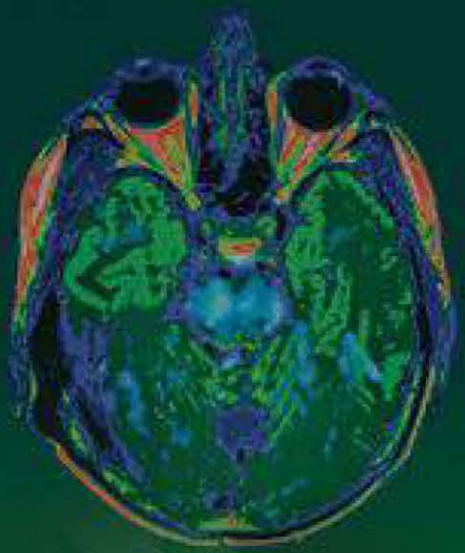
Radiology Review Manual

8th edition



Wolfgang Dähnert

Wolters Kluwer

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“If a little knowledge is dangerous, where is the man who has so much to be out of danger!”

T.H. Huxley, 1825–1895 from Elementary Instruction in Physiology published in 1877

“It is the tragedy of the world that no one knows what he doesn’t know — and the less a man knows, the more sure he is that he knows everything”

Joyce Cary, British author 1888–1957

“Nothing in the world can take the place of persistence.

Talent will not; nothing is more common than unsuccessful men with talent. Genius will not; unrewarded genius is almost a proverb.

Education will not; the world is full of educated derelicts.

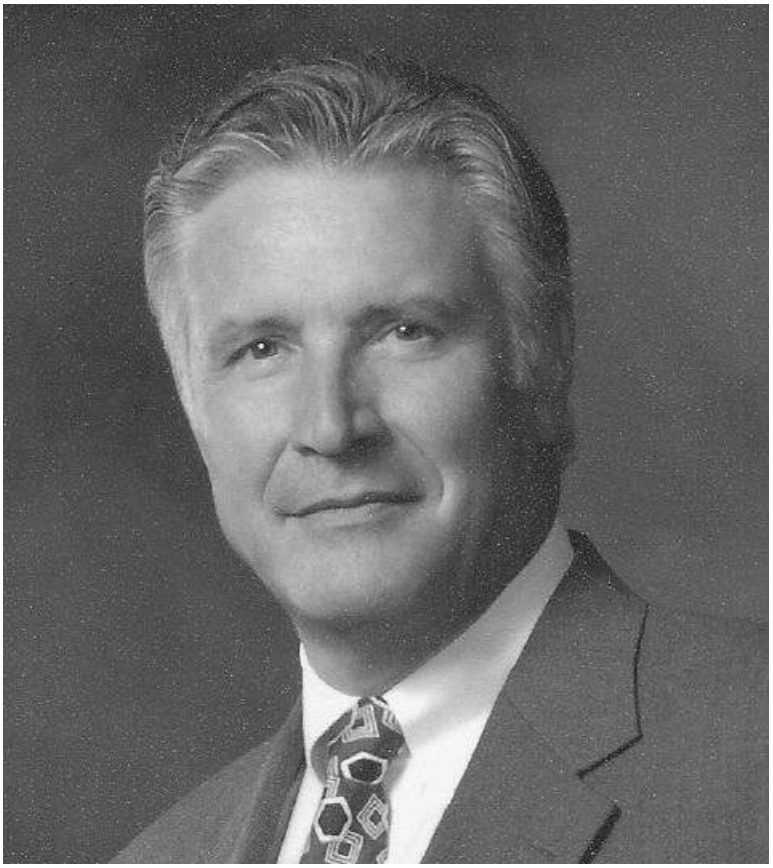
Persistence and determination alone are omnipotent."

Calvin Coolidge 1872–1933

Vice President 1921–1923

President 1923–1929

About the Author



Wolfgang Dähnert, M.D.

Wolfgang Dähnert was born in Hamburg, Germany. After graduating from the Wilhelm-Gymnasium High School in Braunschweig, Lower Saxony, in 1966 he enlisted into the German Air Force for four years. After his discharge from the armed services he studied medicine at the Heinrich-Heine Universität in Düsseldorf, North Rhine-Westphalia, for his preclinical years and at the Johannes-Gutenberg Universität in Mainz, Rhineland-Palatinate, for his clinical years. He graduated from medical school in 1975 and received his doctor of medicine degree shortly thereafter based on his dissertation "Pulse Flow Photocytometry of Prostate Punch Biopsies". A one-year rotating internship in urology, internal medicine and sports medicine at the Johannes-Gutenberg Universität and at the municipal Dr. Horst Schmidt Klinik in Wiesbaden was followed by a one-year residency in general surgery at the Deutsches Rotes Kreuz Krankenhaus in Mainz, Germany. In 1978 he switched to begin a residency in radiology at the municipal and teaching hospital in Darmstadt, Hesse, under the directorship of Prof. H.K. Deininger. He continued his education in diagnostic

and therapeutic radiology at the Johannes-Gutenberg Universität in Mainz under the directorship of Prof. Manfred Thelen and Prof. Rolf W. Günther receiving his German certification for radiology in 1982. Dr. Dähnert started a 2-year fellowship in ultrasound and computed tomography at the Johns Hopkins Hospital in Baltimore in 1984 under the leadership of Roger Sanders / Ulrike Hamper and Stanley Siegelman / Elliot Fishman and was appointed Clinical Instructor in 1986. In 1985 he sat for the federal licensing exam, and in 1987 took his oral exam in diagnostic radiology in Louisville, Kentucky. The American Board of Radiology had approved a 2-year fellowship program for him in lieu of a residency in radiology. The foundation of Radiology Review Manual was laid during the three years at Hopkins while preparing for the ABR exam. Between 1987 and 1989 he worked as Assistant Professor of Radiology in ultrasound at Thomas Jefferson Hospital in Philadelphia under Barry Goldberg. During this period in Philadelphia Radiology Review Manual was taken to fruition culminating in the publication of its first edition in 1991. Dr. Dähnert joined Clinical Diagnostic Radiology & Nuclear Medicine in Phoenix, AZ, in 1989 as director of ultrasound. This group practice of approximately 25 mostly fellowship-trained radiologists served three center city hospitals and their affiliated residency program in radiology, the latter at St. Joseph's Hospital and Medical Center, before it ceased operations in 2006 brought about by a fiscally unsustainable management style and culture. In September of 2004 Dr. Dähnert relocated to Green Bay, Wisconsin, joining a group of eight radiologists as part of a multispecialty group practice at Aurora BayCare Medical Center, the northern hub of Aurora Health Care, one of Wisconsin's largest private-sector employers.

PREFACE

Since the first publication of Radiology Review Manual in 1990 momentous changes have occurred in radiology. We have progressed from films developed in the dark-room to images on a computer screen. We have gone from an initially voluntary lifetime certificate of qualification to a never-ending process of proving to the public that our knowledge, skills, and clinical ability in the area of radiology has kept apace with the times. The first ABR Core Examination took place in October 2013. It tests knowledge and comprehension of anatomy, pathophysiology, physics and all aspects of diagnostic radiology including breast, cardiac, gastrointestinal, interventional, musculoskeletal, neuroradiology, nuclear, pediatric, reproductive/endocrinology, thoracic, urinary, vascular, computed tomography, magnetic resonance, radiography/fluoroscopy, ultrasound, physics, safety and radioisotope safety. The first Certifying Examination was in fall 2015.

Given the predominant practice pattern in the United States I estimate that General Radiology makes up at least 10% to 20% of the work a radiologist with subspecialty training is asked to perform. This is true for the vast majority of radiology practices, with the possible exception of those practices that employ more than 20 radiologists. Our clinical colleagues expect from us a depth of medical knowledge and familiarity with all imaging modalities suitable to address their clinical questions, regardless of our favored subspecialty. To remain relevant to them we need to stay current at their level.

Commensurate with an explosion of knowledge in medicine the number of pages for this volume have more than doubled, while radiologists have been squeezed between knowing more and reading faster. Radiology Review Manual has developed over the years from a simple preparatory text for the “oral boards” to something that has kept pace with my own growth in radiology. Since 1987 and between editions I have never stopped working on this book: new (eg, genetic) insights were added, variations in categorizations amended, words tweaked, numbers changed, and statements clarified. It is my humble attempt to put into a single reference much of the information that is or could be relevant to my practice and, hopefully, also yours. The decision for inclusions or omissions herein have always been governed by my own practical needs. We have conducted a survey among radiology residents to help us with the decision what topics to delete in an effort to diminish the number of pages. The results showed such a wide variation in opinions that I didn’t have the guts to wield the eraser at all. A single author book does not require collaboration, and thankfully I didn’t have to defend this decision.

The popularity of the “green giant” or the “green bible”, as it has been dubbed by residents, and the continued impressive number of sales and several translations into other languages confirms the usefulness of this type of publication. The outline style chosen for the sake of conserving space provides only an extract of information and may, at times, jeopardize the intended meaning of statements without any prior background knowledge of the subject. Accordingly, be careful, this book is not intended for the uninitiated.

How to use this book:

I have selected one of many possible ways to organize a book of this size and scope with the intent

to cover all modalities and provide room for growth and change over time. The material is presented anatomically from head to heel (when possible) to avoid duplications and save space. Systemic diseases have been forced into this topographical scheme rather than occupying a separate section. Departing from prior editions, NUC imaging findings are now relegated to the respective entity. A general section has been introduced that also includes some aspects about techniques in nuclear medicine in addition to contrast media, statistics, sedation, analgesia, and local anesthesia. As in the 6th edition I hope we can again use the inside of the cover pages to provide immediate access for accepted therapies of contrast reactions.

The organization within the individual chapters follows the practical approach of reading images. Often the initial step of image interpretation is to scrutinize for a radiologic pattern that may help suggest the disease process at hand. Therefore, differential diagnoses of radiologic patterns are presented in the first section of a chapter. Occasionally, important clinical signs and their differential diagnoses, relevant to the practice of radiology, are included in the first portion of a chapter as well. Lists of differential diagnoses can be presented in many fashions. There is no right or wrong way, but there certainly is a chaotic versus an organized approach. Accordingly, an attempt is made to categorize differential diagnostic considerations or etiologies of certain diseases in a manner digestible for recapitulation. It is a common experience that this is not always possible, logically satisfactory, or complete.

The majority of this book deals with disease entities presented in the last section of a chapter. The disease entities are presented in alphabetical order and headed by their most commonly used name with other designations listed below. Not infrequently and without explanations name switches occur from one publication to another. As a radiologic diagnosis should be entertained in context with its probability to be correct, percentages in regard to frequency of signs and symptoms are included liberally, often giving the lowest and the highest number found in the literature. The truth may be somewhere in between for nonselected patient populations, and occasionally a third number is provided between the high and low number as the most frequently cited. I had to arbitrate choices when different or contradictory results are found in the literature – unfortunately, an occurrence not at all infrequent.

This latest edition includes text on a gray background to guide the reader toward an emphatic statement made by a speaker or author on a particular topic.

These two sections in each chapter are separated by a few pages of functional, anatomic, or embryologic aspects. Mnemonics (which I personally abhor) have been liberally added. The index, which selectively refers to those pages with significant information, concludes the manual and is usually the starting point for many. The index also includes so-called “buzz words” that are miraculously attached to diseases.

Acknowledgement:

Various sources are responsible for the content: individuals (named in prior editions), ACR syllabi, handouts from various CME courses, major textbooks, hand-written notes taken during lectures, feed-back from board examinees and most importantly the journals dedicated to imaging with brilliant review articles, in particular the practice-oriented publication of Radiographics. Accordingly, the material in this book is a compilation and extraction of other’s work presented from my perspective of relevance and perhaps with omissions of my ignorance. Our radiologic ancestors, mentors, teachers and scientists alike, throughout the world deserve our admiration and gratitude for the collective knowledge passed on to us for the benefit of our profession and our

patients. I realize, in retrospect, that the omission of references may present a problem when certain statements appear unlikely and their verification has to be left to the user. For my defense, I can say that I have tried to extract all data as diligently as possible.

I sincerely hope that Radiology Review Manual will serve you in your preparation for the board exam, in teaching situations, and particularly in your daily work assignments — the way it continues to help me.

Green Bay, August 2016

CONTENTS

ABBREVIATIONS

√	radiologic sign
•	clinical sign, symptom
=	equals, is
≠	is not
@	at anatomic location of
/	or, per
+	and, plus, with
±	with or without
<	less than
>	more than, over
›	separation of points
»	method
◊	important comment
→	leads to, is followed by
←	due to, 2° to, caused by
↑	increased
⇑	much increased
↓	decreased
⇓	much decreased
↔	unchanged
~	about, approximately
÷	ratio
1°	primary
2°	secondary
2-D	two-dimensional
3-D	three-dimensional
5-HIAA	5-hydroxyindole acetic acid

aa.	**arteries**
AAA	abdominal aortic aneurysm
AAAs	abdominal aortic aneurysms
ABC	aneurysmal bone cyst
ABER	abduction + external rotation
ABO	blood group
ABR	American Board of Radiology

AC	abdominal circumference
ACA	anterior cerebral artery
ACE	angiotensin I–converting enzyme
ACEI	angiotensin-converting enzyme inhibitor
ACL	anterior cruciate ligament
aCom	anterior communicating artery
ACR	American College of Radiology
ACTH	adrenocorticotropic hormone
ADC	apparent diffusion coefficient
ADH	antidiuretic hormone; atypical ductal hyperplasia
ADPKD	adult polycystic kidney disease
AF-AFP	amniotic fluid alpha-fetoprotein
AFI	amniotic fluid index
AFP	alpha-fetoprotein
AICA	anterior inferior cerebellar artery
AIDS	acquired immune deficiency syndrome
AIP	acute interstitial pneumonia
AJCC	American Joint Committee on Cancer
ALARA	as low as reasonably achievable
AlkaPhos	alkaline phosphatase
ALL	acute lymphoblastic leukemia
ALPSA	**a**nterior **l**abroligamentous **p**eriosteal **s**leeve **a**vulsion
ALSA	aberrant left subclavian artery
ALT	alanine aminotransferase
AMA	antimitochondrial antibody
AML	acute myeloblastic leukemia; angiomyolipoma
aML	anterior mitral valve leaflet
AMLs	angiomyolipomas
ANA	antinuclear antibodies
ANCA	antineutrophil cytoplasmic autoantibodies
Angio	angiography
ANT	anterior
Ao	aorta
AP	anteroposterior; arterial phase; alkaline phosphatase
APA	aldosterone producing adenoma
aPL-ab	antiphospholipid antibody
approx.	approximately
APUD	amine precursor uptake and decarboxylation
APUDomas	endocrine cells tumors
APVR	anomalous pulmonary venous return

APW	absolute percentage washout
ARA-C	arabinoside C
ARDS	acute respiratory distress syndrome
ARF	acute renal failure
AS	aortic stenosis
ASA	acetylsalicylic acid
ASD	atrial septal defect
ASH	asymmetric septal hypertrophy
AST	aspartate aminotransferase
ATN	acute tubular necrosis
ATP	adenosine triphosphate
AV	arteriovenous; atrioventricular
AVF	arteriovenous fistula
AVM	arteriovenous malformation
AVMs	arteriovenous malformations
AVN	avascular necrosis
AVNA	atrioventricular node artery
Ba	barium
BAH	bilateral adrenal hyperplasia
BAL	bronchoalveolar lavage
BALT	bronchus-associated lymphoid tissue
BCG	bacille Calmette-Guérin
BCNU	bis-chloronitrosourea
BDI	basion-dens interval
BE	barium enema
BF	blood flow
b.i.d.	*bis in die*, Latin = twice per day
BIDA	butyl iminodiacetic acid
BI-RADS	Breast Imaging Reporting and Data System
BIH	benign intracranial hypertension
BKG	background
BKG_{counts}	background counts
BLC	biceps-labral complex
BLL	benign lymphoepithelial lesions
BMD	bone marrow density
BOOP	bronchiolitis obliterans organizing pneumonia
BP	blood pressure
BPD	biparietal diameter
BPH	benign prostatic hyperplasia

bpm	beats per minute
BPP	biophysical profile
Bq	Becquerel (1 Bq = one nucleus decays per sec)
BRCA	breast cancer suppressor gene
BSA	body surface area
BSO	bilateral salpingo-oophorectomy
Bx	biopsy
Ca	calcium
Ca2+	calcium ion
c-ANCA	cytoplasmic pattern of antineutrophil cytoplasmic autoantibodies
CA-125	cancer antigen 125
CABG	coronary artery bypass grafting
CAD	coronary artery disease
CADASIL	cerebral autosomal dominant arteriopathy with subcortical infarcts and leukoencephalopathy
CAM	cystic adenomatoid malformation
CBD	common bile duct
CBF	cerebral blood flow
cBPD	corrected biparietal diameter
CBV	cerebral blood volume
CC	craniocaudad
CCA	common carotid artery
CCK	cholecystokinin
CCMC	common carpometacarpal joint
CCNU	1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea
CD4	specialized lymphocyte responsible for cell-mediated immunity
CDC	Center for Disease Control
CDH	Congenital Diaphragmatic Hernia
CEA	carcinoembryonic antigen
CECT	contrast-enhanced computed tomography
CEMR	contrast-enhanced MR
CF	cystic fibrosis
CFI	color flow imaging
CFTR	cystic fibrosis transmembrane regulator gene
cGy	centigray = rad
CHAOS	Congenital high airway obstruction syndrome
CHD	common hepatic duct; congenital heart defect
CHF	congestive heart failure
CLL	chronic lymphatic leukemia

cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeters
CMC	carpometacarpal
CME	continuing medical education
CML	chronic myelogenous leukemia
CMV	Cytomegalovirus
CN	cranial nerve
CNS	central nervous system
CO	carbon monoxide
CoA	coarctation of aorta
COPD	chronic obstructive pulmonary disease
COW	circle of Willis
CP	cerebellopontine
CPA	cerebellopontine angle
CPAP	continuous positive airway pressure
CPD	cardiopulmonary disease
CPDN	cystic partially differentiated nephroblastoma
cpm	counts per min
CPPD	calcium pyrophosphate dihydrate
CPR	cardiopulmonary resuscitation
cps	counts per sec
cRCC	conventional renal cell cancer; cystic renal cell cancer
CRF	chronic renal failure
CRL	crown rump length
CRT	cathode ray tube
CSF	cerebrospinal fluid
CSI	chemical shift imaging
CST	contraction stress test
C/T	cardiothoracic ratio
CT	computed tomography
CTA	computed tomography angiogram
CVA	cerebrovascular accident
CVC	central venous catheter
CVJ	craniovertebral junction
CVS	chorionic villus sampling
CWP	coal worker's pneumoconiosis
Cx	complication
CXR	chest x-ray
CXRs	chest x-rays

d	day(s)
D5W	solution of 5% dextrose in water
DCBE	double-contrast barium enema
DCIS	ductal carcinoma in situ
DDH	developmental dysplasia of hip
DDx	differential diagnosis
DES	diethylstilbestrol
DEXA	dual energy X-ray absorptiometry
DFSP	dermatofibrosarcoma protuberans
DIC	disseminated intravascular coagulation
DIDA	diethyl iminodiacetic acid
DIP	desquamative interstitial pneumonia; distal interphalangeal
DISH	diffuse idiopathic skeletal hyperostosis
DISIDA	diisopropyl iminodiacetic acid
dist	distal
DIT	diiodotyrosine
DLCL	diffuse large cell lymphoma
D_LCO	diffusion capacity of lung for carbon monoxide
DMSA	dimercaptosuccinic acid
DORV	double outlet right ventricle
DPLD	diffuse parenchymal lung disease
DSA	digital subtraction angiography
DTPA	diethylenetriamine pentaacetic acid
DVT	deep vein thrombosis
DWI	diffusion weighted images
Dx	diagnosis
dz	disease
EAC	external auditory canal
EBV	Epstein-Barr virus
EC-cells	enterochromaffin cells
ECA	external carotid artery
ECD	endocardial cushion defect; ethyl cysteinate dimer
ECF	extracellular fluid
ECG	electrocardiogram
ECHO	echocardiogram; enteric cytopathic human orphan (virus)
ECMO	extracorporeal membrane oxygenation
EDD	enddiastolic diameter
EDTA	ethylenediaminetetraacetic acid

EDV	enddiastolic volume
EEG	electroencephalogram
EF	ejection fraction
EFW	estimated fetal weight
EG	eosinophilic granuloma
eg	exempli gratia
EGA	estimated gestational age
EHDP	ethylene hydroxydiphosphonate
EKG	electrocardiogram
ELISA	enzyme-linked immunosorbent assay
EMA	epithelial membrane antigen
ENT	ear, nose and throat
ErbB	epidermal growth factor receptor gene
ERC	endoscopic retrograde cholangiography
ERCP	endoscopic retrograde cholangiopancreatography
ERPF	effective renal plasma flow
ERV	expiratory reserve volume
ESD	endsystolic diameter
esp.	especially
ESR	erythrocyte sedimentation rate
EtOH	ethanol
ESV	end-systolic volume
F	female; fluorine
Fab	fragment antigen binding
FAI	femoroacetabular impingement
FAP	familial adenomatous polyposis
FDA	Federal Drug Administration
FDG	fluorodeoxyglucose
Fe^{2+}	ferrous ion
Fe^{3+}	ferric state
FEV	forced expiratory volume
FEV_1	FEV at 1 sec
FEV_3	FEV at 3 sec
FHM	fetal heart motion
FIGO	Fédération Internationale de Gynécologie et d'Obstétrique
FISH	fluorescence in situ hybridization
FK-506	code number for tacrolimus
FL	femur length
FLAIR	fluid-attenuated inversion recovery sequence

FLASH	fast low-angle shot
FN	false negative
FNAB	fine needle aspiration biopsy
FNH	follicular nodular hyperplasia
FOOSH	fall on outstretched hand
FP	false positive
Fr	French = unit of linear measure of circumference (1 F = 1/3 mm ≈ 1 mm in diameter)
FRC	functional residual capacity
FS	fractional shortening
FSE	fast spin echo
FSH	follicle stimulating hormone
FVC	forced vital capacity
FWHM	full-width at half-maximum
Fx	fracture
GA	gestational age
GB	gallbladder
GBM	glioblastoma multiforme
GCT	giant cell tumor; granulosa cell tumor
GCTs	giant cell tumors
Gd	gadolinium
GDA	gastroduodenal artery
GE	gastroesophageal
GER	gastroesophageal reflux
GERD	gastroesophageal reflux disease
GFR	glomerular filtration rate
GH	growth hormone
GHA	glucoheptonate
GI	gastrointestinal
GIST	gastrointestinal stromal tumor
GMP	guanosine monophosphate
GMRH	germinal matrix–related hemorrhage
GN	glomerulonephritis
GNRH	gonadotropin releasing hormone
GRASS	gradient recalled acquisition in steady state
GRE	gradient refocused echo
GS	gestational sac
GSV	great saphenous vein
GnRH	gonadotropin releasing hormone

GU	genitourinary
Gy	1 gray = absorption of 1 joule of ionizing radiation by 1 kilogram of matter = 1 J • kg^{-1} = 1 m2 • sec^{-2}
γGT	gamma-glutamyltransferase
HAART	highly active antiretroviral therapy
HAGL	humeral avulsion of the glenohumeral ligament
Hb	hemoglobin
HBME-1	mouse monoclonal antibody to mesothelioma
HBP	high blood pressure
HBV	hepatitis B virus
HC	head circumference
HCC	hepatocellular carcinoma
HCCs	hepatocellular carcinomas
hCG	human chorionic gonadotropin
HCl	hydrochloric acid
Hct	hematocrit
HD	Hodgkin disease
HELLP	hemolysis, elevated liver enzymes, low platelets
Hg	mercury
HHV_8	human herpes virus type 8
HIAA	hydroxyindole acetic acid
HIDA	hepatic 2,6-dimethyl iminodiacetic acid
HIE	hypoxic ischemic encephalopathy
Histo	histology
HIV	human immunodeficiency virus
HL	Hodgkin lymphoma
HLA	human leukocyte antigen
HMB-45	monoclonal antibody against human melanoma black
HMPAO	hexamethylpropyleneamine oxime = exametazime
HNP	herniated nucleus pulposus
HOCM	hypertrophic obstructive cardiomyopathy; high-osmolar contrast media
HPF	high power field (400 x magnification)
HPO	hypertrophic pulmonary osteoarthropathy
HPS	hypertrophic pyloric stenosis
HPT	hyperparathyroidism
HPV	human papilloma virus
hr	hour(s)
HRCT	high-resolution CT
HRT	hormone replacement therapy

HSA	human serum albumin
HSG	hysterosalpingography
HSV	herpes simplex virus
HTN	hypertension
HU	Hounsfield unit
HV	hepatic vein
HypoPT	hypoparathyroidism
Hx	history
IAA	interruption of aortic arch
IAC	internal auditory canal
ICA	internal carotid artery
ICBT	intercostal bronchial trunk a.
ICP	intracranial pressure
IDA	iminodiacetic acid
IDC	invasive ductal carcinoma
IDDM	insulin-dependent diabetes mellitus
IDM	infant of diabetic mother
ie	id est
IgA	Immunoglobulin A
IgE	Immunoglobulin E
IgG	Immunoglobulin G
IGL	inferior glenohumeral ligament
IGHLC	inferior glenohumeral labroligamentous complex
IGL	inferior glenohumeral ligament
IgM	immunoglobulin M
IHSS	idiopathic hypertrophic subaortic stenosis
IIP	idiopathic interstitial pneumonia
ILC	invasive lobular carcinoma
IM	intramuscular
IMA	inferior mesenteric artery
IMH	intramural hematoma
IMV	inferior mesenteric vein
In	indium
inf	inferior
intermed	intermediate
IPF	idiopathic pulmonary fibrosis
IPH	idiopathic pulmonary hemosiderosis; intraparenchymal hemorrhage
IPMT	intraductal papillary mucinous tumor
IQ	intelligence quotient

IR	inversion recovery
IRP	international reference preparation
IRU	inferior radioulnar joint
IRV	inspiratory reserve volume
IS	iliosacral; international standard
IU	international unit = amount of a substance, based on measured biological activity or effect
IUD	intrauterine device
IUGR	intrauterine growth retardation
IUP	intrauterine pregnancy
IV	intravenous
IVC	inferior vena cava
IVDA	intravenous drug abuse
IVH	intraventricular hemorrhage
IVP	intravenous pyelogram
IVS	intraventricular septum
IVU	intravenous urogram
JAA	juxtaposition of atrial appendages
KCC	Kulchitsky cell carcinoma
kDa	atomic weight in terms of kilodaltons
keV	1 kiloelectron volt = 1.60217646 × 10-16 joules
kV	kilovolt
kVp	kilovolt peak
KUB	kidney + ureter + bladder on one film
L	left
L-DOPA	3-(3,4-dihydroxyphenyl)-levo-alanin
LA	left atrium
LAD	left anterior descending
LAO	left anterior oblique
LAT	lateral
LATS	long-acting thyroid stimulating
lbs	pounds (*Libra pondo*, Latin)
LCA	left coronary artery
LCH	Langerhans cell histiocytosis
LCIS	lobular carcinoma in situ
LCL	lateral collateral ligament
LCx	left circumflex coronary artery

LDH	lactate dehydrogenase
LE	lupus erythematosus
LES	lower esophageal sphincter
LFTs	liver function tests
LGA	large for gestational age
LGE	late gadolinium-induced enhancement
LH	luteinizing hormone
LHBB	long head of biceps brachii
LHRH	luteinizing hormone releasing hormone
lig.	ligament
ligg.	ligaments
LIP	lymphocytic interstitial pneumonitis
LL	lower lobes
LLL	left lower lobe
LLQ	left lower quadrant
LM	left main coronary artery; lateromedial
LMP	last menstrual period
Lnn	lymph nodes
LOCM	low-osmolar contrast media
LPA	left pulmonary artery
LPD	lymphoproliferative disease
LPO	left posterior oblique
LPV	left portal vein
L/S	Lecithin-Sphingomyelin (ratio)
LSA	left subclavian artery
LSD	lysergic acid diethylamide
LUL	left upper lobe
LUQ	left upper quadrant
LV	left ventricle
LVEF	left ventricular ejection fraction
LVET	left ventricular ejection time
LVFT1	left ventricular fast filling time
LVOT	left ventricular outflow tract
LVPW	left ventricular posterior wall

M	male
m	meter
m.	muscle
MA	menstrual age
MAA	macroaggregated albumin

MAG	mercaptoacetyltriglycine
MAI	Mycobacterium avium intracellulare
MALT	mucosa-associated lymphoid tissue
Mammo	mammography
max.	maximum
MBC	maximum breathing capacity
MBq	mega Becquerel = 106 Bq
MCA	middle cerebral artery
MCDK	multicystic dysplastic kidney
mCi	millicurie (1 mCi = 3.7×10^7 disintegrations per sec)
MCP	metacarpophalangeal
MCL	medial collateral ligament
MDMA	3,4-methylenedioxymethamphetamine
MDP	methylene diphosphonate
MEA	multiple endocrine adenomas
MED	medial
MELAS	**M**itochondrial myopathy, **E**ncephalopathy, **L**actic acidosis, **A**nd **S**trokelike episodes
MEN	multiple endocrine neoplasms
mEq	milliequivalent
mets	metastases
MFH	malignant fibrous histiocytoma
MGL	middle glenohumeral ligament
mGy	absorbed energy of ionizing radiation (1 Gy = 1 J • kg^{-1} = 1 m^2 • sec^{-2})
MHA	microhemagglutination assay
MIBG	metaiodobenzylguanidine
MIBI	methoxyisobutylisonitril
min.	minimum
min	minute(s)
MIP	maximum intensity projection
MIT	monoiodotyrosine
mIU	1 • 10^{-6} IU
ML	middle lobe
MLCN	multilocular cystic nephroma
MLO	mediolateral oblique
mm.	muscles
MMAA	mini-microaggregated albumin colloid
MMFR	maximal midexpiratory flow rate
mo	month(s)
MoM	multiple of mean

MPA	main pulmonary artery
MPS	mucopolysaccharidosis
MPV	main portal vein
MR	magnetic resonance
MRA	magnetic resonance angiography
MRCP	magnetic resonance cholangiopancreatography
MRV	magnetic resonance venography
MS-AFP	maternal serum - fetoprotein
mSv	millisievert (1 Sv = 1 J/kg)
MT	metatarsal
MTP	metatarsophalangeal
MTT	mean transit time
MUGA	multiple gated acquisition
MV	mitral valve
MVA	motor vehicle accident
MVC	motor vehicle collision
Myelo	myelography
NASCET	North American symptomatic endarterectomy trial
N.B.	nota bene
NCCT	noncontrast CT
NECT	nonenhanced computed tomography
NF1	neurofibromatosis type 1
NG	nasogastric
NHL	non-Hodgkin lymphoma
NIDDM	non-insulin dependent diabetes mellitus
nn.	nerves
NMLE	non-masslike enhancement
NOS	not otherwise specified
npl	neoplasm
NPO	nulla per os
NPV	negative predictive value
NRC	Nuclear Regulatory Commission
NSAID	nonsteroidal antiinflammatory drug
NSAIDs	nonsteroidal antiinflammatory drugs
NSIP	nonspecific interstitial pneumonia
NST	nonstress test
NTD	neural tube defect
NTDs	neural tube defects
NUC	nuclear medicine

OB	**obstetrical**
OB-US	obstetrical ultrasound
OBL	oblique
OEIS	omphalocele, (bladder) exstrophy, imperforate anus, spinal defects
OFD	occipitofrontal diameter
OHSS	ovarian hyperstimulation syndrome
OI	osteogenesis imperfecta
OIH	orthoiodohippurate
OKC	odontogenic keratocyst
P	phosphorus
p-ANCA	perinuclear antineutrophil cytoplasmic autoantibodies
PA	posteroanterior; pulmonary artery
PACs	premature atrial contractions
PAH	para-aminohippurate; precapillary pulmonary arterial hypertension
PALM	premature with accelerated lung maturity
PAP	primary atypical pneumonia; pulmonary alveolar proteinosis
PAPVR	partial anomalous pulmonary venous return
PAS	periodic acid Schiff
PASH	pseudoangiomatous stromal hyperplasia
Path	pathology
PAVM	pulmonary arteriovenous malformation
PAWP	pulmonary artery wedge pressure
PBF	pulmonary blood flow
PCA	posterior cerebral artery
PCKD	polycystic kidney disease
PCL	posterior cruciate ligament
pCom	posterior communicating artery
PCP	Pneumocystis carinii pneumonia
PCWP	pulmonary capillary wedge pressure
PD	posterior descending artery
PDA	patent ductus arteriosus
PE	pulmonary embolism
PEEP	positive end expiratory pressure
PEP	preejection period
PET	positron emission tomography, pancreatic endocrine tumor
PFT	pulmonary function tests
pHPT	primary hyperparathyroidism
PHPV	persistent hyperplastic primary vitreous

PHypoPT	pseudohypoparathyroidism
PICA	posterior inferior cerebellar artery
PID	pelvic inflammatory disease
PIE	pulmonary infiltrate with eosinophilia; pulmonary interstitial emphysema
PIOPED	prospective investigation of pulmonary embolus detection
PIP	proximal interphalangeal
PIPIDA	paraisopropyl iminodiacetic acid
PLCH	pulmonary Langerhans cell histiocytosis
PLSA	posterolateral segment artery
pML	posterior mitral valve leaflet
PMMA	polymethylmethacrylate
PMN	polymorphonuclear
PMNs	polymorphonuclears
PMT	photomultiplier tube
PNET	primitive neuroectodermal tumor
PNST	peripheral nerve sheath tumor
PO	*per os*, Latin = by mouth
pO_2	oxygen pressure
POST	posterior
PPD	purified protein derivative
PPG	photoplethysmography
PPHypoPT	pseudopseudohypoparathyroidism
ppm	parts per million
PPROM	preterm premature rupture of membranes
PPV	positive predictive value; positive-pressure ventilation
pRCC	papillary renal cell cancer
preval	prevalence
p.r.n.	*pro re nata*, Latin = as the circumstance arises
PS	pulmonary stenosis
PSA	prostate-specific antigen
PSS	progressive systemic sclerosis
PSV	peak systolic velocity
PTA	percutaneous transluminal angioplasty
PTC	percutaneous transhepatic cholangiography
PTH	parathyroid hormone
pTL	posterior tricuspid valve leaflet
PTU	propylthiouracil
PV	portal vein; pulmonary valve
PVC	polyvinyl chloride
PVCs	premature ventricular contractions

PVH	pulmonary venous hypertension
PVL	periventricular leukomalacia
PVNS	pigmented villonodular synovitis
PVP	portal venous phase
PVR	pulse volume recording; postvoid residual
PYP	pyrophosphate
QPS	quantitative perfusion SPECT
R	right
RA	rheumatoid arthritis; right atrium
RAA	right aortic arch; right atrial appendage
rad	radiation absorbed dose, in 1975 replaced by gray (Gy)
RAIU	radioactive iodine uptake
RAO	right anterior oblique
Rb	Rubidium
RB-ILD	respiratory bronchiolitis-associated interstitial lung disease
RBC	red blood cell
RBCs	red blood cells
RCA	right coronary artery
RCC	renal cell carcinoma
RCCs	renal cell carcinomas
RDS	respiratory distress syndrome
rel.	relative
RES	reticuloendothelial system
RHV	right hepatic vein
RI	resistive index
RIBA	recombinant immunoblot assay
RIND	reversible ischemic neurologic deficit
RISA	radioiodine serum albumin
RLAT	right lateral
RLL	right lower lobe
RLQ	right lower quadrant
RML	right middle lobe
RMS	root mean square
ROC	receiver operating characteristic
ROI	region of interest
ROIs	regions of interest
RPF	renal plasma flow
RPO	right posterior oblique

RPV	right portal vein
RPW	relative percentage washout
RSV	respiratory syncytial virus
RTA	renal tubular acidosis
RUL	right upper lobe
RUQ	right upper quadrant
RV	residual volume; right ventricle
RVOT	right ventricular outflow tract
RVT	renal vein thrombosis
Rx	therapy
S1Q3T3	prominent S wave in lead I + Q wave and inverted T wave in lead III
S/P	status post
SAE	subcortical arteriosclerotic encephalopathy
SAG	sagittal
SAH	subarachnoid hemorrhage
SBE	subacute bacterial endocarditis
SBFT	small bowel follow-through
SBO	small bowel obstruction
SCC	squamous cell carcinoma
SCBE	single-contrast barium enema
SCLC	small cell lung cancer
SCMM	sternocleidomastoid muscle
S/D	systolic / diastolic (ratio)
SD	standard deviation
SDS	summed difference score
SE	spin echo
Sens	sensitivity
SGA	small for gestational age
SGL	superior glenohumeral ligament
sHPT	secondary hyperparathyroidism
SI	signal intensity
SIJ	sacroiliac joint
SIS	Second International Standard
SLAP	superior labral tear from anterior to posterior
SLE	systemic lupus erythematosus
SMA	superior mesenteric artery
SMV	superior mesenteric vein
Sn	stannum
SNHL	sensorineural hearing loss

SOB	shortness of breath
S/P	status post
Specif	specificity
SPECT	single photon emission
SPIO	superparamagnetic iron oxide
SQ	subcutaneous
SRS	summed rest score
SSS	summed stress score
STH	somatotrophic hormone
STIR	short tau inversion recovery
supp	suppositorium, suppository
Surg	surgery
SUV	standardized uptake values
SVC	superior vena cava
SVCs	superior venae cavae
T1WI	T1-weighted image
T2WI	T2-weighted image
TAH	total abdominal hysterectomy
TAPVR	total anomalous pulmonary venous return
TB	tuberculosis
TBG	thyroxin-binding globulin
Tc	Technetium
TCC	transitional cell carcinoma
TDLU	terminal ductal lobular unit
TDLUs	terminal ductal lobular units
TE	echo time
TEF	tracheoesophageal fistula
TGA	transposition of great arteries
TGV	transposition of great vessels
tHPT	tertiary hyperparathyroidism
TIA	transitory ischemic attack
TIAs	transitory ischemic attacks
TLC	total lung capacity
Tm	transport maximum across tubular cells
T_{max}	time to maximum peak
TMB-IDA	2,4,6-trimethylbromo-acetanilide iminodiacetic acid
TN	true negative
TNF	tumor necrosis factor
TNM	tumor nodes metastasis

TOA	tuboovarian abscess
TOF	tetralogy of Fallot; time of flight
TORCH	toxoplasmosis, rubella, cytomegalovirus, herpes virus
TP	true positive
TPN	total parenteral nutrition
TPROM	term premature rupture of membranes
TR	repetition time
TRH	thyrotropin-releasing hormone
TRV	transverse
TSC	tuberous sclerosis
TSH	thyroid-stimulating hormone
TURP	transurethral resection of prostate
TV	tidal volume
UA	umbilical artery
UCL	ulnar collateral ligament
uE3	unconjugated estriol
UGI	upper gastrointestinal series
UICC	Union Internationale Contre le Cancer
UIP	usual interstitial pneumonia
UL	upper lobe
UPJ	ureteropelvic junction
URI	upper respiratory infection
US	ultrasound
USA	United States of America
USP	United States Pharmacopoeia
USP XX	United States Pharmacopoeia, 20th edition
UTI	urinary tract infection
UTIs	urinary tract infections
UVJ	ureterovesical junction
Uvol	urine volume
VACTERL	vertebral, **a**norectal, **c**ardiovascular, **t**racheo-**e**sophageal fistula, **r**enal, **l**imb anomalies
VC	vital capacity
VCUG	voiding cystourethrogram
VDRL	venereal disease research laboratory
vHL	Von Hippel-Lindau disease
VIP	vasoactive intestinal peptides
VMA	vanillylmandelic acid

VP	ventriculoperitoneal
V/Q	ventilation perfusion
VR	Virchow-Robin space
vs.	versus
VSD	ventricular septal defect
VSDs	ventricular septal defects
VUR	vesicoureteral reflux
vv.	venae, veins
WAGR	Wilms tumor, aniridia, genital abnormalities, mental retardation
WBC	white blood cell
WBCs	white blood cells
WDHA	watery diarrhea, hypokalemia, achlorhydria
WDHH	watery diarrhea, hypokalemia, hypochlorhydria
WM	white matter
wk	week(s)
w/o	without
WPW	Wolff-Parkinson-White
wt/vol	weight/volume percent = amount of solute in g per amount of solution in mL
XGP	xanthogranulomatous pyelonephritis
YS	yolk sac
yr	year(s)

TREATMENT OF ADVERSE CONTRAST REACTIONS[1]

PRINCIPLES OF TREATMENT

1. Give high doses of oxygen
2. Infuse physiologic fluids
3. Establish adequate airway
4. Monitor heart rate & blood pressure

◊ No therapeutic role in acute adverse reaction: antihistamines, H_2 antagonists, corticosteroids

VASOVAGAL REACTION

- **hypotension** (systolic blood pressure < 80 mmHg) **with** sinus **bradycardia** (pulse < 60 bpm)
- dizziness, diaphoresis
- loss of consciousness

⇒ Monitor vital signs

⇒ Leg elevation > 60° + Trendelenburg position

⇒ Secure airway + **O_2** 6–10 L/min

⇒ Secure IV access + rapid IV infusion of isotonic Ringer's lactate / normal saline

if symptoms persist, add:

⇒ **atropine** slowly IV 0.6–1.0 mg

⇒ Repeat atropine every 3–5 min slowly IV up to a total dose of 0.04 mg/kg (3 mg) in adults [pediatric: 0.02 mg/kg IV; starting dose: min. 0.1 mg, max. 0.6 mg; may repeat to total dose of 2 mg]

DERMAL CONTRAST REACTION

- hives = urticaria
- itching = pruritus
- flushing
- facial angioedema (= nonpruritic SQ edema of eyelid / peroral)

Mild Urticaria

⇒ Discontinue injection if not completed

⇒ No treatment needed in most cases

⇒ H_1-antihistamine, ie

diphenhydramine (Benadryl®) PO/IM/IV 25–50 mg

or

hydroxyzine (Vistaril®) PO/IM/IV 25–50 mg

Severe Urticaria

add H_2-antihistamine:

⇒ **cimetidine** (Tagamet®) 300 mg PO / slowly IV (diluted in 20 mL D5W solution)

[pediatric: 5–10 mg/kg diluted in 20 mL D5W solution]
or
ranitidine (Zantac®) 50 mg PO / slowly IV (diluted in 20 mL D5W solution)

if widely disseminated:
⇒ IV line started + kept open (with normal saline / Ringer's lactate)
⇒ **epinephrine IV** (1÷10,000) IV slowly over 2–5 min 1.0 mL (= 0.1 mg) if no cardiac contraindication

NAUSEA / VOMITING

may be the 1st signs of a more severe reaction
⇒ watch patient closely

RESPIRATORY DISTRESS

- wheezing (inconsequential)
- bronchoconstriction (life-threatening)
- laryngeal edema (life-threatening)

Facial / Laryngeal Edema

⇒ **epinephrine SQ** (1÷1,000) 0.1–0.2 mL (= 0.1–0.2 mg)
or – if patient hypotensive –
epinephrine (1÷10,000) slowly IV 1.0 mL (= 0.1 mg)
Repeat after 15 min up to a maximum of 1.0 mg
⇒ **O_2** 6–10 L/min (via mask)
monitor: ECG; O_2 saturation (pulse oximeter); BP

If not responsive to therapy:
⇒ Seek assistance (CODE team)
⇒ Consider intubation

Bronchospasm (isolated)

⇒ **O_2** 6–10 L/min (by mask, not nasal prongs)
monitor: ECG; O_2 saturation (pulse oximeter); BP
⇒ β_2-agonist metered dose inhaler in 2–3 deep inhalations: **metaproterenol** (Alupent®) / **terbutaline** (Brethaire®) / **albuterol** (Proventil®)
NOT: diphenhydramine as it thickens secretions

If unrelieved
with normal blood pressure + stable bronchospasm
⇒ **epinephrine SQ** (1÷1,000) 0.1–0.2 mL (= 0.1–0.2 mg); may give 0.3 mg
[pediatric: 0.01 mg/kg up to 0.3 mg max.]
with decreased blood pressure + progressive bronchospasm
⇒ **epinephrine IV** (1÷10,000) slowly over 2–5 min IV 1.0 mL (= 0.1 mg)
[pediatric: 0.01 mg/kg IV]
Repeat after 15 min up to a maximum of 1.0 mg

Alternatively

⇒ **aminophylline** 6 mg/kg IV in D5W over 15–20 min (loading dose); then 0.4–1.0 mg/kg/hr

Cx: hypotension, cardiac arrhythmia

or

terbutaline 0.25–0.50 mg IM/SQ

⇒ 200–400 mg hydrocortisone IV

if unsuccessful, may require intubation

if anxiety exacerbates bronchospasm, sedation with 5–10 mg Demerol IV

⇒ Call for assistance (CODE team) for severe bronchospasm / if O_2 saturation persists < 88%

TREATMENT OF ADVERSE CONTRAST REACTIONS[2]

ANAPHYLACTOID REACTION

= acute rapidly progressing generalized systemic reaction characterized by multisystem involvement

- tachycardia (pulse > 100 bpm)
- hypotension (systolic blood pressure < 80 mmHg)
- dizziness, diaphoresis
- loss of consciousness

Hypotension with Tachycardia

⇒ leg elevation > 60° + Trendelenburg position
⇒ monitor: ECG; pulse oximeter; BP
⇒ **O_2** 6–10 L/min (via mask, not nasal prongs)
⇒ rapid IV infusion of isotonic Ringer's lactate / normal saline
⇒ suction as needed

if poorly responsive to fluid therapy add vasopressors
⇒ call CODE
⇒ **epinephrine IV** (1÷10,000) slowly over 2–5 min IV 1.0 mL (= 0.1 mg);
[pediatric: 0.02 mg/kg IV; starting dose of min. 0.1 mg to max. 0.6 mg; may repeat to 2 mg total dose]
repeat after 15 min up to a maximum of 1.0 mg (titrated to effect)
⇒ dopamine

if still poorly responsive:
⇒ transfer to ICU

in adults without IV access:
⇒ **epinephrine SQ** (1÷1,000) 0.3 mL (= 0.3 mg)

in infants / children:
⇒ epinephrine SQ (1÷1,000) with body weight determining the correct dose

Seizure / Convulsion

⇒ protect patient from injury
⇒ monitor airway from obstruction by tongue
⇒ suction as needed
⇒ **O_2** 6–10 L/minute (by mask)

if uncontrolled:
⇒ **diazepam** (Valium®) 5.0 mg / **midazolam** (Versed®) 2.5 mg IV
⇒ monitor: ECG, O_2 saturation (pulse oximeter), BP

if longer effect needed:
⇒ obtain consultation

⇒ **phenytoin** (Dilantin®) infusion 15–18 mg/kg at 50 mg/minute
⇒ consider CODE for intubation

Pulmonary Edema

⇒ Elevate torso
⇒ Apply rotating tourniquets for venous compression
⇒ **O_2** 6–10 L/minute (via mask)
⇒ **furosemide** (Lasix®) 40 mg IV, slow push
⇒ Consider morphine
⇒ Transfer to ICU
⇒ Corticosteroids optional

SEVERE HYPERTENSION

⇒ monitor: ECG, pulse oximeter, BP
⇒ IV fluids very slowly to maintain venous access
⇒ **nitroglycerin** 0.4 mg tablet sublingual; may repeat x 3; topical 1–2" strip of 2% ointment
⇒ **sodium nitroprusside** arterial line (infusion pump necessary to titrate)
⇒ transfer to ICU

for pheochromocytoma:

⇒ **phentolamine** (Regitin®)
Adult dose: 5.0 mg IV; Pediatric dose: 1.0 mg IV

ANGINA

⇒ **O_2** 6–10 L/min (via mask, not nasal prongs)
⇒ IV fluids, very slowly
⇒ **nitroglycerin** 0.4 mg, sublingually; may repeat q 15 minutes
⇒ **morphine** 2 mg IV

AIR EMBOLISM

- air hunger, dyspnea, expiratory wheezing, cough
- chest pain, pulmonary edema, tachycardia, hypotension
- stroke ← decreased cardiac output / paradoxical air embolism / pulmonary AVM / R-to-L intracardiac shunt

Rx: ⇒ 100% **O_2** administration
⇒ left lateral decubitus position

CONTRAST EXTRAVASATION

= escape of contrast material from vascular lumen + infiltration of interstitial tissue during injection

Incidence: 0.1–0.4%; no direct correlation with injection flow rate (although frequent with power injectors)

Risk: fragile veins, IV catheter indwelling for many days, multiple puncture attempts during IV placement

Effect: (a) acute inflammatory response (peaking in 24–48 hrs) related to hyperosmolality of

contrast material

(b) compartment syndrome

(c) ulceration + tissue necrosis (as early as 6 hours)

(d) fibrosis

(e) muscle atrophy

- may be asymptomatic; edema, erythema
- swelling, tightness, tenderness, stinging, burning pain

Evaluate for:

(1) Skin injury (blanching, discoloration)
(2) Nerve compromise
(3) Vascular compromise

Dx: (1) Palpate catheter venipuncture site during initial seconds of injection
(2) Ask patient to report any sensation of pain / swelling at injection site

Severe Cx (uncommon): compartment syndrome, skin ulceration, tissue necrosis

Rx: (1) Elevation of affected extremity above heart → decrease capillary hydrostatic pressure
(2) Cold compress → decreases cellular uptake
(3) Warm compress → vasodilatation promotes absorption
(4) Discharge with instructions to watch for symptoms that indicate a need for surgical evaluation
(5) Surgical consultation if
› extravasation > 50 mL
› ↑ in swelling / pain after 2–4 hours
› ↓ in capillary refill time
› change in sensation (paresthesia) in affected limb
› skin ulceration / blistering
(5) Documentation in medical record
(6) Notification of referring physician
(7) 24-hour follow up (phone call, examination)

MUSCULOSKELETAL SYSTEM

DIFFERENTIAL DIAGNOSIS OF MUSCULOSKELETAL DISORDERS

UNIVERSAL DIFFERENTIAL DIAGNOSIS

mnemonic: VINDICATE

Vascular and cardiac
Infectious, **I**nflammatory
Neoplasm
Drugs
Iatrogenic, **I**diopathic, **I**ntoxication
Congenital
Autoimmune, **A**llergic
Trauma
Endocrine and metabolic

DIAGNOSTIC GAMUT OF BONE DISORDERS

Conditions to be considered = "dissect bone disease with a DIATTOM"

Dysplasia + **D**ystrophy
Infection
Anomalies of development
Tumor + tumorlike conditions
Trauma
Osteochondritis + ischemic necrosis
Metabolic disease

Dysplasia = disturbance of bone growth
Dystrophy = disturbance of nutrition

LIMPING CHILD

Limping Child at 1–4 Years

A. CONGENITAL
   1. Developmental dysplasia of hip
B. TRAUMATIC
   1. Toddler's fracture
   2. Nonaccidental trauma
   3. Other fractures
   4. Foreign body
C. INFLAMMATORY
   1. Diskitis

2. Septic arthritis
3. Osteomyelitis
4. Transient synovitis of hip

Limping Child at 4–10 Years

A. TRAUMATIC
B. INFLAMMATORY
   1. Septic arthritis
   2. Osteomyelitis
   3. Transient synovitis of hip
   4. Diskitis
   5. Juvenile rheumatoid arthritis
C. VASCULAR
   1. Legg-Perthes disease

Limping Child at 10–15 Years

A. TRAUMATIC
   1. Stress fracture
   2. Osteochondritis dissecans
   3. Osgood-Schlatter disease
B. INFLAMMATORY
   1. Juvenile rheumatoid arthritis
   2. Ankylosing spondylitis
   3. Septic arthritis
   4. Osteomyelitis
C. HORMONAL
   1. Epiphyseolysis of femoral head

DELAYED BONE AGE

A. CONSTITUTIONAL
   1. Familial
   2. IUGR
B. METABOLIC
   1. Hypopituitarism
   2. Hypothyroidism
   3. Hypogonadism (Turner syndrome)
   4. Cushing disease, steroid therapy
   5. Diabetes mellitus
   6. Rickets
   7. Malnutrition
   8. Irradiation of brain (for cerebral tumor / ALL)
C. SYSTEMIC DISEASE
   1. Congenital heart disease
   2. Renal disease
   3. GI disease: celiac disease, Crohn disease, ulcerative colitis

4. Anemia
5. Bone marrow transplantation (< 5 years of age)

D. SYNDROMES
1. Trisomies
2. Noonan disease
3. Cornelia-de-Lange syndrome
4. Cleidocranial dysplasia
5. Lesch-Nyhan disease
6. Metatropic dwarfism

UPTAKE PATTERN IN BONE LESIONS

Superscan

Cause:

A. METABOLIC
1. Renal osteodystrophy
2. Osteomalacia
√ randomly distributed focal sites of intense activity
= Looser zones = pseudofractures
= Milkman fractures (most characteristic)
3. Hyperparathyroidism
√ focal intense uptake ← site of brown tumors
4. Hyperthyroidism
→ rate of bone resorption > rate of bone formation (= decrease in bone mass)
• hypercalcemia (occasionally)
• elevated alkaline phosphatase
√ radiographically NOT visible
√ susceptible to fracture

B. Widespread bone lesions
1. Diffuse skeletal metastases: prostate, breast, multiple myeloma, lymphoma, lung, bladder, colon, stomach (most frequent)
2. Myelofibrosis / myelosclerosis
3. Aplastic anemia, leukemia
4. Waldenström macroglobulinemia
5. Systemic mastocytosis
6. Widespread Paget disease

√ diffusely increased activity in bones: particularly prominent in axial skeleton, calvarium, mandible, costochondral junctions (= "rosary beading"), sternum (= "tie sternum"), long bones
√ increased metaphyseal + periarticular activity
√ increased bone-to-soft-tissue ratio
√ "absent kidney" sign = little / no activity in kidneys but good visualization of urinary bladder
√ femoral cortices become visible

CAVE: scan may be interpreted as normal, particularly in patients with poor renal function!

Hot Bone Lesions

mnemonic: NATI MAN

Neoplasm
Arthropathy
Trauma
Infection
Metastasis
Aseptic **N**ecrosis

Long Segmental Diaphyseal Uptake

A. BILATERALLY SYMMETRIC
   1. Hypertrophic pulmonary osteoarthropathy
   2. Thigh / shin splints = mechanical enthesopathy
   3. Ribbing disease
   4. Engelmann disease = progressive diaphyseal dysplasia

B. UNILATERAL
   1. Inadvertent arterial injection
   2. Melorheostosis
   3. Chronic venous stasis
   4. Osteogenesis imperfecta
   5. Vitamin A toxicity
   6. Osteomyelitis
   7. Paget disease
   8. Fibrous dysplasia

Doughnut Sign of Bone Lesion

= radiotracer accumulation at periphery of bone lesion with little activity at its center

1. Aneurysmal bone cyst
2. Giant cell tumor
3. Chondrosarcoma
4. Telangiectatic osteosarcoma

Photon-deficient Bone Lesion

= decreased radiotracer uptake

A. Interruption of blood flow in local bone
   = vessel trauma or vascular obstruction by thrombus / tumor
   1. Early osteomyelitis
   2. Radiation therapy
   3. Posttraumatic aseptic necrosis
   4. Sickle cell crisis

B. Replacement of bone by destructive process
   1. Metastases (most common cause): central axis skeleton > extremity, most commonly in carcinoma of kidney + lung + breast + multiple myeloma

2. Primary bone tumor (exceptional)

mnemonic: HM RANT

Histiocytosis X
Multiple myeloma
Renal cell carcinoma
Anaplastic tumors (reticulum cell sarcoma)
Neuroblastoma
Thyroid carcinoma

Radionuclide Uptake in Benign Bone Lesions

A. NO TRACER UPTAKE
   1. Bone island
   2. Osteopoikilosis
   3. Osteopathia striata
   4. Fibrous cortical defect
   5. Nonossifying fibroma

B. INCREASED TRACER UPTAKE
   1. Fibrous dysplasia
   2. Paget disease
   3. Eosinophilic granuloma
   4. Melorheostosis
   5. Osteoid osteoma
   6. Enchondroma
   7. Exostosis

BONE SCLEROSIS

Diffuse Osteosclerosis

mnemonic: 5 M'S To PROoF

Metastases
Myelofibrosis
Mastocytosis
Melorheostosis
Metabolic: hypervitaminosis D, fluorosis, hypothyroidism, phosphorus poisoning
Sickle cell disease
Tuberous sclerosis
Pyknodysostosis, Paget disease
Renal osteodystrophy
Osteopetrosis
Fluorosis

Acquired Syndromes with Increased Bone Density

1. Renal osteodystrophy
2. Osteoblastic metastases
3. Paget disease of bone

4. Erdheim-Chester disease
5. Myelofibrosis
6. Sickle cell disease

Constitutional Sclerosing Bone Disease

1. Progressive diaphyseal dysplasia
2. Infantile cortical hyperostosis
3. Melorheostosis
4. Osteopathia striata
5. Osteopetrosis
6. Osteopoikilosis
7. Pachydermoperiostosis
8. Pyknodysostosis
9. Van Buchem disease
10. Williams syndrome

Sclerosing Bone Dysplasia

Endochondral bone formation:

primary spongiosa forms at 7th week of embryogenesis → resorption around 9th week with conversion into secondary spongiosa → osteoclastic remodeling into trabeculae + medullary cavity

Target sites for endochondral bone formation:

tubular + flat bones, vertebrae, skull base, ethmoids, ends of clavicle

Intramembranous ossification:

= transformation of mesenchymal cells into cortical bone without intervening cartilaginous matrix beginning at 9th week of fetal life to beyond closure of growth plates

Target sites for intramembranous bone formation:

cortex of tubular + flat bones, calvaria, upper facial bones, tympanic temporal bone, vomer, medial pterygoid process

A. DYSPLASIA OF ENDOCHONDRAL OSSIFICATION (PRIMARY SPONGIOSA)
   = failure in resorption + remodeling of primary immature spongiosa by osteoclasts
   √ accumulation of calcified cartilage matrix packing the medullary cavity
   1. Osteopetrosis
   2. Pyknodysostosis

B. DYSPLASIA OF ENDOCHONDRAL OSSIFICATION (SECONDARY SPONGIOSA)
   = errors in resorption + remodeling of secondary spongiosa
   √ focal densities / striations along trabecular bone
   1. Osteopoikilosis
   2. Osteopathia striata

C. DYSPLASIA OF INTRAMEMBRANOUS OSSIFICATION
   = disequilibrium between periosteal bone formation + endosteal bone resorption
   1. Progressive diaphyseal dysplasia
   2. Hereditary multiple diaphyseal sclerosis
   3. Hyperostosis corticalis generalisata
   4. Diaphyseal dysplasia with anemia

5. Oculodento-osseous dysplasia
6. Trichodento-osseous dysplasia
7. Kenny-Caffey syndrome

D. MIXED SCLEROSING DYSPLASIAS = OVERLAP SYNDROME

(a) predominantly endochondral disturbance

1. Dysosteosclerosis
2. Metaphyseal dysplasia (Pyle disease)
3. Craniometaphyseal dysplasia
4. Frontometaphyseal dysplasia

(b) predominantly intramembranous defects

1. Melorheostosis
2. Craniodiaphyseal dysplasia
3. Lenz-Majewski hyperostotic dwarfism
4. Progressive diaphyseal dysplasia

Nonhereditary Sclerosing Dysplasia

1. Intramedullary osteosclerosis
2. Melorheostosis
3. Overlap syndromes
   = disorder of endochondral + intramembranous ossification
   Combination: melorheostosis + osteopoikilosis + osteopathia striata

Solitary Osteosclerotic Lesion

A. DEVELOPMENTAL

1. Bone island

B. VASCULAR

1. Old bone infarct
2. Aseptic / ischemic / avascular necrosis

C. HEALING BONE LESION

(a) trauma: callus formation in stress fracture
(b) benign tumor: fibrous cortical defect / nonossifying fibroma; brown tumor; bone cyst
(c) malignant tumor: lytic metastasis after radiation, chemotherapy, hormone therapy

D. INFECTION / INFLAMMATION
(low-grade chronic infection / healing infection)

1. Osteoid osteoma
2. Chronic / healed osteomyelitis: bacterial, tuberculous, fungal
3. Sclerosing osteomyelitis of Garré
4. Granuloma
5. Brodie abscess

E. BENIGN TUMOR

1. Osteoma
2. Osteoblastoma
3. Ossifying fibroma
4. Healed fibrous cortical defect
5. Enchondroma / osteochondroma

F. MALIGNANT TUMOR
   1. Osteoblastic metastasis: prostate, breast
   2. Lymphoma
   3. Sarcoma: osteo-, chondro-, Ewing sarcoma

G. OTHERS
   1. Sclerotic phase of Paget disease
   2. Fibrous dysplasia

Cortical Sclerotic Lesion in Child

1. Osteoid osteoma
2. Stress fracture
3. Chronic osteomyelitis
4. Healed fibrous cortical defect

Multiple Osteosclerotic Lesions

A. FAMILIAL
   1. Osteopoikilosis
   2. Enchondromatosis = Ollier disease
   3. Melorheostosis
   4. Multiple osteomas: associated with Gardner syndrome
   5. Osteopetrosis
   6. Pyknodysostosis
   7. Osteopathia striata
   8. Chondrodystrophia calcificans congenita
   9. Multiple epiphyseal dysplasia = Fairbank disease

B. SYSTEMIC DISEASE
   1. Mastocytosis = urticaria pigmentosa
   2. Tuberous sclerosis

Bone-within-bone Appearance

= endosteal new bone formation

1. Normal
   (a) thoracic + lumbar vertebrae (in infants)
   (b) growth recovery lines (after infancy)
2. Infantile cortical hyperostosis (Caffey)
3. Sickle cell disease / thalassemia
4. Congenital syphilis
5. Osteopetrosis / oxalosis
6. Radiation
7. Acromegaly
8. Paget disease
9. Gaucher disease

mnemonic: BLT PLT RSD RSD

Bismuth ingestion

Lead ingestion

Thorium ingestion
Petrosis (osteopetrosis)
Leukemia
Tuberculosis
Rickets
Scurvy
D toxicity (vitamin D)
RSD (reflex sympathetic dystrophy)

Dense Metaphyseal Bands

mnemonic: DENSE LINES
D-vitamin intoxication
Elemental arsenic + heavy metals: lead, bismuth, phosphorus
Normal variant
Systemic illness
Estrogen to mother during pregnancy
Leukemia
Infection (TORCH), **I**diopathic hypercalcemia
Never forget healed rickets
Early hypothyroidism (cretinism)
Scurvy, congenital **S**yphilis, **S**ickle cell disease
also: methotrexate therapy

OSTEOPENIA

= decrease in bone quantity maintaining normal quality
√ increased radiolucency of bone:
√ vertical striations in vertebral bodies
√ accentuation of tensile + compressive trabeculae of proximal femur
√ reinforcement lines (= bone bars) crossing marrow cavity about knee
√ cortical resorption of 2nd metacarpal:
√ measuring outer cortical diameter (W) and width of medullary cavity (m) at mid portion of bone and reporting combined cortical thickness (CCT = W + m)
√ subperiosteal tunneling

Categories:

A. DIFFUSE OSTEOPENIA
1. Osteoporosis = decreased osteoid production
2. Osteomalacia = undermineralization of osteoid
3. Hyperparathyroidism
4. Multiple myeloma / diffuse metastases
5. Drugs
6. Mastocytosis
7. Osteogenesis imperfecta

B. REGIONAL OSTEOPENIA

Osteoporosis

= reduced bone mass of normal composition secondary to
(a) osteoclastic resorption (85%): trabecular, endosteal, intracortical, subperiosteal
(b) osteocytic resorption (15%)

Prevalence: 7% of all women aged 35–40 years;
12% for males + females aged 50–79 years;
◊ Most common of all metabolic bone disorders; 14 million worldwide by 2020

Classification:

(a) Primary / involutional osteoporosis ← cumulative bone loss as people age and undergo sex hormone changes
1. Type I (postmenopausal) osteoporosis
= accelerated trabecular bone resorption ← estrogen deficiency
Fracture pattern: spine and wrist
2. Type II (senile) osteoporosis
= proportionate loss of cortical and trabecular bone
Fracture pattern: hip, proximal humerus, tibia, pelvis

(b) Secondary osteoporosis (in 20–30%) = consequence of various medical conditions / use of certain medications

Etiology:

A. CONGENITAL DISORDERS
1. Osteogenesis imperfecta
◊ The only osteoporosis with bending of bones!
2. Homocystinuria

B. IDIOPATHIC (bone loss begins earlier + proceeds more rapidly in women)
1. Juvenile osteoporosis: < 20 years
2. Adult osteoporosis: 20–40 years
3. Postmenopausal osteoporosis: > 50 years
(40–50% lower trabecular bone mineral density in elderly than in young women)
4. Senile osteoporosis: > 60 years
progressively decreasing bone density at a rate of 8% (3%) in females (males) per year

C. NUTRITIONAL DISTURBANCES scurvy; calcium deficiency; protein deficiency (nephrosis, chronic liver disease, alcoholism, anorexia nervosa, kwashiorkor, starvation, malnutrition, malabsorption)

D. ENDOCRINOPATHY Cushing disease, hypogonadism (Turner syndrome, eunuchoidism), hyperthyroidism, hyperparathyroidism, acromegaly, Addison disease, diabetes mellitus, pregnancy, paraneoplastic phenomenon in liver tumors

E. RENAL OSTEODYSTROPHY
decrease / same / increase in spinal trabecular bone; rapid loss in appendicular skeleton

F. IMMOBILIZATION = disuse osteoporosis

G. COLLAGEN DISEASE, RHEUMATOID ARTHRITIS

H. BONE MARROW REPLACEMENT infiltration by lymphoma / leukemia (ALL), multiple myeloma, diffuse metastases, marrow hyperplasia ← hemolytic anemia

I. DRUG THERAPY
corticosteroids, heparin (15,000–30,000 U for > 6 months), methotrexate, excessive alcohol consumption, smoking, Dilantin, aromatase inhibitors, gonadotropin-releasing hormone antagonist

J. RADIATION THERAPY

K. LOCALIZED OSTEOPOROSIS
immobilization / disuse, Sudeck dystrophy, transient osteoporosis of large joints, regional migratory osteoporosis of lower extremities

- serum calcium, phosphorus, alkaline phosphatase frequently normal
- hydroxyproline may be elevated during acute stage

Significant predictors of osteoporotic fractures:

1. Age
2. History of fracture
3. Failed chair test (= inability to rise from a chair in 3 successions without using arms)
4. Fall within past 12 months

Clinical manifestation:

(1) Vertebral compression fracture (HALLMARK)
(2) Femoral fracture: neck + intertrochanteric region
(3) Fracture of distal radius (Colles) and tibia

Technique of Bone Densitometry:

(1) **Single-Photon Absorptiometry** measures primarily cortical bone of appendicular bones, single-energy ^{125}I radioisotope source
Site: distal radius (= wrist bone density), os calcis
Dose: 2–3 mrem
Precision: 1–3%

(2) **Dual-Photon Absorptiometry** radioactive energy source with 2 photon peaks; should be reserved for patients < 65 years of age because of interference from osteophytosis + vascular calcifications
Site: vertebrae, femoral neck
Dose: 5–10 mrem
Precision: 2–4%

(3) **Single X-ray Absorptiometry**
= area projectional technique for quantitative bone density measurement
Site: distal radius, calcaneus
Dose: low
Precision: 0.5–2%

(4) **Dual Energy X-ray Absorptiometry (DXA / DEXA)**
= quantitative digital radiography
◊ Most widely used & most precise technique!
◊ Standard of reference for diagnosis of osteoporosis in conjunction with *Fracture Risk Assessment Tool* at http://www.shef.ac.uk/FRAX/ for results of a 10-year probability of a major osteoporotic fracture in hip, spine, proximal humerus, distal

forearm

Technique:

» mobile x-ray source composed of 2 different photon energy levels (constant + pulsed) moves together with detection system
» rectilinear / fan-beam scanners
» attenuation values of soft tissues are subtracted, leaving only the attenuation values of bone
» lateral scanning of spine increases accuracy without superimposition of posterior elements + marginal osteophytes + vascular calcifications

Advantage:

(1) low radiation dose with higher radiation flux than radioisotope source of dual-photon absorptiometry
(2) uses sites where osteoporotic fractures occur
(3) low cost; ease of use; rapidity of measurement

Limitation of 2-dimensional (areal) technique:

(1) no distinction between cortical + trabecular bone
(2) no discrimination between changes secondary to bone geometry + increased bone density
(3) regulatory oversight for ionizing radiation

Site: (a) lumbar spine (L1–L4)
(b) proximal femur (total hip, femoral neck, trochanter, Ward area)
(c) calcaneus (95% trabecular bone)
(d) forearm (suboptimal ← mostly cortical bone)

Dose: < 3 mrem

Precision: 1–2%

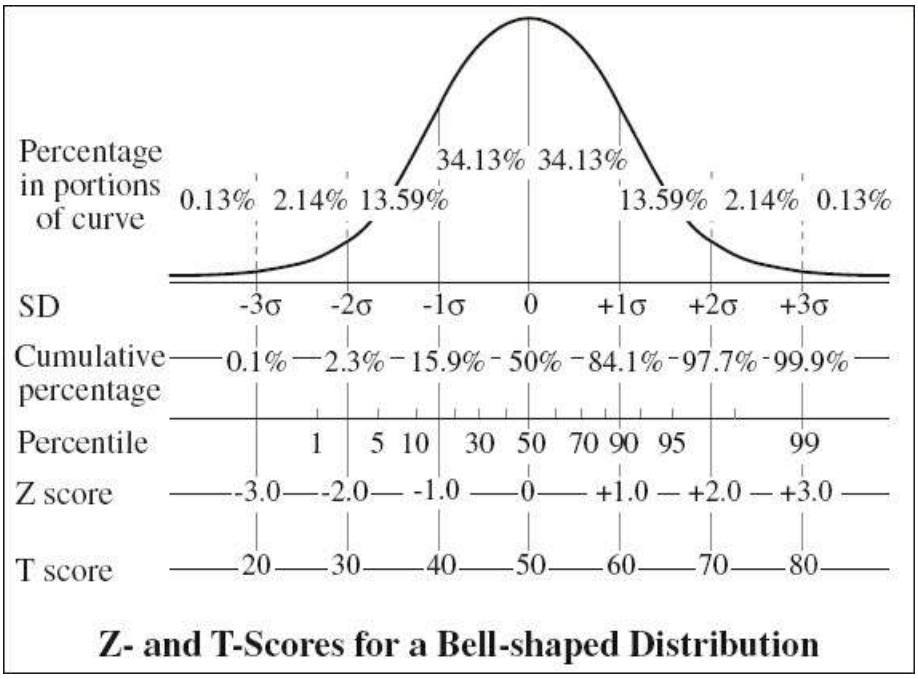
Data collected:

BMD (bone marrow density) value (g/cm^2)
T-score = how far is the score from the mean of 50 with a SD of 10 compared with young adults 20–30 years of age (= peak of bone mass)
Z-score = location of a score compared to age-matched + gender-matched controls in a distribution with a mean of 0 and a SD of 1.0; particularly important in patients aged > 75 years

Interpretation:

normal (≥ –1.0); osteopenia (< –1.0 but > –2.5); osteoporosis (≤ –2.5); severe osteoporosis (≤ –2.5 with a fragility fracture)

Pitfalls:



Z- and T-Scores for a Bell-shaped Distribution

› weekly phantom calibration to detect scanner drift
› improper patient positioning (decentering of lumbar spine, abduction / external rotation of hip)
› improper numbering of vertebrae, placement of intervertebral markers, detection of bone edges
› blurring / irregular contour of bone margins ← patient motion
› anatomic artifacts from
(a) superimposed disease: degenerative disk disease, compression fracture, postsurgical defect, overlying atherosclerotic calcifications
(b) implanted devices: stent + vena cava filter, GI barium, hardware, vertebroplasty cement
(c) external objects: piercing, bra clips, metallic buttons
◊ Results from different scanners not interchangeable ← differences in scanners and software programs

(5) **Quantitative Computed Tomography**
= determines true volumetric density (mg/cm^3) by providing separate estimates of trabecular + cortical bone BMD over 2–4 vertebrae (T12–L4)
• high-turnover cancellous bone is important for vertebral strength and has high responsiveness
• trabecular bone + low-turnover compact bone can be measured separately
Advantage:
› allows separate analysis of trabeculae + cortices
› selective assessment of metabolically active trabecular bone in center of vertebral body
› better sensitivity than projectional methods (DXA)
› exclusion of structures not contributing to spine mechanical resistance

Disadvantage:
› high radiation dose
› poor precision limited to longitudinal assessment
› high costs
› high degree of operator dependence
› need for considerable amount of space
› limited scanner access

Pitfalls affecting measurements:
myelofibrosis + hematopoietic disorders + fat

Technique:
» use of low-dose commercial CT scanner
» compared to external bone mineral reference phantom that is scanned simultaneously with patient to calibrate CT attenuation measurements
» 10-mm–thick section with gantry angle correction through center of vertebral body
» results expressed as absolute values / Z and T scores

Site: vertebrae L1–L3, other sites

Use: assessment of vertebral fracture risk; measurement of age-related bone loss; follow-up of osteoporosis + metabolic bone disease

(a) single energy: 300–500 mrem; 6–25% precision
(b) dual energy: 750–800 mrem; 5–10% precision

◊ Most sensitive technique!

(6) **Peripheral Quantitative CT**

= exact 3-dimensional localization of target volumes with multisection data acquisition capability covering a large volume of bone

Site: distal radius

(7) **Quantitative Heel Ultrasound**

= determines US stiffness index(SI) using formula

SI = 0.67 • BUA [dB/MHz] + 0.28 • SOS [m/s] – 420 SOS = speed of sound BUA = broadband ultrasound attenuation for 200–600 kHz

as a risk assessment independent from DEXA

◊ Fracture risk increases with decrease in SI

Precision: 2.2%

Disadvantage: lack of sensitivity, equipment drift

Location: axial skeleton (lower dorsal + lumbar spine), proximal humerus, neck of femur, wrist, ribs

Radiographs:

◊ Radiographs: insensitive prior to bone loss of 25–30%
◊ Bone scans do NOT show a diffuse increase in activity
√ increased radiolucency = decreased number + thickness of trabeculae = osteopenia ("poverty of bone"):
√ relatively prominent primary trabeculae ← initially selective loss of secondary trabeculae
√ juxtaarticular osteopenia with trabecular bone predominance (eg, distal radius + proximal femur):
√ accentuation of compressive + tensile trabeculae

√ sparsely trabeculated region in inferomedial femoral neck between converging primary and secondary compressive groups = **Ward triangle**

◊ Trabecular bone responds to metabolic changes faster than cortical bone

√ cortical thinning (endosteal + intracortical + periosteal resorption):

√ scalloping of inner cortical margin

√ widening of marrow canal

√ prominent longitudinal cortical striations = tunneling

√ irregular definition of outer bone surface

◊ Most specific finding of high bone turnover

√ delayed fracture healing with poor callus formation (DDx: abundant callus formation in osteogenesis imperfecta + Cushing syndrome)

Cx: fracture for 1÷2 women + 1÷4 men > age 50 years

(1) Fractures at sites rich in labile trabecular bone (eg, vertebrae, wrist) in postmenopausal osteoporosis

(2) Fractures at sites containing cortical + trabecular bone (eg, hip) in senile osteoporosis

Rx: calcitonin, sodium fluoride, diphosphonates, parathyroid hormone supplements, estrogen replacement

Osteoporosis of Spine

Clinical manifestation:

- vertebral compression fracture occurring
  (a) spontaneously
  (b) during lifting / bending / coughing
  (c) load simply caused by muscle contraction
- progressive loss of stature → shortening of paraspinal musculature requiring prolonged active contraction for maintenance of posture → pain from muscle fatigue

Location: thoracolumbar junction (T12, L1), midthoracic area (T7, T8)

√ diminished radiographic density

√ vertical striations = rarefaction of trabeculae ← marked thinning of secondary horizontal (transverse) trabeculae + relative accentuation of primary vertical trabeculae along lines of stress

√ accentuation of endplates

√ "picture framing" (= accentuation of cortical outline with preservation of external dimensions ← endosteal + intracortical resorption

√ <u>anterior wedge fracture</u> resulting in spinal deformity:

√ kyphosis ← multiple fractures in 20–30%

◊ The greater the degree of osteoporosis the greater the number of fractures!

√ "dowager's hump"

√ reduction in thoracic and abdominal space →

- impaired pulmonary function
- protuberant abdomen
- alteration in body shape

√ <u>endplate fracture</u> = compression deformity with reduction in mid height + protrusion of intervertebral disks:

√ biconcavity of vertebra
√ Schmorl nodes

√ crush fracture = reduction of overall height of a vertebra relative to adjacent vertebrae:
√ height loss > 4 mm (posterior height is normally 1–3 mm more than anterior height for thoracic vertebra)
√ decreased height of vertebrae → loss of body height
√ absence of osteophytes

MR:
√ heterogeneously hyperintense SI on T1WI:
√ focal fatty marrow usually has a round morphology
√ round lesions coalesce to involve entire vertebral body
√ variable T2 signal intensity

Osteoporosis of Appendicular Skeleton

@ Hand (on industrial hard-copy film)
√ corticomedullary index = evaluation of cortical thickness of 2nd metacarpal bone
Digital X-ray Radiogrammetry (DXR)
= digitized PA radiograph with automatic segmentation of cortex + medulla of midshafts of 2nd + 3rd + 4th metacarpal bones → average cortical thickness + average bone width in region of interest
Advantage: high reproducibility; capacity to predict future fracture; widely available; inexpensive; low radiation dose

@ Femur
√ Singh classification system = trabeculae in proximal femur disappear in predictable sequence

@ Calcaneus
√ Jhamaria index = lateral radiograph of calcaneus

Osteomalacia

= accumulation of excessive amounts of uncalcified osteoid with bone softening + insufficient mineralization of osteoid due to
(a) high remodeling rate: excessive osteoid formation + normal / little mineralization
(b) low remodeling rate: normal osteoid production + diminished mineralization

Etiology:
(1) dietary deficiency of vitamin D3 + lack of solar irradiation
(2) deficient metabolism of vitamin D:
› chronic renal tubular disease
› chronic administration of phenobarbital (alternate liver pathway)
› diphenylhydantoin (interferes with vitamin D action on bowel)
(3) decreased absorption of vitamin D:
› malabsorption syndromes (most common)
› partial gastrectomy (self-restriction of fatty foods)
(4) diminished deposition of calcium in bone
› diphosphonates (for treatment of Paget disease)

Histo: excess of osteoid seams + decreased appositional rate

- bone pain / tenderness; muscular weakness
- serum calcium slightly low / normal
- decreased serum phosphorus
- elevated serum alkaline phosphatase

√ uniform osteopenia
√ fuzzy indistinct trabecular detail of endosteal surface
√ coarsened frayed trabeculae decreased in number + size
√ thin cortices of long bone
√ bone deformity from softening:
  √ hourglass thorax
  √ bowing of long bones
  √ acetabular protrusion
  √ buckled / compressed pelvis
  √ biconcave vertebral bodies
√ increased incidence of insufficiency fractures
√ pseudofractures = Looser zones
√ mottled skull

Localized / Regional Osteopenia

1. Disuse osteoporosis / atrophy
   Etiology: local immobilization secondary to
   (a) fracture (more pronounced distal to fracture site)
   (b) neural paralysis
   (c) muscular paralysis
2. Reflex sympathetic dystrophy = Sudeck dystrophy
3. Regional migratory osteoporosis, transient regional osteoporosis of hip
4. Rheumatologic disorders
5. Infection: osteomyelitis, tuberculosis
6. Osteolytic tumor
7. Lytic phase of Paget disease
8. Early phase of bone infarct and hemorrhage
9. Burns + frostbite

Bone Marrow Edema

= hypointense on T1WI + hyperintense on T2WI relative to fatty marrow

1. Trauma
   (a) "bone bruise"
   (b) radiographically occult acute fracture
   (c) recent surgery
2. Infection = osteomyelitis
3. Aseptic arthritis
4. Osteonecrosis = early stage of AVN
5. Neuropathic osteoarthropathy
6. Reflex sympathetic dystrophy (some cases)
7. Transient osteoporosis of hip

8. Infiltrative neoplasm

Transverse Lucent Metaphyseal Lines

mnemonic: LINING

Leukemia
Illness, systemic (rickets, scurvy)
Normal variant
Infection, transplacental (congenital syphilis)
Neuroblastoma metastases
Growth lines

Frayed Metaphyses

mnemonic: CHARMS

Congenital infections (rubella, syphilis)
Hypophosphatasia
Achondroplasia
Rickets
Metaphyseal dysostosis
Scurvy

MYELOPROLIFERATIVE DISORDERS

= autonomous clonal disorder initiated by an acquired pluripotential hematopoietic stem cell

Types:

1. Polycythemia vera
2. Chronic granulomatous / myelogenous leukemia
3. Essential idiopathic thrombocytopenia
4. Agnogenic myeloid metaplasia (= primary myelofibrosis + extramedullary hematopoiesis in liver + spleen)

Pathophysiology:

› self-perpetuating intra- and extramedullary hematopoietic cell proliferation without stimulus
› trilinear panmyelosis (RBCs, WBCs, platelets)
› myelofibrosis with progression to myelosclerosis
› myeloid metaplasia = extramedullary hematopoiesis (normocytic anemia, leukoerythroblastic anemia, low platelet count, reticulocytosis, normal / reduced WBC count)

BONE TUMOR

Role of Radiologist

1. Is there a lesion?
2. Is it a bone tumor?
3. Is the tumor benign or malignant?
4. Is a biopsy necessary?
5. Is histologic diagnosis consistent with radiographic image?

Assessment of Bone Tumor

A systematic approach is imperative for assessment of a bone tumor with attention to size, number, and location of lesions; margins and zone of transition; periosteal reaction; matrix mineralization; soft-tissue component.

1. **Age** (and gender) of patient
2. Precise tumor **location**
   (a) transverse: medullary, cortical, juxtacortical
   (b) longitudinal: epi-, meta-, diaphyseal
3. Pattern of **bone destruction / aggressiveness**
   (a) nonaggressive
      √ well-defined sharp margins
      √ smooth solid-appearing periosteal reaction
   (b) aggressive infiltrative osseous process
      √ broad zone of transition
      √ poorly defined borders
      √ disrupted / "sunburst" appearance
      DDx: destructive metabolic / infectious process
4. Lesion **matrix**
   √ "rings-and-arcs" appearance = chondral origin
   √ opaque cloud-like matrix = osseous mineralization
   √ osteolytic lesion → FEGNOMASHIC
   √ CT for cortical continuity / disruption

Action Following Bone Tumor Assessment

A. BENIGN
   1. Diagnosis certain: no further work-up necessary
   2. Asymptomatic lesion with highly probable benign diagnosis may be followed clinically
   3. Symptomatic lesion with highly probable benign diagnosis may be treated without further work-up

B. CONFUSING LESION
   not clearly categorized as benign or malignant; needs staging work-up

C. MALIGNANT: needs staging work-up

Staging work-up:

Bone scan: identifies polyostotic lesions (eg, multiple myeloma, metastatic disease, primary osteosarcoma with bone-forming metastases, histiocytosis, Paget disease)

Chest CT: identifies metastatic deposits + changes further work-up and therapy

Local staging with MR imaging:
   (1) Margins: encapsulated / infiltrating
   (2) Compartment: intra- / extracompartmental
   (3) Intraosseous extent + skip lesions
   (4) Soft-tissue extent (DDx: hematoma, edema)
   (5) Joint involvement

(6) Neurovascular involvement

Local assessment with CT imaging:

√ matrix / rim calcifications

VESSEL AND NERVE INVOLVEMENT

√ tumor encasement of neurovascular bundle by

– 180–360° = indicates infiltration by tumor

– 90–180° = indeterminate for infiltration by tumor

– 0–90° = infiltration by tumor unlikely

Tumorlike Conditions

1. Solitary bone cyst
2. Juxtaarticular ("synovial") cyst
3. Aneurysmal bone cyst
4. Nonossifying fibroma; cortical defect; cortical desmoid
5. Eosinophilic granuloma
6. Reparative giant cell granuloma
7. Fibrous dysplasia (monostotic; polyostotic)
8. Myositis ossificans
9. "Brown tumor" of hyperparathyroidism
10. Massive osteolysis

Pseudomalignant Appearance

1. Osteomyelitis
2. Aggressive osteoporosis

Pattern of Bone Tumor Destruction / Aggressiveness

A. GEOGRAPHIC BONE DESTRUCTION

Cause: (a) slow-growing usually benign tumor

(b) rarely malignant: plasma cell myeloma, metastasis

(c) infection: granulomatous osteomyelitis

√ well-defined smooth / irregular margin

√ narrow zone of transition

B. MOTH-EATEN BONE DESTRUCTION

Cause: (a) rapidly growing malignant bone tumor

(b) osteomyelitis

√ less well-defined / demarcated lesional margin

√ broad zone of transition

mnemonic: H LEMMON

Histiocytosis X

Lymphoma

Ewing sarcoma

Metastasis

Multiple myeloma

Osteomyelitis

Neuroblastoma

C. PERMEATIVE BONE DESTRUCTION
Cause: aggressive bone tumor with rapid growth potential (eg, Ewing sarcoma)
√ poorly demarcated lesion imperceptibly merging with uninvolved bone
√ broad zone of transition

Size, Shape, and Margin of Bone Tumors

◊ Primary malignant tumors are larger than benign tumors
√ elongated lesion (= greatest diameter of > 1.5 times the least diameter): Ewing sarcoma, histiocytic lymphoma, chondrosarcoma, angiosarcoma
√ sclerotic margin (= reaction of host tissue to tumor)

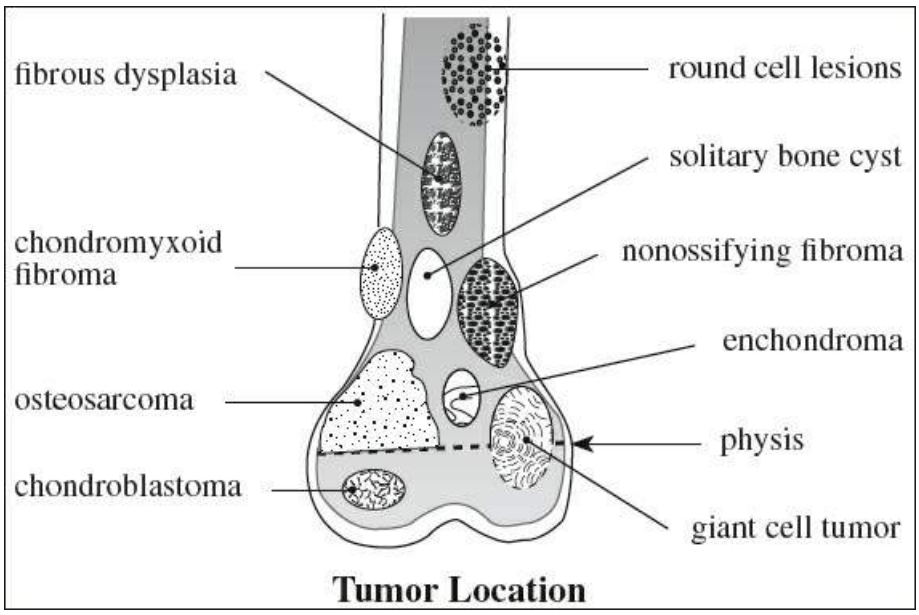
Tumor Position in Transverse Plane

A. CENTRAL MEDULLARY LESION
1. Enchondroma
2. Solitary bone cyst

B. ECCENTRIC MEDULLARY LESION
1. Giant cell tumor
2. Osteogenic sarcoma, chondrosarcoma, fibrosarcoma
3. Chondromyxoid fibroma

C. CORTICAL LESION
1. Nonossifying fibroma
2. Osteoid osteoma

D. PERIOSTEAL / JUXTACORTICAL LESION
1. Juxtacortical chondroma / osteosarcoma
2. Osteochondroma
3. Parosteal osteogenic sarcoma



Tumor Location

Tumor Position in Longitudinal Plane

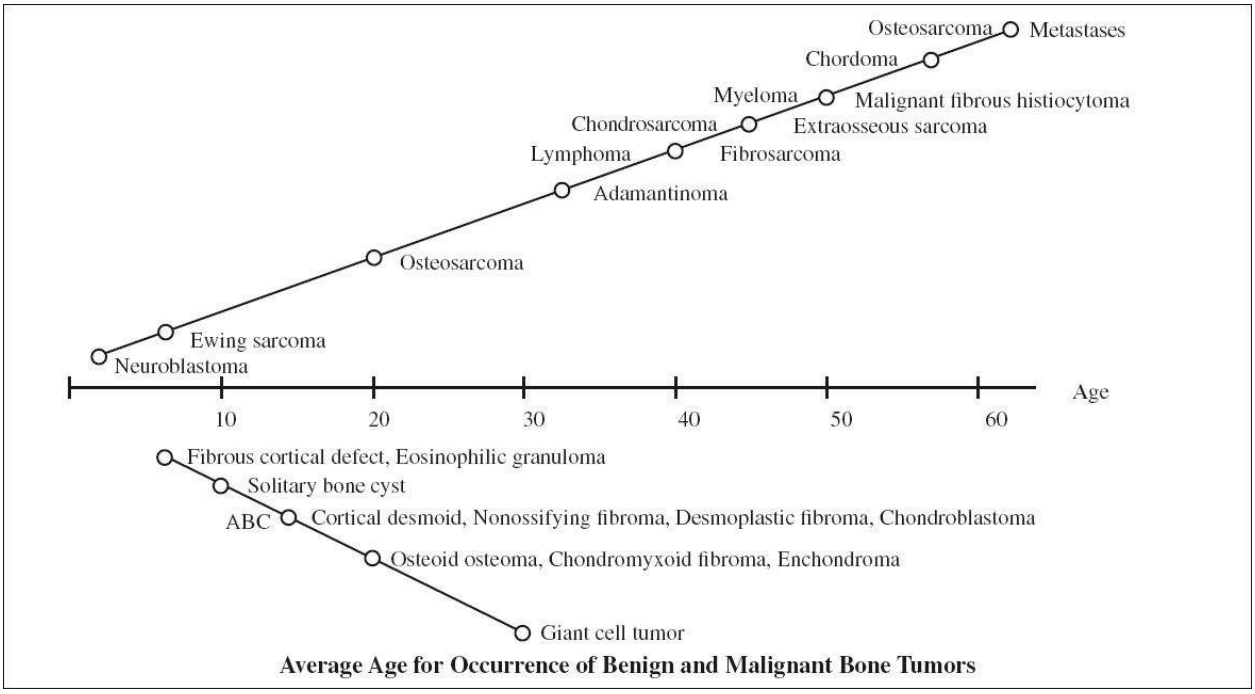
A. EPIPHYSEAL LESION
   1. Chondroblastoma (prior to closure of growth plate)
   2. Intraosseous ganglion, subchondral cyst
   3. Giant cell tumor (originating in metaphysis)
   4. Clear cell chondrosarcoma
   5. Fibrous dysplasia
   6. Abscess

   mnemonic: CAGGIE
      Chondroblastoma
      Aneurysmal bone cyst
      Giant cell tumor
      Geode
      Infection
      Eosinophilic granuloma
         [after 40 years of age throw out "CEA" and insert metastases / myeloma]

B. METAPHYSEAL LESION
   1. Nonossifying fibroma (close to growth plate)
   2. Chondromyxoid fibroma (abutting growth plate)
   3. Solitary bone cyst
   4. Osteochondroma
   5. Brodie abscess
   6. Osteogenic sarcoma, chondrosarcoma

C. DIAPHYSEAL LESION
   1. Round cell tumor (eg, Ewing sarcoma)
   2. Nonossifying fibroma
   3. Solitary bone cyst
   4. Aneurysmal bone cyst
   5. Enchondroma
   6. Osteoblastoma
   7. Fibrous dysplasia

   mnemonic: FEMALE
      Fibrous dysplasia
      Eosinophilic granuloma
      Metastasis
      Adamantinoma



Average Age for Occurrence of Benign and Malignant Bone Tumors

Leukemia, **L**ymphoma
Ewing sarcoma

Tumors Localizing to Hematopoietic Marrow

1. Metastases
2. Plasma cell myeloma
3. Ewing sarcoma
4. Histiocytic lymphoma

Diffuse Bone Marrow Abnormalities in Childhood

A. REPLACED BY TUMOR CELLS
   (a) metastatic disease
      1. Neuroblastoma (in young child)
      2. Lymphoma (in older child)
      3. Rhabdomyosarcoma (in older child)
   (b) primary neoplasm
      1. Leukemia

B. REPLACED BY RED CELLS
   = red cell hyperplasia = reconversion
   (a) severe anemia: sickle cell disease, thalassemia, hereditary spherocytosis
   (b) chronic severe blood loss
   (c) marrow replacement by neoplasia
   (d) treatment with granulocyte-macrophage colony stimulating factor

C. REPLACED BY FAT
   1. Myeloid depletion = aplastic anemia

D. REPLACED BY FIBROUS TISSUE

1. Myelofibrosis

Incidence of Bone Tumors

◊ 80% of bone tumors are correctly determined on the basis of age alone!

Most Frequent Benign Bone Tumor

1. Osteochondroma 20–30%
2. Enchondroma 10–20%
3. Simple bone cyst 10–20%
4. Osteoid osteoma
5. Nonossifying fibroma
6. Aneurysmal bone cyst 5%
7. Fibrous dysplasia
8. Giant cell tumor

Most Frequent Malignant Bone Tumor

A. Bone malignancy
   1. Metastasis
B. Primary bone malignancy
   1. Multiple myeloma
   2. Osteosarcoma
   3. Chondrosarcoma
   4. Ewing sarcoma
C. Primary bone malignancy in children & adolescents
   1. Osteosarcoma
   2. Ewing sarcoma

Sarcomas by Age

mnemonic: **E**very **O**ther **R**unner **F**eels **C**rampy **P**ain **O**n **M**oving

Ewing sarcoma	0–10 years
Osteogenic sarcoma	10–30 years
Reticulum cell sarcoma	20–40 years
Fibrosarcoma	20–40 years
Chondrosarcoma	40–50 years
Parosteal sarcoma	40–50 years
Osteosarcoma	60–70 years
Metastases	60–70 years

EWING SARCOMA FAMILY

1. Ewing sarcoma of bone
2. Extraskeletal Ewing sarcoma
3. Primitive neuroectodermal tumor
4. Askin tumor

Malignancy with Soft-tissue Involvement

mnemonic: **M**y **M**other **E**ats **C**hocolate **F**udge **O**ften
Metastasis
Myeloma
Ewing sarcoma
Chondrosarcoma
Fibrosarcoma
Osteosarcoma

Tumor Matrix of Bone Tumors

Cartilage-forming Bone Tumors

√ centrally located ringlike / flocculent / flecklike radiodensity

A. BENIGN
   1. Enchondroma
   2. Parosteal chondroma
   3. Chondroblastoma
   4. Chondromyxoid fibroma
   5. Osteochondroma

B. MALIGNANT
   1. Chondrosarcoma
   2. Chondroblastic osteosarcoma

Bone-forming Tumors

√ inhomogeneous / homogeneous radiodense collections of variable size + extent

A. BENIGN
   1. Osteoma
   2. Osteoid osteoma
   3. Osteoblastoma
   4. Ossifying fibroma

B. MALIGNANT
   1. Osteogenic sarcoma

Fibrous Connective Tissue Tumors

A. BENIGN FIBROUS BONE LESIONS
   (a) cortical
      1. Benign cortical defect
      2. Avulsion cortical irregularity
   (b) medullary
      1. Herniation pit
      2. Nonossifying fibroma
      3. Ossifying fibroma
      4. Congenital generalized fibromatosis
   (c) corticomedullary
      1. Nonossifying fibroma
      2. Ossifying fibroma
      3. Fibrous dysplasia

4. Cherubism
5. Desmoplastic fibroma
6. Fibromyxoma
7. Benign fibrous histiocytoma

B. MALIGNANT
1. Fibrosarcoma

Tumors of Histiocytic Origin

A. LOCALLY AGGRESSIVE
1. Giant cell tumor
2. Benign fibrous histiocytoma

B. MALIGNANT
1. Malignant fibrous histiocytoma

Tumors of Fatty Tissue Origin

A. BENIGN
1. Intraosseous lipoma
2. Parosteal lipoma

B. MALIGNANT
1. Intraosseous liposarcoma

◊ Lipomas follow the SI of subcutaneous fat in all sequences!

Tumors of Vascular Origin

< 1% of all bone tumors

A. BENIGN
1. Hemangioma
2. Glomus tumor
3. Lymphangioma
4. Cystic angiomatosis
5. Hemangiopericytoma

B. MALIGNANT
1. Malignant hemangiopericytoma
2. Angiosarcoma = hemangioendothelioma

Metastatic sites: lung, brain, lymph nodes, other bones

Tumors of Neural Origin

A. BENIGN
1. Solitary neurofibroma
2. Neurilemmoma

B. MALIGNANT
1. Neurogenic sarcoma = malignant schwannoma

Bone Tumors with Fluid-Fluid Levels

1. Aneurysmal bone cyst
2. Telangiectatic osteosarcoma
3. Giant cell tumor

4. Chondroblastoma
5. Fibrous dysplasia

Round Cell Tumor

Location: arises in midshaft
√ osteolytic lesion
√ reactive new bone formation
√ NO tumor new bone
mnemonic: LEMON
Leukemia, **L**ymphoma
Ewing sarcoma, **E**osinophilic granuloma
Multiple myeloma
Osteomyelitis
Neuroblastoma

INTRAOSSEOUS LESION

Bubbly Bone Lesion

mnemonic: FOGMACHINES
Fibrous dysplasia, **F**ibrous cortical defect
Osteoblastoma
Giant cell tumor
Myeloma (plasmacytoma), **M**etastases from kidney, thyroid, breast
Aneurysmal bone cyst / **A**ngioma
Chondromyxoid fibroma, **C**hondroblastoma
Hyperparathyroid brown tumor, **H**emangioma, **H**emophilia, **H**istiocytosis X
Infection (Brodie abscess, Echinococcus, coccidioidomycosis)
Nonossifying fibroma
Eosinophilic granuloma, **E**nchondroma, **E**pithelial inclusion cyst
Solitary bone cyst
mnemonic: FEGNOMASHIC
Fibrous dysplasia
Enchondroma / **E**osinophilic granuloma
Giant cell tumor
Nonossifying fibroma
Osteoblastoma
Metastasis, **M**yeloma
Aneurysmal bone cyst
Simple bone cyst
Hyperparathyroidism
Infection
Chondroblastoma, **C**hondromyxoid fibroma

Infectious Bubbly Lesion

1. Brodie abscess (Staph. aureus)

2. Coccidioidomycosis
3. Echinococcus
4. Atypical mycobacterium
5. Cystic tuberculosis

Blowout Lesion

A. METASTASES
   Carcinoma of thyroid, kidney, breast
B. PRIMARY BONE TUMOR
   1. Fibrosarcoma
   2. Multiple myeloma (sometimes)
   3. Aneurysmal bone cyst
   4. Hemophilic pseudotumor

Nonexpansile Well-demarcated Bone Defect

Unilocular Well-demarcated Bone Defect

1. Fibrous cortical defect
2. Nonossifying fibroma
3. Simple unicameral bone cyst
4. Giant cell tumor
5. Brown tumor of HPT
6. Eosinophilic granuloma
7. Enchondroma
8. Epidermoid inclusion cyst
9. Posttraumatic / degenerative cyst
10. Pseudotumor of hemophilia
11. Intraosseous ganglion
12. Histiocytoma
13. Arthritic lesion
14. Endosteal pigmented villonodular synovitis
15. Fibrous dysplasia
16. Infectious lesion

Multilocular Well-demarcated Bone Defect

1. Aneurysmal bone cyst
2. Giant cell tumor
3. Fibrous dysplasia
4. Simple bone cyst

Expansile Unilocular Well-demarcated Osteolysis

1. Simple unicameral bone cyst
2. Enchondroma
3. Aneurysmal bone cyst
4. Juxtacortical chondroma
5. Nonossifying fibroma

6. Eosinophilic granuloma
7. Brown tumor of HPT

Poorly Demarcated Osteolytic Lesion

Osteolytic Lesion <u>without</u> Periosteal Reaction

A. NONEXPANSILE
   1. Metastases from any primary neoplasm
   2. Multiple myeloma
   3. Hemangioma

B. EXPANSILE
   1. Chondrosarcoma
   2. Giant cell tumor
   3. Metastasis from kidney / thyroid

Osteolytic Lesion <u>with</u> Periosteal Reaction

1. Osteomyelitis
2. Ewing sarcoma
3. Osteosarcoma

Mixed Sclerotic and Lytic Lesion

Mixed Bone Lesion <u>without</u> Sequestrum

1. Osteomyelitis
2. Tuberculosis
3. Ewing sarcoma
4. Metastasis
5. Osteosarcoma

Mixed Bone Lesion <u>with</u> Button Sequestrum

√ bone opacity surrounded by a well-defined lucent area

common:

1. Osteomyelitis
2. Eosinophilic granuloma
3. Fibrosarcoma, desmoplastic fibroma, MFH
4. Lymphoma

uncommon:

partially calcified intraosseous lipoma, tuberculous osteitis, radiation necrosis, metastatic carcinoma, fibrous dysplasia, dermoid & epidermoid cyst, hemangioma, meningioma

Trabeculated Bone Lesion

1. Giant cell tumor: delicate thin trabeculae
2. Chondromyxoid fibroma: coarse thick trabeculae
3. Nonossifying fibroma: lobulated
4. Aneurysmal bone cyst: delicate, horizontally oriented trabeculae

5. Hemangioma: striated radiating trabeculae

Lytic Bone Lesion Surrounded by Marked Sclerosis

mnemonic: BOOST

Brodie abscess
Osteoblastoma
Osteoid osteoma
Stress fracture
Tuberculosis

Multiple Lytic Lesions

mnemonic: FEEMHI

Fibrous dysplasia
Enchondromas
Eosinophilic granuloma
Metastases, **M**ultiple myeloma
Hyperparathyroidism (brown tumors), **H**emangiomas
Infection

Multiple Lytic Lesions in Child

1. Histiocytosis X
2. Metastatic neuroblastoma / leukemia
3. Fibrous dysplasia
4. Enchondromatosis
5. Rare: cystic angiomatosis, multifocal osteomyelitis

Lytic Bone Lesion in Patient < 30 Years of Age

mnemonic: CAINES

Chondroblastoma
Aneurysmal bone cyst
Infection
Nonossifying fibroma
Eosinophilic granuloma
Solitary bone cyst

Lytic Bone Lesion on Both Sides of Joint

mnemonic: SAC

Synovioma
Angioma
Chondroid lesion

Multiple Bone Lesions with Soft-tissue Tumor

1. Neurofibromatosis & fibroxanthomas
2. Maffucci syndrome = enchondromatosis & hemangioma
3. Mazabraud syndrome = fibrous dysplasia & myxoma
4. Metastases

(a) Multiple myeloma
(b) Malignant melanoma
(c) Lymphoma

Osteoblastic Bone Lesion

A. BENIGN
   1. Bone island
   2. Osteoma
   3. Osteoid osteoma

B. MALIGNANT
   1. Osteosarcoma
   2. Parosteal sarcoma

Widespread Osteosclerotic Lesions

1. Metastases: prostate, breast, lung, bladder, pancreas, stomach, colon, carcinoid, brain
2. Paget disease
3. Sarcoma
4. Myelofibrosis
5. Mastocytosis

BONE OVERGROWTH

Bone Overdevelopment

1. Marfan syndrome
2. Klippel-Trénaunay syndrome
3. Nerve territory-oriented macrodactyly
   (a) Macrodystrophia lipomatosa
   (b) Fibrolipomatous hamartoma with macrodactyly

Erlenmeyer Flask Deformity

= expansion of distal end of long bones, usually femur

1. Gaucher disease, Niemann-Pick disease
2. Hemolytic anemia: thalassemia, sickle cell
3. Osteopetrosis
4. Heavy metal poisoning
5. Metaphyseal dysplasia = Pyle disease
6. Rickets
7. Fibrous dysplasia
8. Down syndrome
9. Achondroplasia
10. Rheumatoid arthritis
11. Hypophosphatasia
12. Leukemia

mnemonic: TOP DOG
Thalassemia

Osteopetrosis
Pyle disease
Diaphyseal aclasis
Ollier disease
Gaucher disease

PERIOSTEAL REACTION / PERIOSTITIS

1. Trauma, hemophilia
2. Infection
3. Inflammatory: arthritis
4. Neoplasm
5. Congenital: physiologic in newborn
6. Metabolic: hypertrophic osteoarthropathy, thyroid acropachy, hypervitaminosis A
7. Vascular: venous stasis

Solid Periosteal Reaction

= reaction to periosteal irritant
√ even + uniform thickness > 1 mm
√ persistent + unchanged for weeks
Patterns:
(a) thin: eosinophilic granuloma; osteoid osteoma
(b) dense undulating: vascular disease
(c) thin undulating: pulmonary osteoarthropathy
(d) dense elliptical: osteoid osteoma; long-standing malignant disease (with destruction)
(e) cloaking: storage disease; chronic infection

Interrupted Periosteal Reaction

= pleomorphic, rapidly progressing process undergoing constant change
(a) buttressing = periosteal bone formation merges with underlying cortex: eosinophilic granuloma
(b) laminated = "onion skin": acute osteomyelitis; malignant tumor (osteosarcoma, Ewing sarcoma)
(c) radiating spicules = "sunburst": osteosarcoma; Ewing sarcoma; chondrosarcoma; fibrosarcoma; leukemia; metastasis; acute osteomyelitis
(d) perpendicular spicules = "hair-on-end": Ewing sarcoma
(e) amorphous: malignancy (deposits may represent extension of tumor / periosteal response); osteosarcoma
(f) Codman triangle: hemorrhage; malignancy (osteosarcoma, Ewing sarcoma); acute osteomyelitis; fracture
[Ernest Armory Codman (1869–1940), orthopedic surgeon at Massachusetts General Hospital, Harvard Medical School]

Symmetric Periosteal Reaction in Adulthood

1. Venous stasis (lower extremity)
2. Hypertrophic osteoarthropathy
3. Pachydermoperiostosis
4. Thyroid acropachy
5. Fluorosis
6. Rheumatoid arthritis
7. Psoriatic arthritis
8. Reiter syndrome
9. Idiopathic-degenerative

Periosteal Reaction in Childhood

(a) benign

1. Physiologic (up to 35%): symmetric involvement of diaphyses during first 1–6 months of life
2. Nonaccidental trauma = battered child syndrome
3. Infantile cortical hyperostosis: < 6 months of age
4. Hypervitaminosis A
5. Scurvy
6. Osteogenesis imperfecta
7. Congenital syphilis

(b) malignant

1. Multicentric osteosarcoma
2. Metastases from neuroblastoma + retinoblastoma
3. Acute leukemia

mnemonic: PERIOSTEAL SOCKS

Physiologic, Prostaglandin
Eosinophilic granuloma
Rickets
Infantile cortical hyperostosis
Osteomyelitis
Scurvy
Trauma
Ewing sarcoma
A-hypervitaminosis
Leukemia + neuroblastoma
Syphilis
Osteosarcoma
Child abuse
Kinky hair syndrome
Sickle cell disease

Periosteal Reaction in Infant

› before 6 months of age

1. Infantile cortical hyperostosis

2. Physiologic
3. Extracorporeal membrane oxygenation

› after 6 months of age

1. Hypervitaminosis A
2. Scurvy
3. Rickets

› anytime during infancy

1. Nonaccidental trauma
2. Syphilis
3. Metastatic neuroblastoma / leukemia
4. Prostaglandin therapy: within 40 days
5. Sickle cell dactylitis

DDx: motion artifact

Enthesopathy

[*en*, Greek = in; *thesis*, Greek = position]

Enthesis = osseous attachment of tendon composed of 4 zones, ie, tendon itself + unmineralized fibrocartilage + mineralized fibrocartilage + bone

Cause:

1. Degenerative disorder
2. Seronegative arthropathies: ankylosing spondylitis, Reiter disease, psoriatic arthritis
3. Diffuse idiopathic skeletal hyperostosis
4. Acromegaly
5. Rheumatoid arthritis (occasionally)

Location: at site of tendon + ligament attachment

√ bone proliferation (enthesophyte)
√ calcification of tendon + ligament
√ erosion

BONE TRAUMA

Childhood Fractures

1. Greenstick fracture
2. Bowing fracture
3. Traumatic epiphyseolysis
4. Battered child syndrome
5. Epiphyseal plate injury

Pseudarthrosis in Long Bones

1. Nonunion of fracture
2. Fibrous dysplasia
3. Neurofibromatosis
4. Osteogenesis imperfecta
5. Congenital: clavicular pseudarthrosis

Exuberant Callus Formation

1. Steroid therapy / Cushing syndrome
2. Neuropathic arthropathy
3. Osteogenesis imperfecta
4. Congenital insensitivity to pain
5. Paralysis
6. Renal osteodystrophy
7. Multiple myeloma
8. Battered child syndrome

EPIPHYSIS

Premature Epiphyseal Ossification

@ Proximal femoral and humeral epiphyses
   1. Jeune asphyxiating thoracic dysplasia
   2. Ellis-van Creveld chondroectodermal dysplasia

Epiphyseal / Apophyseal Lesion

1. Chondroblastoma
2. Brodie abscess
3. Fungal / tuberculous infection
4. Langerhans cell histiocytosis
5. Osteoid osteoma
6. Chondromyxoid fibroma
7. Enchondroma
8. Bone cyst
9. Foreign-body granuloma

mnemonic: ICEBAGS

Infection
Chondroblastoma (age <40)
Eosinophilic granuloma
Brown tumor
Aneurysmal bone cyst
Giant cell tumor
Subchondral cyst

Subarticular Lesion

(a) T2 hypo- to isointense matrix
   1. Giant cell tumor

(b) T2 hyperintense matrix
   2. Solitary subchondral cyst
   3. Intraosseous ganglion
   4. Brodie abscess
   5. Clear cell chondrosarcoma