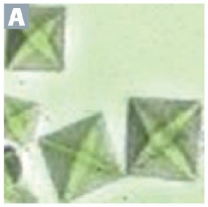
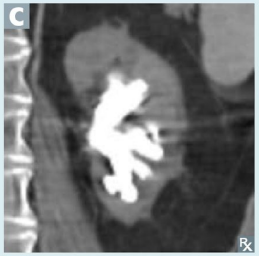
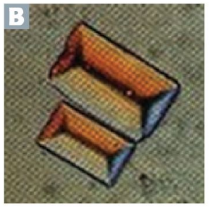
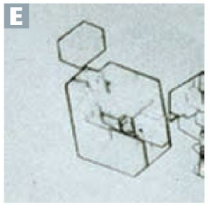


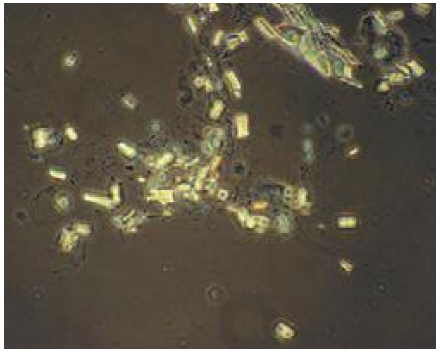


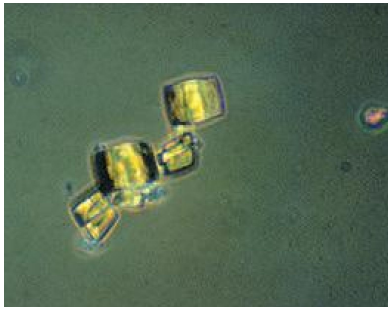


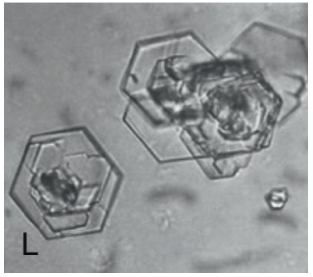


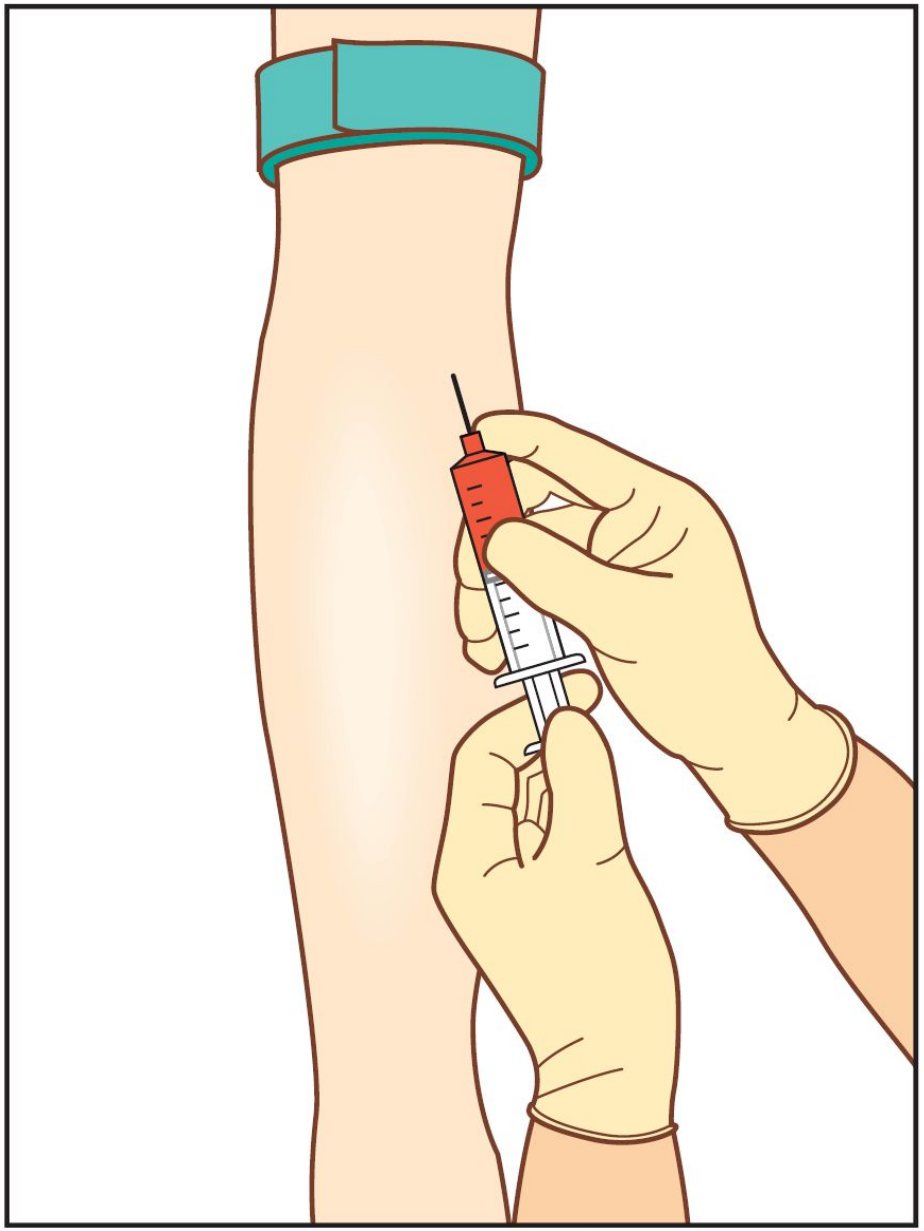


Calcium (80%)	↑ pH (calcium phosphate) ↓ pH (calcium oxalate)	Radiopaque	Envelope A or dumbbell shaped 	Calcium oxalate, calcium phosphate, or both. Promoted by hypercalciuria (idiopathic or 2° to conditions that cause hypercalcemia, such as cancer and ↑ PTH). Oxalate crystals can result from ethylene glycol (antifreeze), vitamin C abuse, or Crohn disease. Treatments for recurrent stones include thiazides and citrate. Most common kidney stone presentation: calcium oxalate stone in a patient with hypercalciuria and normocalcemia.
Ammonium magnesium phosphate (15%) 	↑ pH	Radiopaque	Coffin lid B 	Also known as struvite. Caused by infection with urease ⊕ bugs (*Proteus mirabilis*, *Staphylococcus*, *Klebsiella*) that hydrolyze urea to ammonia → urine alkalinization. Can form staghorn calculi C that can be a nidus for UTIs. Treatment: eradication of underlying infection and surgical removal of stone.
Uric acid (5%)	↓ pH	RadiolUcent	Rhomboid or rosettes D 	Risk factors: ↓ urine volume, arid climates, and acidic pH. Visible on CT and ultrasound, but not x-ray. Strong association with hyperuricemia (e.g., gout). Often seen in diseases with ↑ cell turnover, such as leukemia. Treatment: alkalinization of urine.
Cystine (1%)	↓ pH	Radiopaque	Hexagonal E 	Mostly seen in children, 2° to cystinuria. Can form staghorn calculi. Sodium nitroprusside test ⊕. Treatment: alkalinization of urine and hydration.









Blood tests for abnormal creatinine and electrolytes

- Cr, мочевина
- Электролиты
- HbA1c
- Маркеры почечного повреждения – острого (NGAL) и хронического (цистатин С)
- …

Азот мочевины (BUN) или мочевина

- 7 to 18 mg/dL
- Образуется в орнитиновом цикле, фильтруется, частично реабсорбируется, при высоком уровне может выводится через кожу, кишечник
- Зависит от: 1. фильтрации (клубочек),
  2. реабсорбции,
  3. орнитинового цикла,
  4. потребления белка
  5. интенсивности катаболизма

CAUSE	DISCUSSION
Increased Serum BUN	
Decreased cardiac output	CHF, shock (e.g., hemorrhage) MCC ↓Cardiac output → ↓GFR → ↑proximal tubule reabsorption of urea → ↑serum BUN
Increased protein intake	High-protein diet, blood in gastrointestinal tract ↑Amino acid degradation → ↑serum BUN (more synthesized)
Increased tissue catabolism	Third-degree burns, postoperative state ↑Amino acid degradation → ↑serum BUN (more synthesized)
Acute glomerulonephritis	Poststreptococcal glomerulonephritis ↓GFR → ↑serum BUN (more reabsorbed in proximal tubules)
Acute or chronic renal failure	Acute tubular necrosis, diabetic glomerulopathy ↓GFR → ↑serum BUN (backs up behind the failed kidneys)
Postrenal disease	Urinary tract obstruction (e.g., urinary stone, BPH) ↓GFR back-diffusion of urea → ↑serum BUN
Decreased Serum BUN	
Increased plasma volume	Normal pregnancy, SIADH ↑Plasma volume → ↑GFR → ↓serum BUN (less reabsorbed)
Decreased urea synthesis	Cirrhosis, Reye syndrome, fulminant liver failure Dysfunctional urea cycle → ↓serum BUN (less synthesized)
Decreased protein intake	Kwashiorkor (↑CHO is protein sparer; refer to Chapter 8), starvation gluconeogenesis in kidneys ↓Amino acid degradation → ↓serum BUN (less synthesized)

Креатинин

- 0.6 to 1.2 mg/dL или
- Фильтруется, НЕ реабсорбируется, незначительно секретируется, поэтому подходит для оценки СКФ

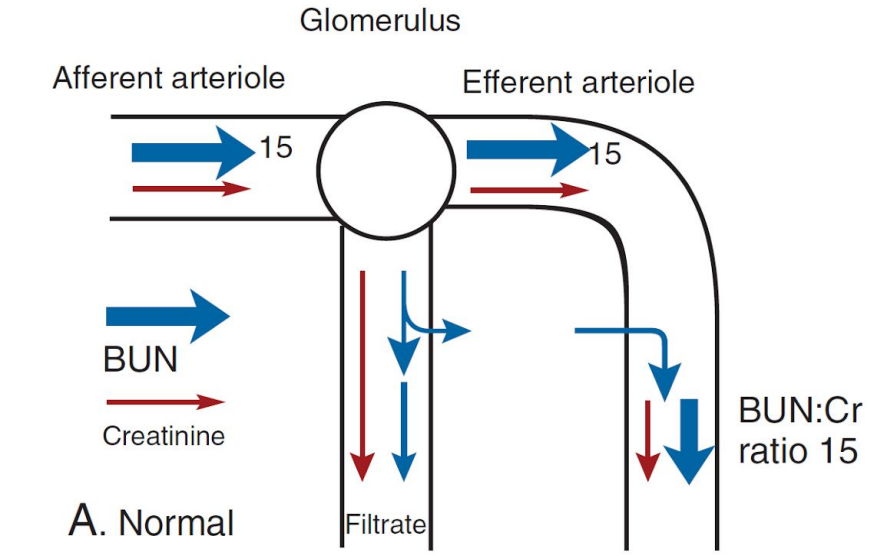
Клиренс креатинина

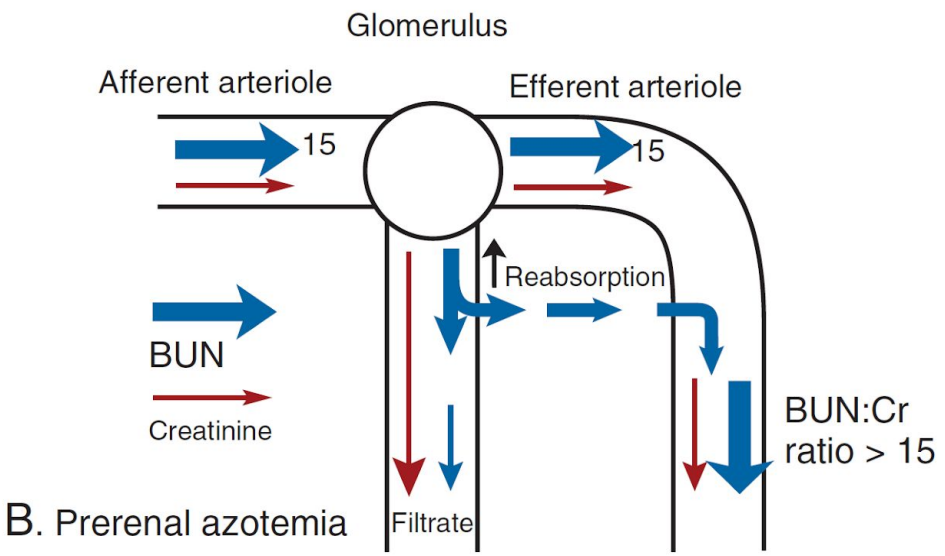
- КК = Cr в моче (mg/dL) × объем **24ч.** мочи (mL/min) ÷ Cr в плазме (mg/dL)
- Точность метода зависит от правильного сбора мочи (**24 часа**)
- Норма: 97 - 137 mL/min, коррелирует с СКФ
- Не подходит для оценки СКФ в ряде случаев, напр., у пожилых пациентов, атлетов
- После 50 лет КК уменьшается на 1 mL/min каждый год

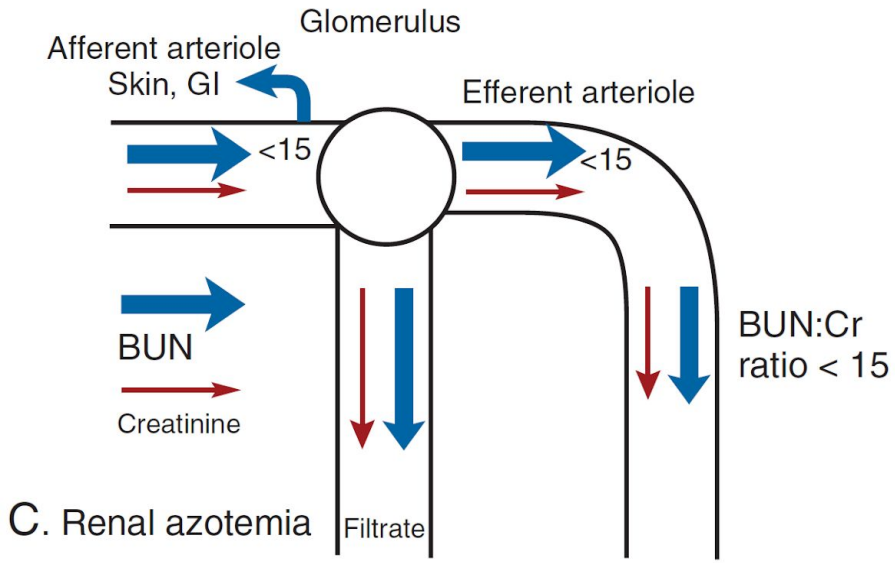
CAUSE	DISCUSSION
Increased CCr	
Normal pregnancy	Normal increase in plasma volume causes an increase in the GFR leading to an increase in CCr; highest at the end of the first trimester
Early diabetic glomerulopathy	Efferent arteriole becomes constricted due to hyaline arteriolosclerosis causing an increase in the GFR and CCr. Increased GFR damages the glomerulus (hyperfiltration injury).
Decreased CCr	
Elderly people	GFR normally decreases with age causing a corresponding decrease in the CCr; danger when using nephrotoxic drugs; therefore the dose amount and interval must be adjusted accordingly for the person's age and CCr
Acute and chronic renal disease	ARF due to acute tubular necrosis, CRF due to diabetic glomerulopathy, chronic pyelonephritis, renal amyloidosis

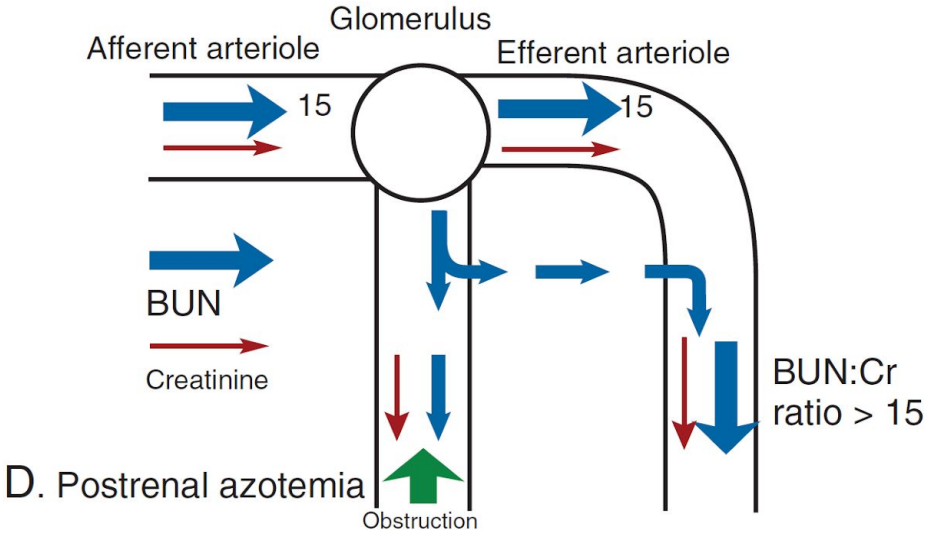
соотношение BUN/Cr

- норма -15
- Cr НЕ реабсорбируется, мочевина – реабсорбируется
- Используется для оценки
- Преренальная азотемия - > 15
- Ренальная (с поражением канальца) - < 15 (экстраренальное выведение)
- Постренальная - > 15


Glomerulus
Afferent arteriole
Efferent arteriole
15
15
BUN
Creatinine
BUN:Cr
ratio 15
A. Normal
Filtrate

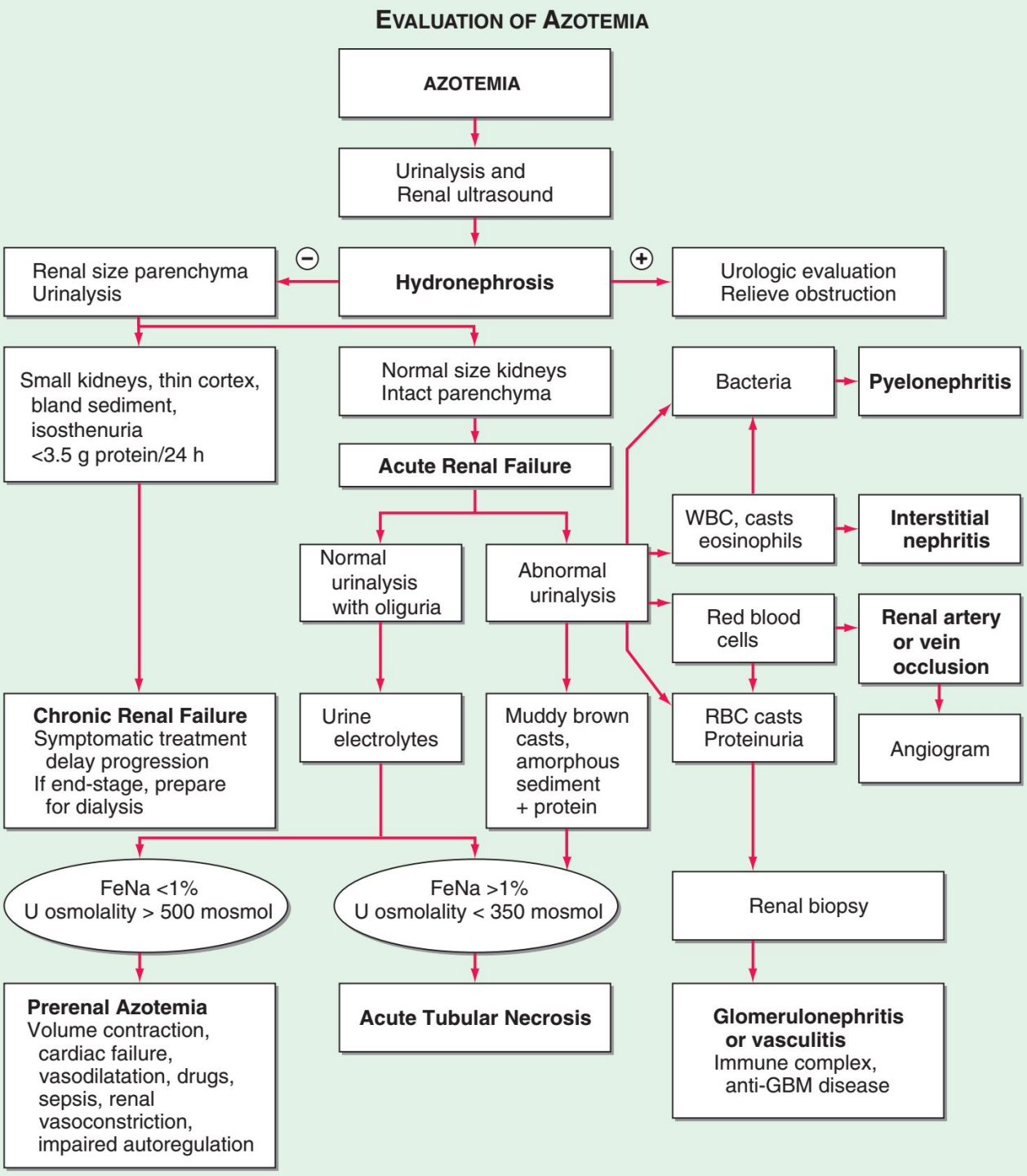

Glomerulus
Afferent arteriole
Efferent arteriole
15
15
Reabsorption
BUN
Creatinine
BUN:Cr
ratio > 15
B. Prerenal azotemia
Filtrate


Glomerulus
Afferent arteriole
Skin, GI
Efferent arteriole
<15
<15
BUN
Creatinine
BUN:Cr
ratio < 15
C. Renal azotemia
Filtrate


Glomerulus
Afferent arteriole
Efferent arteriole
15
15
BUN
Creatinine
BUN:Cr
ratio > 15
D. Postrenal azotemia
Obstruction

Test	SI units	US units
BUN (Urea)		7–20 mg/dL
Urea	2.5–10.7 mmol/L	20–40 mg/dL
Creatinine	62–106 μmol/L	0.7–1.2 mg/dL

BUN:Cr	Urea:Cr	Location	Mechanism
>20:1	>100:1	Prerenal (before the kidney)	BUN reabsorption is increased. BUN is disproportionately elevated relative to creatinine in serum. Dehydration or hypoperfusion is suspected.
10–20:1	40–100:1	Normal or Postrenal (after the kidney)	Normal range. Can also be postrenal disease. BUN reabsorption is within normal limits.
<10:1	<40:1	Intrarenal (within kidney)	Renal damage causes reduced reabsorption of BUN, therefore lowering the BUN:Cr ratio.


EVALUATION OF AZOTEMIA
AZOTEMIA
Urinalysis and Renal ultrasound
Renal size parenchyma Urinalysis
Hydronephrosis
Urologic evaluation Relieve obstruction
Small kidneys, thin cortex, bland sediment, isosthenuria <3.5 g protein/24 h
Normal size kidneys Intact parenchyma
Acute Renal Failure
Bacteria
Pyelonephritis
WBC, casts eosinophils
Interstitial nephritis
Normal urinalysis with oliguria
Abnormal urinalysis
Red blood cells
Renal artery or vein occlusion
Angiogram
Chronic Renal Failure Symptomatic treatment delay progression If end-stage, prepare for dialysis
Urine electrolytes
Muddy brown casts, amorphous sediment + protein
RBC casts Proteinuria
FeNa <1% U osmolality > 500 mosmol
FeNa >1% U osmolality < 350 mosmol
Renal biopsy
Prerenal Azotemia Volume contraction, cardiac failure, vasodilatation, drugs, sepsis, renal vasoconstriction, impaired autoregulation
Acute Tubular Necrosis
Glomerulonephritis or vasculitis Immune complex, anti-GBM disease

МАРКЕРЫ ПОЧЕЧНОГО ПОВРЕЖДЕНИЯ

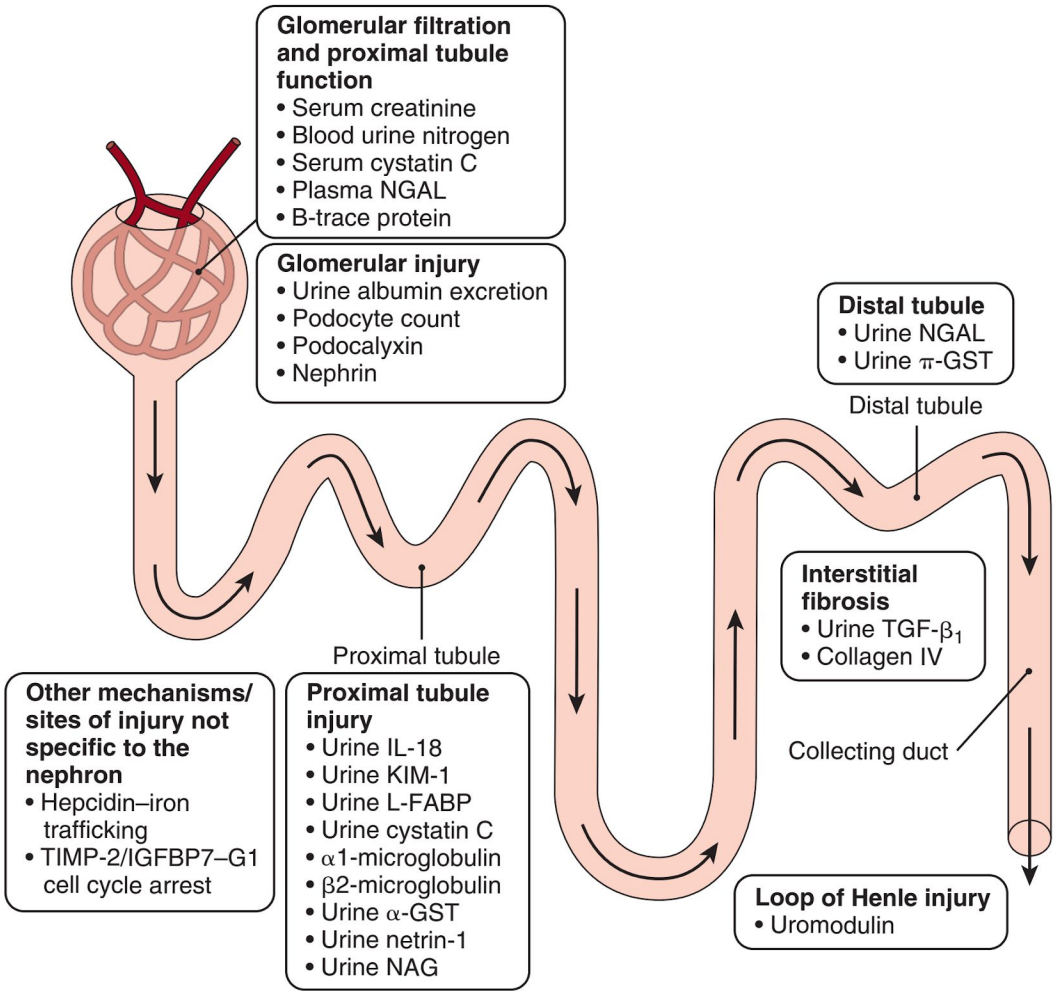


Figure 30.2 Biomarkers in relation to their site of injury in the nephron. GST, glutathione *S*-transferase; IGFBP7, insulin-like growth factor–binding protein-7; IL-18, interleukin-18; KIM-1, kidney injury molecule-1; L-FABP, liver-type fatty acid–binding protein; NAG, *N*-acetyl-β-D-glucosaminidase; NGAL, neutrophil gelatinase–associated lipocalin; TGF-β1, transforming growth factor-β1; TIMP-2, tissue inhibitor metalloproteinase-2. (Adapted from Koyner JL, Parikh CR: Clinical utility of biomarkers of AKI in cardiac surgery and critical illness. *Clin J Am Soc Nephrol* 8:1034-1042, 2013.)

НефрИтический синдром

- ГЕМАТУРИЯ + эритр.циллиндры
- ОЛИГУРИЯ ➡ АЗОТЕМИЯ
- BUN/Cr >15 (канальцы не повреждены)
- АГ
- ОТЕКИ

} МЕХАНИЗМ – ЗАДЕРЖКА ЖИДКОСТИ

НефрОтический синдром

- Протеинурия > **3,5** г/сут
- Гипоальбуминенмия < **30** г/л
- Отеки → МЕХАНИЗМЫ – 1. ОНКОТИЧЕКОГО ДАВЛЕНИЯ, 2.задержка жидкости (альдостерон)
- Гиперлипидемия

\+ **Гипертензия / гипотензия (нефротический криз)**

Гиперкоагуляция (потеря антитромбина)

Иммунодефицит (потеря Ig)

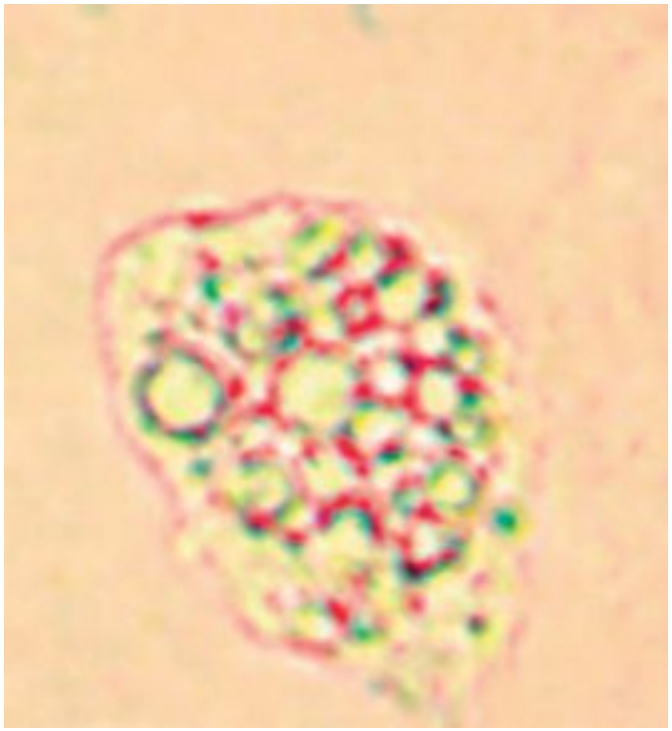
Oval fat bodies

При асците - риск спонтанного бактериального перитонита (*S. pneumoniae, E. coli)*

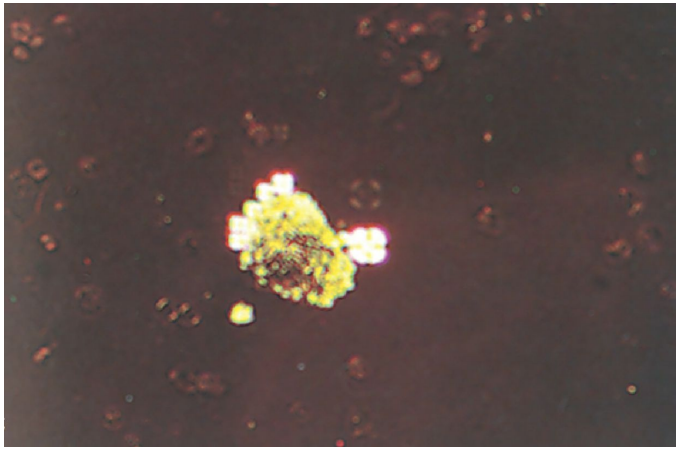
Причины НС

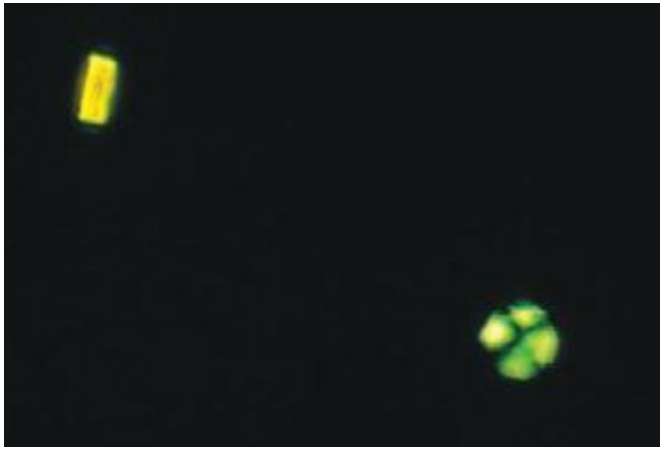
- У детей - #1 - болезнь минимальных изменений
- У взрослых европеоидов (кроме латиноамер.) - #1 – мембранозная нефропатия
- У остальных взрослых - #1 – ФСГС
- Также: диабетический гломерулосклероз (тип 1 -35%–45% случаев, тип 2 - 20%), амилоидоз, другие первичные и вторичные гломерулопатии

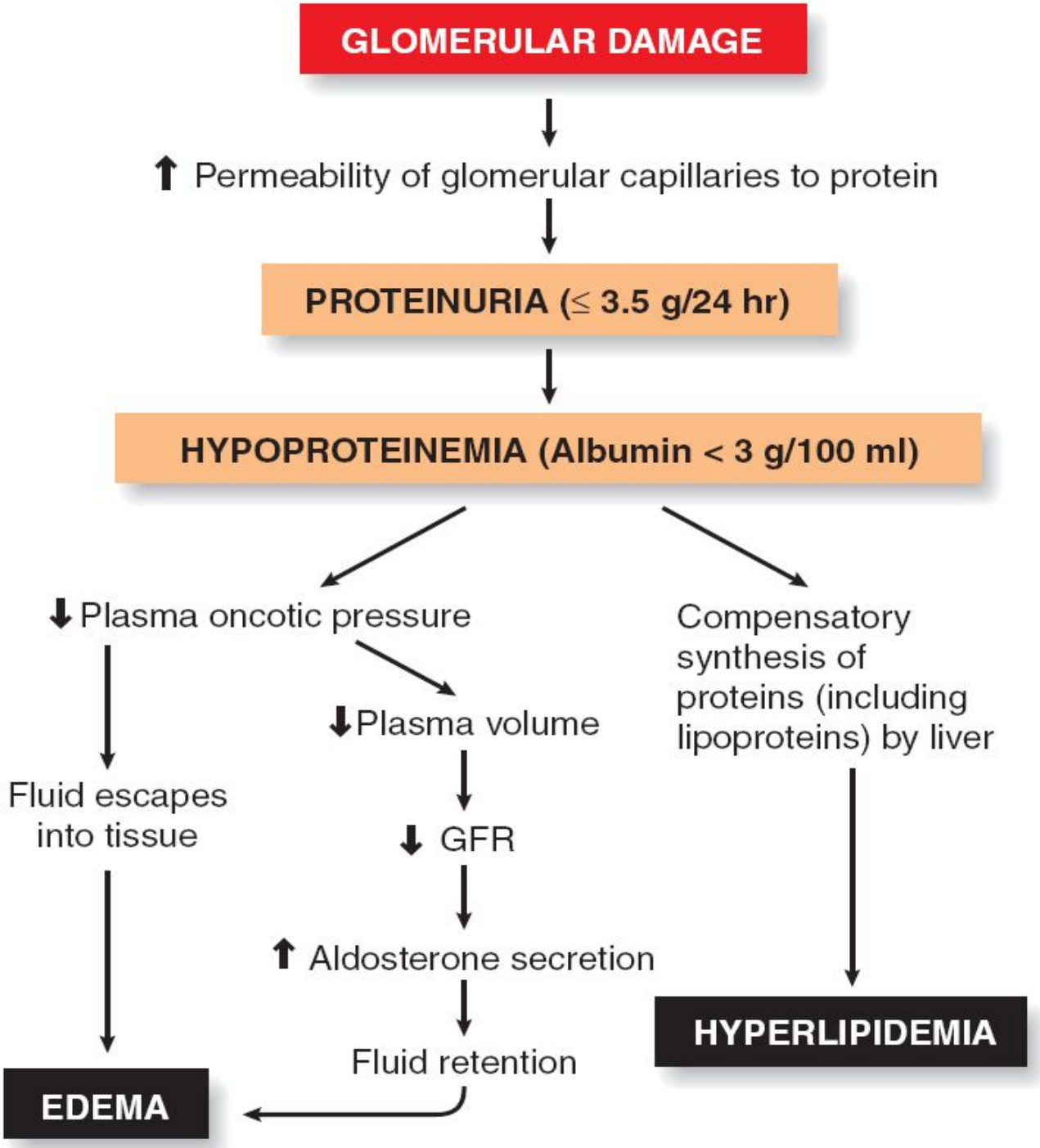
Oval fat bodies



- renal tubular cells with lipid
- Maltese crosses are due to cholesterol, which is always increased in nephrotic syndrome






GLOMERULAR DAMAGE
⬆ Permeability of glomerular capillaries to protein
PROTEINURIA (≤ 3.5 g/24 hr)
HYPOPROTEINEMIA (Albumin < 3 g/100 ml)
⬇ Plasma oncotic pressure
Compensatory synthesis of proteins (including lipoproteins) by liver
⬇ Plasma volume
Fluid escapes into tissue
⬇ GFR
⬆ Aldosterone secretion
HYPERLIPIDEMIA
Fluid retention
EDEMA

Поражение клубочка

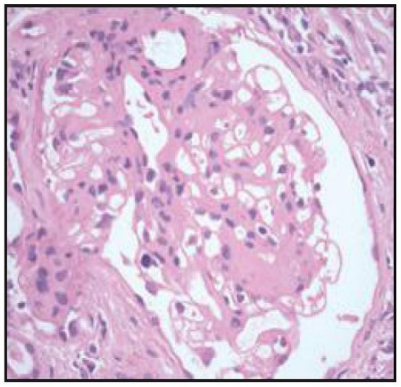
Поражение канальца

- Артериальная гипертензия
- Мочевой синдром (разные изменения)
- Почечная недостаточность

- Нефр**и**тический синдром
- Нефр**о**тический синдром

- Нарушения образования и выделения мочи:

гипо-, изостенурия



SLE

IgA nephropathy

Minimal change nephropathy

FSGS

Membranous nephropathy

Amyloid

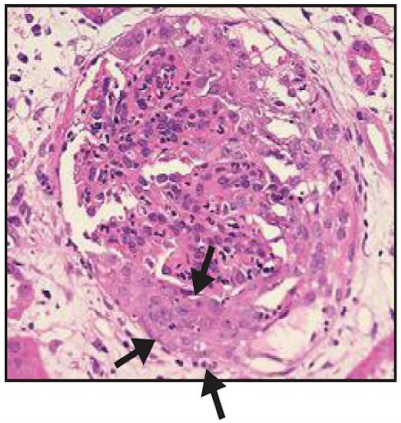
Diabetic nephropathy

MCGN

Post-streptococcal glomerulonephritis

Small-vessel vasculitis

Anti-GBM disease



Nephrotic

Mechanism

- Injury to podocytes
- Changed architecture
  Scarring
  Deposition of matrix or other elements

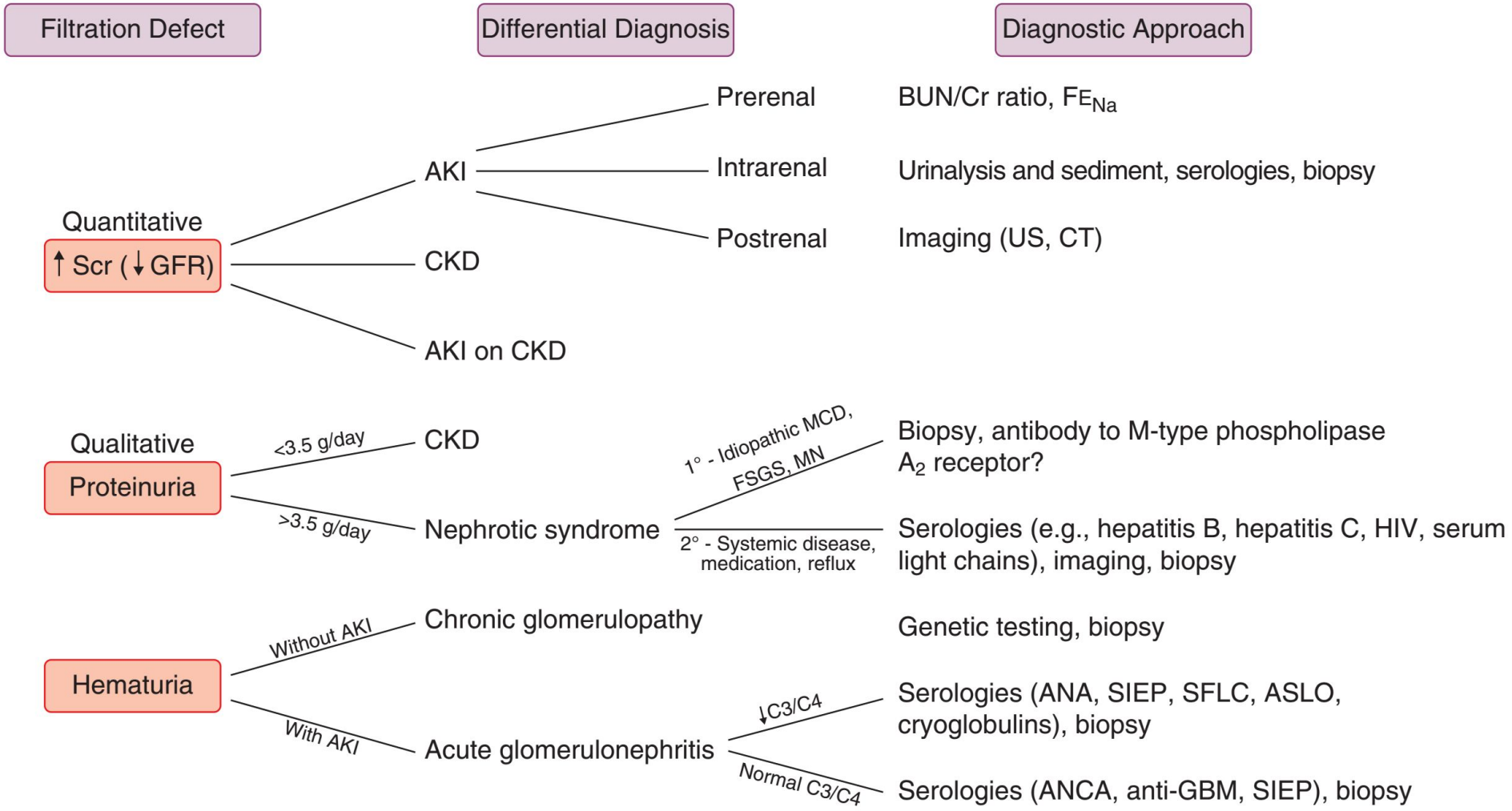
Haematuria

Proteinuria

Nephritic

Mechanism

- Inflammation
- Reactive cell proliferation
- Breaks in GBM
- Crescent formation


Filtration Defect
Differential Diagnosis
Diagnostic Approach
Quantitative
↑ Scr (↓ GFR)
AKI
Prerenal
BUN/Cr ratio, FE_{Na}
Intrarenal
Urinalysis and sediment, serologies, biopsy
Postrenal
Imaging (US, CT)
CKD
AKI on CKD
Qualitative
Proteinuria
<3.5 g/day
CKD
>3.5 g/day
Nephrotic syndrome
1° - Idiopathic MCD, FSGS, MN
Biopsy, antibody to M-type phospholipase A_2 receptor?
2° - Systemic disease, medication, reflux
Serologies (e.g., hepatitis B, hepatitis C, HIV, serum light chains), imaging, biopsy
Hematuria
Without AKI
Chronic glomerulopathy
Genetic testing, biopsy
With AKI
Acute glomerulonephritis
↓C3/C4
Serologies (ANA, SIEP, SFLC, ASLO, cryoglobulins), biopsy
Normal C3/C4
Serologies (ANCA, anti-GBM, SIEP), biopsy

Syndrome	Important Clues to Diagnosis	Common Findings
Acute or rapidly progressive renal failure	Anuria	Hypertension, hematuria
	Oliguria	Proteinuria, pyuria
	Documented recent decline in GFR	Casts, edema
Acute nephritis	Hematuria, RBC casts	Proteinuria
	Azotemia, oliguria	Pyuria
	Edema, hypertension	Circulatory congestion
Chronic renal failure	Azotemia for >3 months	Proteinuria
	Prolonged symptoms or signs of uremia	Casts
	Symptoms or signs of renal osteodystrophy	Polyuria, nocturia
	Kidneys reduced in size bilaterally	Edema, hypertension
	Broad casts in urinary sediment	Electrolyte disorders
Nephrotic syndrome	Proteinuria, with >3.5 g/24 h per 1.73 m^2	Casts
	Hypoalbuminemia	Lipiduria
	Edema	Hypercoagulable state
	Hyperlipidemia	
Asymptomatic urinary abnormalities	Hematuria	
	Proteinuria (below nephrotic range)	
	Sterile pyuria, casts	
Urinary tract infection/pyelonephritis	Bacteriuria, with $>10^5$ cfu/mL	Hematuria
	Other infectious agent documented in urine	Mild azotemia
	Pyuria, leukocyte casts	Mild proteinuria
	Frequency, urgency	Fever
	Bladder tenderness, flank tenderness	
Renal tubule defects	Electrolyte disorders	Hematuria
	Polyuria, nocturia	"Tubular" proteinuria (<1 g/24 h)
	Renal calcification	Enuresis
	Large kidneys	
	Renal transport defects	
Hypertension	Systolic/diastolic hypertension	Proteinuria
		Casts
		Azotemia
Nephrolithiasis	Previous history of stone passage or removal	Hematuria
	Previous history of stone seen by x-ray	Pyuria
	Renal colic	Frequency, urgency
Urinary tract obstruction	Azotemia, oliguria, anuria	Hematuria
	Polyuria, nocturia, urinary retention	Pyuria
	Slowing of urinary stream	Enuresis, dysuria
	Large prostate, large kidneys	
	Flank tenderness, full bladder after voiding	

Abbreviations: cfu, colony-forming units; GFR; glomerular filtration rate; RBC, red blood cell.