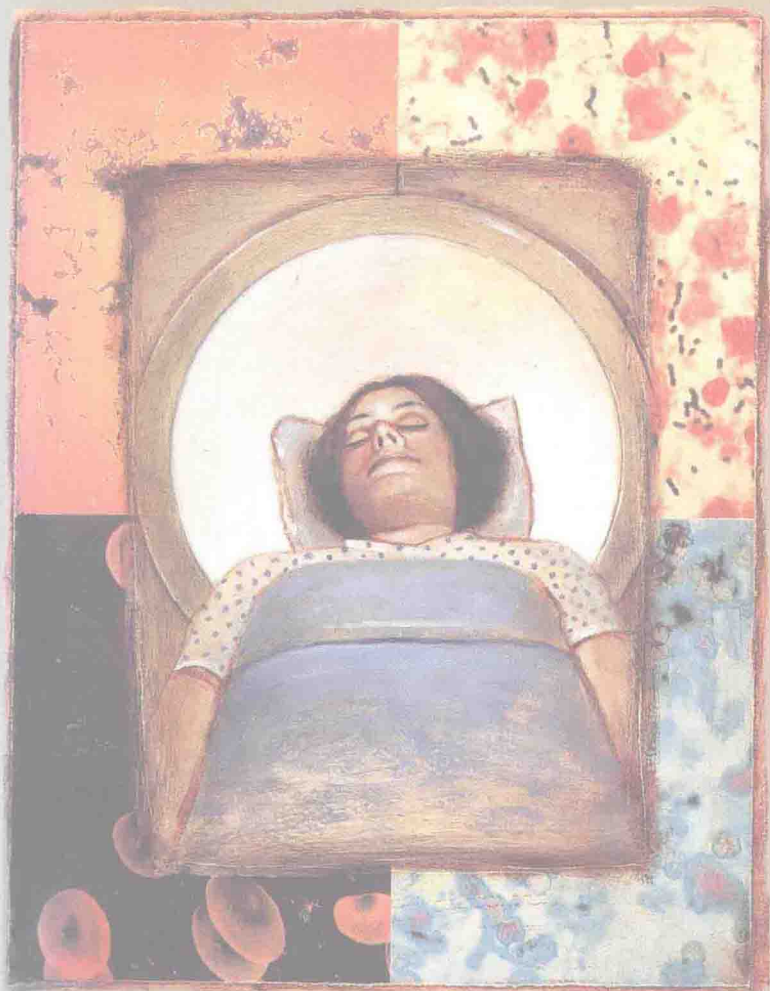


SPRINGHOUSE

HANDBOOK OF

DIAGNOSTIC TESTS
SECOND EDITION



LABORATORY TESTS • DIAGNOSTIC PROCEDURES • PATIENT CARE

HANDBOOK OF DIAGNOSTIC TESTS

SECOND EDITION

Springhouse Corporation
Springhouse, Pennsylvania

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The clinical procedures described and recommended in this publication are based on research and consultation with medical and nursing authorities. To the best of our knowledge, these procedures reflect currently accepted clinical practice; nevertheless, they can't be considered absolute and universal recommendations. For individual application, treatment recommendations must be considered in light of the patient's clinical condition and, before administration of new or infrequently used drugs, in light of the latest package-insert information. The authors and the publisher disclaim responsibility for any adverse effects resulting directly or indirectly from the suggested procedures, from any undetected errors, or from the reader's misunderstanding of the text.

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SECOND EDITION

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FOREWORD

Medical knowledge at the end of the twentieth century continues to grow at an exponential rate. Keeping up with this growth is a daunting challenge for the busy clinician. The new edition of the *Handbook of Diagnostic Tests* provides an efficient way for all health care professionals to review the latest advances in medical diagnosis and treatment.

In clinical medicine, choosing the appropriate diagnostic tests and interpreting the results knowledgeably is often the difference between success and failure, especially when treating seriously ill patients. The *Handbook of Diagnostic Tests*, Second Edition, provides the latest information about commonly used tests in a format that is clear, concise, and easy to access.

Many of the newer diagnostic tests have had a dramatic effect on patient care. Changes in the diagnostic approach to patients suspected of having acute appendicitis provide a good example of how improvements in technology and increasing skill in interpreting imaging studies have changed patient care. Before abdominal and pelvic ultrasound examinations and computed tomography (CT) scanning were generally available, surgeons operating on a presumed diagnosis of appendicitis had an 80% diagnostic accuracy. Twenty percent of surgeries for possible appendicitis revealed no abnormalities, nor did they indicate that some other process (such as diverticulitis, pelvic inflammatory disease, mesenteric adenitis, and Crohn's disease) was responsible for the patient's symptoms. However, improving the preoperative diagnostic accuracy by waiting until symptoms become more definite risks a ruptured appendix. Today, the ready availability of abdominal ultrasound and CT scanning has greatly changed the management of these patients. When clinical findings are equivocal, an immediate ultrasound can be obtained. When the ultrasound suggests appendicitis, surgery is often done at an earlier stage in the disease than it might have otherwise. If the ultrasound examination is not diagnostic, a CT scan may clarify the diagnosis; sometimes it diagnoses appendicitis when the ultrasound is normal. With this approach, the diagnostic accuracy in patients with acute appendicitis is over 95% instead of 80%, meaning that thousands of patients every year can avoid unnecessary surgery and can sooner undergo safer and more appropriate therapy.

The *Handbook of Diagnostic Tests*, Second Edition, is a valuable guide to understanding how and when these newer diagnostic approaches are used and how to interpret the results. The book is divided into two sections. Part One presents the key diagnostic findings for more than 500 disorders arranged alphabetically. Besides providing a quick cross-reference linking specific disorders to tests, this section provides a sound foundation that the practitioner can use in developing a diagnostic and therapeutic strategy.

Part Two provides specific details about hundreds of diagnostic tests in a clear, consistent, and easy-to-use format. In addition to a general description of each test, its purpose, patient preparation and teaching, and any special equipment needed to obtain a specimen or perform the test, the format covers the steps of the procedure, patient care during it and afterward, precautions to ensure test quality and avoid patient complications, normal results, the clinical significance of abnormal results, and the factors that can interfere with test accuracy.

The book's content ranges over the entire scope of laboratory tests and diagnostic procedures that are important to clinicians. The first five chapters discuss tests done on blood samples, including blood chemistry, hematology, coagulation, and endocrine and immunologic assays. Chapters 6 through 8 cover urine, sputum, and bacteriologic testing. Chapter 9 discusses biopsies, and chapter 10 explains endoscopic procedures. The next three chapters convey the latest information on imaging modalities, including the use of ultrasound, plain X-rays, CT scanning, magnetic resonance imaging, and nuclear medicine scanning. Chapter 15 discusses clinical monitoring and catheterization studies, and the final chapter provides information about special function tests, including those for vision and hearing, gastric acidity, and renal function. What's more, tests within most chapters are logically organized by body system, making it easy to find relevant information.

New features in the second edition include a thorough review and updating of all tests and the addition of more than 35 tests, including new ones for cancer, Alzheimer's disease, deep-vein thrombosis, and osteoporosis, and a new type of mammography. Every test now includes a list of interfering factors, such as specific foods and drugs, that can skew test results. Also added are "clinical alert" icons that remind the practitioner of important clinical signs to watch for in certain procedures or point out when special testing procedures may be helpful. Three extremely useful new appendices include a quick-reference listing of normal laboratory values, normal and abnormal test levels for major therapeutic drugs, and a whole section of teaching aids for the most-used home self-tests.

The *Handbook of Diagnostic Tests*, Second Edition, is a comprehensive guide that provides essential information about hundreds of laboratory tests and diagnostic procedures. The information is current and presented with a practical, hands-on approach. I am sure it will prove to be a valuable reference source for all health care professionals, including nurses, medical technologists, radiographers, physician assistants, respiratory therapists, and students.

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CONTENTS

ix *Contributors and Consultants*

xi *Foreword*

Part One	KEY DIAGNOSTIC FINDINGS IN MAJOR DISORDERS	1
-----------------	---	----------

Part Two	DIAGNOSTIC TESTS	83
-----------------	-------------------------	-----------

Chapter 1	HEMATOLOGY AND COAGULATION TESTS	84
------------------	---	-----------

- 85 Red blood cells
- 92 Hemoglobin
- 102 White blood cells
- 107 Platelet activity
- 113 Coagulation

Chapter 2	BLOOD CHEMISTRY TESTS	127
------------------	------------------------------	------------

- 129 Arterial blood gases
- 132 Electrolytes
- 141 Cardiac enzymes and proteins
- 145 Hepatic enzymes and proteins
- 153 Pancreatic enzymes
- 155 Special enzymes
- 166 Lipids and lipoproteins
- 173 Proteins and protein metabolites
- 182 Pigments
- 184 Carbohydrates

Chapter 3	HORMONE TESTS	195
------------------	----------------------	------------

- 196 Pituitary hormones
- 214 Thyroid and parathyroid hormones
- 224 Adrenal and renal hormones
- 232 Pancreatic and gastric hormones
- 236 Gonadal hormones
- 240 Placental hormones

Chapter 4	VITAMIN AND TRACE ELEMENT TESTS	243
------------------	--	------------

- 244 Vitamins
- 250 Trace elements

CHAPTER 5 IMMUNOLOGIC TESTS	253
255 Immunohematology	
264 General cellular function	
269 General humoral function	
277 Autoantibodies	
290 Viruses	
301 Bacteria and fungi	
310 Miscellaneous tests	
Chapter 6 URINE TESTS	319
321 Urinalysis	
329 Enzymes	
334 Hormones	
341 Metabolites	
351 Proteins and protein metabolites	
361 Pigments	
369 Sugars, ketones, and mucopolysaccharides	
374 Vitamins	
376 Minerals	
Chapter 7 ADDITIONAL SPECIMEN TESTS	383
384 Respiratory system	
387 Gastrointestinal system	
402 Reproductive system	
421 Miscellaneous tests	
Chapter 8 CULTURES	437
438 General cultures	
453 Genital cultures	
Chapter 9 BIOPSY	459
460 Respiratory system	
463 Gastrointestinal system	
467 Reproductive system	
472 Skeletal system	
479 Other organ-specific biopsies	
Chapter 10 ENDOSCOPY	489
490 Respiratory system	
496 Gastrointestinal system	
505 Reproductive system	
508 Skeletal system	

Chapter 11 ULTRASONOGRAPHY 513

- 514 Cardiovascular system
- 524 Gastrointestinal system
- 531 Miscellaneous tests

Chapter 12 RADIOGRAPHY 537

- 539 Neurologic system
- 545 Eye
- 548 Respiratory system
- 558 Cardiovascular system
- 562 Gastrointestinal system
- 583 Genitourinary system
- 604 Reproductive system
- 607 Skeletal system
- 611 Miscellaneous tests

Chapter 13 COMPUTED TOMOGRAPHY AND MAGNETIC RESONANCE IMAGING 615

- 616 Neurologic system
- 621 Gastrointestinal system
- 625 Musculoskeletal system
- 631 Miscellaneous tests

Chapter 14 NUCLEAR MEDICINE SCANS 639

- 640 Thyroid
- 643 Respiratory system
- 646 Cardiovascular system
- 651 Miscellaneous tests

Chapter 15 MONITORING AND CATHETERIZATION 665

- 666 Fetal monitoring
- 671 Neurologic monitoring
- 679 Cardiac monitoring and catheterization

Chapter 16 SPECIAL FUNCTION TESTS 709

- 710 Eyes and vision
- 716 Ears and hearing
- 723 Gastrointestinal function
- 726 Renal function
- 733 Miscellaneous tests

APPENDICES AND INDEX 745

- 746 *Appendix A: Normal laboratory test values*
- 748 *Appendix B: Normal and abnormal serum drug levels*
- 751 *Appendix C: Illustrated guide to home testing*
- 764 *Index*

KEY DIAGNOSTIC FINDINGS IN MAJOR DISORDERS

Abbreviations used in Part One

The following list shows abbreviations that are used throughout Part One.

ABG	arterial blood gas
ALT	alanine aminotransferase
APTT	activated partial thromboplastin time
AST	aspartate aminotransferase
BUN	blood urea nitrogen
CBC	complete blood count
CK	creatinine kinase
CSF	cerebrospinal fluid
CT	computed tomography
CXR	chest X-ray
DNA	deoxyribonucleic acid
ECG	electrocardiogram
EEG	electroencephalogram
ELISA	enzyme-linked immunosorbent assay
ESR	erythrocyte sedimentation rate
Hb	hemoglobin
hCG	human chorionic gonadotropin
HCT	hematocrit
Ig	immunoglobulin
KUB	kidney-ureter-bladder
LD	lactate dehydrogenase
MRI	magnetic resonance imaging
PaCO ₂	partial pressure of arterial carbon dioxide
PaO ₂	partial pressure of arterial oxygen
PET	positron emission tomography
PFT	pulmonary function test
PT	prothrombin time
PTT	partial thromboplastin time
RBC	red blood cell
WBC	white blood cell

Abdominal aortic aneurysm

- CT scan, MRI, or ultrasonography reveals the size, shape, and location of the aneurysm.
- Anteroposterior and lateral X-rays of the abdomen may detect aortic calcification, which outlines the mass.
- Aortography shows the condition of vessels proximal and distal to the aneurysm and the extent of the aneurysm but may underestimate aneurysm diameter, because it visualizes only the blood flow channel and not the surrounding clot.

Abnormal premenopausal bleeding

- Serum hormone levels reflect adrenal, pituitary, or thyroid dysfunction.
- Urine 17-ketosteroids reveal adrenal hyperplasia, hypopituitarism, or polycystic ovarian disease.
- Pelvic ultrasonography rules out uterine masses.
- Hysteroscopy allows visualization of the endometrium.
- Endometrial biopsy rules out malignancy and should be performed in all patients who experience abnormal premenopausal bleeding.
- Pelvic examination and Papanicolaou smear rule out local or malignant causes.

Abruptio placentae

- History includes mild to moderate vaginal bleeding (usually during second half of pregnancy).
- Amniocentesis reveals "port wine" fluid.
- Coagulation tests reveal a rise in fibrin split product levels.
- CBC reveals decreased Hb level and platelet counts.
- Pelvic ultrasonography reveals abnormal echo patterns.

Acceleration-deceleration cervical injuries

- Full cervical spine CT scans or X-rays indicate absence of cervical fracture.
- If the X-rays are negative for obvious cervical fracture, examination emphasizes motor ability and sensation below the cervical spine to detect signs of nerve root compression.

Acquired immunodeficiency syndrome

- ELISA identifies the HIV-1 antibody.
- Western blot test may also reveal the HIV-1 antibody and should be performed after a positive ELISA to confirm the diagnosis (antibody may not be detected in late stages due to inability to mount an antibody response).
- CD4⁺ T-lymphocyte assay reveals a lymphocyte count < 200 cells/ μ l in an HIV-infected individual.

Actinomycosis

- Culture of tissue or exudate identifies *Actinomyces israelii*.
- Gram staining of excised tissue or exudates reveals branching gram-positive rods.
- CXR reveals lesions in unusual locations such as the shaft of a rib.

Acute leukemia

- Bone marrow aspiration indicates a proliferation of immature WBCs.
- Bone marrow biopsy reveals cancerous cells.
- CBC indicates pancytopenia with circulating blasts.

Acute poststreptococcal glomerulonephritis

- History includes recent streptococcal infection.
- Serum electrolyte studies show elevated calcium, chloride, phosphate, potassium, and sodium levels.

- BUN and serum creatinine levels are elevated.
- Urinalysis reveals RBCs, WBCs, mixed cell casts, and protein.
- Antistreptolysin-O test reveals elevated streptozyme titers, indicating a recent streptococcal infection (in 80% of patients).
- Anti-Dnase B titers are elevated, indicating a recent streptococcal infection.
- Serum complement assay levels are low, indicating recent streptococcal infection.
- Throat culture may show group A beta-hemolytic streptococci.
- KUB X-rays show bilateral kidney enlargement.
- Renal biopsy reveals histologic changes indicating glomerulonephritis.

Acute pyelonephritis

- Urinalysis reveals sediment containing leukocytes singly, in clumps, and in casts and, possibly, a few RBCs as well as low specific gravity and osmolality and a slight alkaline urine pH.
- Urine culture reveals more than 100,000 organisms/ μ l of urine.
- KUB X-rays may reveal calculi, tumors, or cysts in the kidneys and the urinary tract.
- Excretory urography may show asymmetrical kidneys.

Acute renal failure

- History includes renal disease.
- BUN and serum creatinine levels are elevated.
- ABG analysis indicates a blood pH < 7.35 and an HCO_3^- level < 22 mEq/L.

Acute respiratory failure in chronic obstructive pulmonary disease

- ABG measurements show progressive deterioration when compared with normal values for patient; increased

HCO_3^- level may indicate metabolic alkalosis or metabolic compensation for chronic respiratory acidosis.

- CXR reveals pulmonary pathology such as emphysema, atelectasis, lesions, pneumothorax, infiltrates, or effusions.
- Hb and HCT levels are decreased.
- Serum electrolyte studies reveal hypokalemia.
- WBC count is elevated if bacterial infection is present.
- ECG indicates arrhythmias that suggest cor pulmonale and myocardial hypoxia.

Acute tubular necrosis

- Urinalysis reveals urinary sediment containing RBCs and casts, specific gravity of 1.010 or less, and osmolality $< 400 \text{ mOsm/kg}$.
- Urine sodium level is between 40 and 60 mEq/L.
- BUN and serum creatinine levels are elevated.
- Serum electrolyte studies reveal hyperkalemia.
- ABG analysis indicates blood pH < 7.25 and HCO_3^- level $< 22 \text{ mEq/L}$.

Adenoid hyperplasia

- Nasopharyngoscopy or rhinoscopy reveals abnormal tissue mass.
- Lateral pharyngeal X-rays show obliteration of the nasopharyngeal air column.

Adrenal hypofunction

- Plasma cortisol levels are decreased.
- Fasting blood glucose and serum sodium levels are decreased (in Addison's disease).
- Serum potassium and BUN levels are increased.
- CBC reveals increased HCT and elevated lymphocyte and eosinophil counts.
- X-rays reveal a small heart.
- Corticotropin level is increased.

- Rapid corticotropin test reveals low cortisol levels.

- Sweat test reveals elevated sodium level ($> 46 \text{ mmol/L}$ or mEq/L) and chloride level ($> 43 \text{ mmol/L}$).
- Urine 17-hydroxycorticosteroid levels and urine 17-ketosteroid (17-KS) levels are decreased.

Adrenogenital syndrome

- Physical examination reveals pseudohermaphroditism in females or precocious puberty in patients of either sex.
- Urine 17-KS levels are elevated and can be suppressed by administering dexamethasone by mouth.
- Levels of urine hormone metabolites (particularly pregnanetriol) and plasma 17-hydroxyprogesterone are elevated.
- Urine 17-hydroxycorticosteroid levels are normal or decreased.
- Symptoms of adrenal hypofunction or adrenal crisis in the first week of life strongly suggest congenital adrenal hyperplasia; elevated serum calcium, chloride, and sodium levels (in the presence of excessive levels of urine 17-KS and pregnanetriol) and decreased urine aldosterone levels confirm it.

Age-related macular degeneration

- Indirect ophthalmoscopy reveals gross macular changes.
- I.V. fluorescein angiography reveals leaking vessels.
- Amsler's grid reveals visual field loss.

Albinism

- Family history suggests inheritance pattern.
- Inspection shows pale skin (in whites) and white-to-yellow hair.
- Microscopic examination of the skin and of hair follicles reveals the amount of pigment present.

- Pigmentation testing of plucked hair roots by incubating them in tyrosine distinguishes tyrosinase-positive albinism from tyrosinase-negative albinism; tyrosinase-positive hair roots will develop color.

Alcoholism

- History includes chronic and excessive ingestion of alcohol.
- Liver function studies reveal increased levels of serum cholesterol, LD, ALT, AST, and CK in patients with liver damage.
- Serum amylase and lipase levels are elevated (in pancreatitis).

Allergic rhinitis

- Personal or family history includes allergies.
- Sputum and nasal smears reveal a large numbers of eosinophils.
- Skin test for specific allergen is positive, supported by tested response to environmental stimuli.

Alport's syndrome

- Family history includes recurrent hematuria, deafness, and renal failure (especially in men).
- Urinalysis indicates presence of RBCs.
- Renal biopsy reveals histologic changes characteristic of Alport's syndrome.
- Blood tests reveal Ig and complement components.
- Eye examination may reveal cataracts and, less commonly, keratoconus, microspherophakia, myopia, nystagmus, and retinitis pigmentosa.

Alzheimer's disease

- History includes progressive personality, mental status, and neurologic changes.
- PET scan reveals alteration in the metabolic activity of the cerebral cortex.

- Elevated Tau proteins with low levels of soluble amyloid beta-protein precursor in CSF correlate with Alzheimer's disease.

- EEG and CT scan may help diagnose later stages of illness.

- Autopsy reveals neurofibrillary tangles, neuritic plaques, and granulovascular degeneration.

Amebiasis

- Culture of stool, sputum, or aspirates from abscesses, ulcers, or tissue reveal *Entamoeba histolytica* (cysts and trophozoites).
- CT scan may reveal abscess.

Amputation, traumatic

- History and examination reveal trauma to an extremity.
- CBC reveals decreased Hb and HCT, indicating hemorrhage.

Amyloidosis

- Histologic examination of tissue specimen (rectal mucosa, gingiva, skin, or nerve biopsy) or abdominal fat pad aspiration using a polarizing or electron microscope and appropriate tissue staining reveals amyloid deposits.
- Liver function studies are generally normal, except for slightly elevated serum alkaline phosphatase levels.
- ECG shows low voltage and conduction or rhythm abnormalities resembling those characteristic of myocardial infarction (with cardiac amyloidosis).
- Echocardiography (M-mode and two-dimensional) may detect myocardial infiltration.

Amyotrophic lateral sclerosis

- Upper and lower motor neuron degeneration occurs without sensory impairment.
- Electromyography may show abnormalities of electrical activity of involved muscles.

- Muscle biopsy may disclose atrophic fibers interspersed among normal fiber.
- Nerve conduction studies are usually normal.
- CSF analysis reveals increased protein content in one-third of patients.
- CT scan and EEG may help rule out other disorders.

Anal fissure

- Digital examination elicits pain and bleeding.
- Gentle traction on perianal skin allows for visualization of fistula.
- Anoscopy reveals longitudinal tear and confirms the diagnosis.
- Patient may complain of local itching, tenderness, or pain aggravated by bowel movements.

Anaphylaxis

- Patient's history, physical examination, and signs and symptoms establish the diagnosis. They may include a rapid onset of severe respiratory or cardiovascular symptoms after ingestion or injection of a drug, vaccine, diagnostic agent, food, or food additive or after an insect sting.

Ankylosing spondylitis

- Family history includes the disorder.
- X-rays reveal blurring of the bony margins of joints (in early stage), bilateral sacroiliac involvement, patchy sclerosis with superficial bony erosions, squaring of vertebral bodies, and "bamboo spine" (with complete ankylosis).
- Serum HLA-B27 is present in about 95% of patients with primary disease and 80% of patients with secondary disease.
- CBC reveals slightly elevated ESR and alkaline phosphatase and creatine phosphatase levels in active disease.
- Serum IgA levels may be elevated.

Anorectal abscess and fistula

Examination of rectum helps to distinguish type of abscess:

- Perianal abscess produces a red, tender, localized, oval swelling close to the anus, which may drain pus. Sitting or coughing increases pain.
- Ischiorectal abscess involves the entire perianal region on the affected side of the anus. Digital examination reveals a tender induration bulging into the anal canal, which may not produce drainage.
- Patient may report constipation, ribbon-formed stools, and pain with bowel movements.
- Submucous or high intramuscular abscess may produce a dull, aching pain in the rectum, tenderness and, occasionally, induration. Digital examination reveals a smooth swelling of the upper part of the anal canal or lower rectum.
- Pelvirectal abscess produces fever, malaise, and myalgia but no local anal or external rectal signs or pain. Digital examination reveals a tender mass high in the pelvis, perhaps extending into one of the ischiorectal fossae.
- Sigmoidoscopy, barium enema, and colonoscopy may be performed to rule out other conditions.

Anorectal stricture, stenosis, or contracture

- Visual inspection reveals narrowing of the anal canal.
- Digital examination reveals tenderness and tightness.

Anorexia nervosa

- History includes weight loss of 25% or greater with no organic basis, compulsive dieting and bulimic episodes or gorging and purging, and laxative or diuretic abuse.
- Emaciated appearance is accompanied by maintenance of physical vigor.

- CBC reveals decreased Hb levels, platelet levels, WBC count, and ESR.
- Bleeding time is prolonged (due to thrombocytopenia).
- Serum creatinine, BUN, uric acid, cholesterol, total protein, albumin, sodium, potassium, chloride, and calcium levels are decreased.
- Fasting blood glucose level is decreased.
- ECG reveals nonspecific ST interval, T-wave changes, prolonged PR interval, and ventricular arrhythmias.
- Additional diagnostic testing may be performed to rule out other disorders that may cause wasting.

Anthrax

- History includes exposure to wool, hides, or other animal products.
- Inspection reveals a large, pruritic, painless skin lesion.
- Tissue culture with Gram stain reveals large gram-positive rods.
- Drainage cultures reveal *Bacillus anthracis*.
- Indirect hemagglutination reveals a fourfold rise in titer.

Aortic insufficiency

- Cardiac catheterization shows reduced arterial diastolic pressure, aortic insufficiency, and valvular abnormalities.
- Echocardiography reveals left ventricular enlargement and changes in left ventricular function; it may show a dilated aortic root, a flail leaflet, thickening of the cusps, or valve prolapse.
- Doppler echocardiography readily detects mild degrees of aortic insufficiency that may be inaudible. It also shows a rapid, high-frequency, diastolic fluttering of the anterior mitral leaflet that results from aortic insufficiency.
- ECG may show left ventricular hypertrophy, ST-segment depression, and T-wave inversion.

- Radionuclide angiography helps to determine the degree of regurgitant blood flow and assess left ventricular function.

Aortic stenosis

- Cardiac catheterization reveals the pressure gradient across the aortic valve (indicating the severity of obstruction), increased left ventricular end-diastolic pressures (indicating left ventricular dysfunction), and the number of cusps.
- CXR shows valvular calcification, left ventricular enlargement, dilation of the ascending aorta, pulmonary venous congestion and, in later stages, left atrial, pulmonary artery, right atrial, and right ventricular enlargement.
- Echocardiography demonstrates a thickened aortic valve and left ventricular wall and possible coexistent mitral valve stenosis.
- Doppler echocardiography allows calculation of the aortic pressure gradient.
- ECG reveals left ventricular hypertrophy and ST-segment and T-wave abnormalities. As hypertrophy progresses in severe aortic stenosis, left atrial enlargement is noted. Up to 10% of patients have atrioventricular and intraventricular conduction defects.

Aplastic or hypoplastic anemia

- CBC reveals normochromic and normocytic RBCs with a total count of 1 million or less as well as decreased platelet, neutrophil, and WBC counts.
- Serum iron is elevated. (Hemosiderin is present and tissue iron storage is visible microscopically.)
- Bleeding time is prolonged.
- Bone marrow biopsy yields a "dry tap" or shows severely hypocellular or aplastic marrow, with a varying amount of fat, fibrous tissue, or gelatinous replacement; absence of tagged