Mayo Clinic Cardiology

Board Review Questions and Answers

Written by

Mayo Clinic Cardiovascular Fellows

Editors

Margaret A. Lloyd, M.D.

Joseph G. Murphy, M.D.

MAYO CLINIC SCIENTIFIC PRESS

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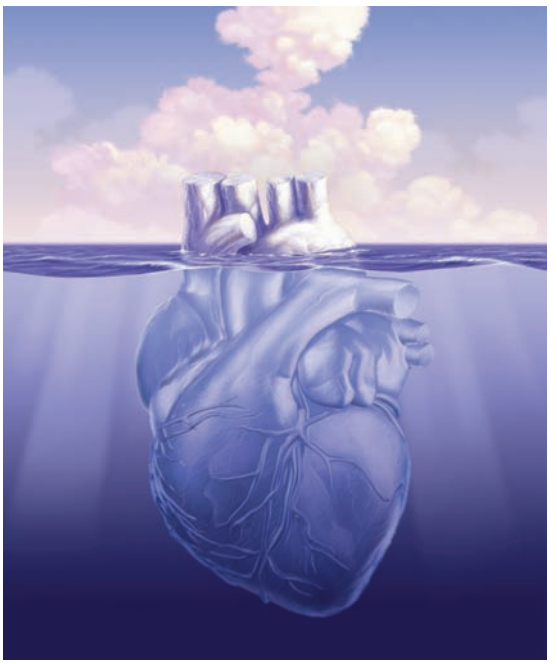

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Preface

This publication, organized in a question-and-answer multiple-choice format, is a companion to *Mayo Clinic Cardiology: Concise Textbook*, 3rd edition. It was written by cardiology fellows, primarily for fellows in training, and focuses on hot topics in cardiology and likely board examination areas. It will also be useful for practicing cardiologists preparing for recertification in cardiology.

It was an honor for us to edit the work of five talented cardiovascular fellows training at Mayo Clinic in Rochester, Minnesota. They are the heart and soul of this project, and this book would not have been successfully completed without them.

Busy clinical demands mean that preparation time for the certification examination in cardiology be used judiciously. The topics and question format were developed to help trainees and recertifying physicians focus their preparation for the American Board of Internal Medicine cardiology examination. The book is designed to allow readers to self-test before the examination and to identify areas that need further review. We strongly encourage trainees to read beyond the multiple-choice answers and develop a deeper understanding of the science that underpins cardiovascular medicine.

As always, thanks are due to the many persons involved in the production of this book. Rick A. Nishimura, MD, and Steve R. Ommen, MD, directors of the annual Mayo Clinic Cardiovascular Review Course, provided encouragement for this book and *Mayo Clinic Cardiology: Concise Textbook*. Patra A. Baker assisted with typing the manuscripts. Roberta J. Schwartz (production editor), Traci J. H. Post (scientific publications specialist), and LeAnn M. Stee and Randall J. Fritz, DVM (editors), all staff in Mayo Clinic Scientific Publications, were of tremendous assistance. Karen Barrie (art director) provided guidance on the design. Sandra Beberman, Vice President, Informa Healthcare, provided valuable advice.

Every effort was made to ensure that the answers and discussion are timely and accurate. If errors are noted, please contact us so that corrections can be made in future editions. We are also interested in additional topics you would like to have included in future editions of this review book.

Margaret A. Lloyd, MD
Consultant, Division of Cardiovascular Diseases,
Mayo Clinic, Rochester, Minnesota
Assistant Professor of Medicine,
College of Medicine, Mayo Clinic
lloyd.margaret@mayo.edu

Joseph G. Murphy, MD
Consultant, Division of Cardiovascular
Diseases, and Chair, Section of Scientific
Publications, Mayo Clinic,
Rochester, Minnesota
Professor of Medicine, College of Medicine,
Mayo Clinic

Affiliations

Editors

Margaret A. Lloyd, MD, Consultant, Division of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota; Assistant Professor of Medicine, College of Medicine, Mayo Clinic

Joseph G. Murphy, MD, Consultant, Division of Cardiovascular Diseases, and Chair, Section of Scientific Publications, Mayo Clinic, Rochester, Minnesota; Professor of Medicine, College of Medicine, Mayo Clinic

Authors

T. Jared Bunch, MD, is from Logan, Utah. He graduated from Utah State University with undergraduate degrees in chemistry, liberal arts, and sciences. He received his MD from the University of Utah. He completed a residency in internal medicine and a fellowship in cardiovascular diseases and is currently a fellow in electrophysiology at Mayo School of Graduate Medical Education, College of Medicine, Mayo Clinic.

Garvan C. Kane, MD, PhD, is from Dublin, Ireland, and received his MD and PhD from University College Dublin, Ireland. He completed his internal medicine residency and clinical pharmacology and cardiovascular diseases fellowships at Mayo School of Graduate Medical Education, College of Medicine, Mayo Clinic. He is completing his cardiovascular fellowship, and he is an Assistant Professor of Medicine, College of Medicine, Mayo Clinic. His clinical focus will include echocardiography and pulmonary vascular diseases.

Charles X. Kim, MD, is from Chicago, Illinois. He received dual BS degrees in cellular biology and chemistry from the University of Illinois, Urbana-Champaign, and his MD from the University of Chicago. He completed his residency in internal medicine at Northwestern University in Chicago. He is a fellow in cardiovascular diseases at Mayo School of Graduate Medical Education, College of Medicine, Mayo Clinic, and his areas of expertise are coronary care and interventional cardiology.

Matthew W. Martinez, MD, is from Wading River, New York. He attended Longwood University in Farmville, Virginia, and received his BS in biological sciences from Wright State University in Dayton, Ohio. He received his MD at Mayo Medical School and completed his residency in internal medicine at Mayo School of Graduate Medical Education, College of Medicine, Mayo Clinic. He is a fellow in cardiovascular diseases at Mayo School of Graduate Medical Education and an Instructor in Medicine, College of Medicine, Mayo Clinic. His area of expertise is advanced cardiac imaging in MRI, CT, echocardiography, and nuclear cardiology. His clinical interests include cardiomyopathies and cardiac assessment in athletes.

Brian P. Shapiro, MD, is from Miami, Florida. He received his undergraduate degree from the University of Florida in history, and his MD from the University of Miami. He completed his residency in internal medicine and a clinical investigator research fellowship (in heart failure) and he is currently a cardiovascular fellow at Mayo School of Graduate Medical Education, College of Medicine, Mayo Clinic, with expertise in imaging (MRI, CT, echocardiography, nuclear cardiology).

Table of Contents

Abbreviations

5-HIAA	5-Hydroxyindoleacetic acid
AAA	Abdominal aortic aneurysm
ACC	American College of Cardiology
ACE	Angiotensin-converting enzyme
ACS	Acute coronary syndrome
ACUITY	Acute Catheterization and Urgent Intervention Triage Strategy
ADMIRAL	Abciximab Before Direct Angioplasty and Stenting in Myocardial Infarction Regarding Acute and Long-Term Follow-up
AF	Atrial fibrillation
AFFIRM	Atrial Fibrillation Follow-up Investigation of Rhythm
AHA	American Heart Association
AMI	Acute myocardial infarction
ANP	Atrial natriuretic peptides
Ao	Aorta
AR	Aortic regurgitation
ARB	Angiotensin receptor blocker
ARDS	Acute respiratory distress syndrome
AS	Aortic stenosis
ASA	Aminosalicylic acid
ASD	Atrial septal defect
AV	Aortic valve
AVA	Aortic valve area
AVNRT	Atrioventricular node reentry tachycardia
AVR	Aortic valve replacement
AVRT	Atrioventricular reentrant tachycardia
BARI	Bypass Angioplasty Revascularization Investigation
BARI 2D	Bypass Angioplasty Revascularization 2—Diabetes
BENESTENT	Belgium Netherlands Stent Study Group
BID	Twice daily
BIV-ICD	Biventricular implantable cardioverter defibrillator
BMI	Body mass index
BNP	Brain natriuretic peptide
BP	Blood pressure
bpm	Beats per minute
BSA	Body surface area
CABG	Coronary artery bypass graft/Coronary artery bypass grafting
CAD	Coronary artery disease
CARE-HF	Cardiac Resynchronization in Heart Failure
CASS	Coronary Artery Surgery Study
CBC	Complete blood count
CCS	Canadian Cardiovascular Society
CCU	Critical care unit
CHF	Congestive heart failure
CK	Creatine kinase
CK-MB	Creatine kinase myocardial fraction
CNS	Central nervous system
CO	Cardiac output

COMPANION	Comparison of Medical Therapy, Pacing, and Defibrillation in Heart Failure
COPD	Chronic obstructive pulmonary disease
COURAGE	Clinical Outcomes Utilizing Revascularization and Aggressive Drug Evaluation
CPR	Cardiopulmonary resuscitation
CREDO	Clopidogrel For Reduction of Events During Observation
CRP	C-reactive protein
CRT	Cardiac resynchronization therapy
CS	Coronary sinus
CT	Computed tomography
CURE	Clopidogrel in Unstable Angina to Prevent Recurrent Events
CV	Cardiovascular
CVA	Cerebrovascular accident
DANAMI	Danish Multicenter Randomized Study on Fibrinolytic Therapy Versus Acute Coronary Angioplasty in Acute Myocardial Infarction
DC	Direct current
DES	Drug-eluting stent
DINAMIT	Defibrillator in Acute Myocardial Infarction Trial
DM	Diabetes mellitus
DOE	Dyspnea on exertion
E/A	E:A wave ratio
EBCT	Electron beam computed tomography
ECG	Electrocardiographic/Electrocardiogram/Electrocardiography
ECSS	European Cooperative Surgery Study
ED	Emergency department/Emergency room
EECP	Enhanced external counterpulsation
EF	Ejection fraction
EOA	Effective orifice area
EP	Electrophysiology
ERASER	Evaluation of ReoPro and Stenting to Eliminate Restenosis
ET-A	Endothelin-A
ET-B	Endothelin-B
FA	Femoral artery
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
FDG	Fluorodeoxyglucose
FFV	Forward flow volume
FMD	Fibromuscular dysplasia
FREEDOM	Future Revascularization Evaluation in Patients with Diabetes
GISSI	Gruppo Italiano per lo Studio della Streptochinasi nell'Infarto Miocardico
GUSTO-I	Global Utilization of Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Artery
Hgb	Hemoglobin
HCM	Hypertrophic cardiomyopathy/Hypertrophic obstructive cardiomyopathy
HCTZ	Hydrochlorothiazide
HDL	High-density lipoprotein
HIT	Heparin-induced thrombocytopenia
HR	Heart rate
HRA	High right atrium
HTN	Hypertension
ICD	Implantable cardioverter defibrillator
ICH	Intracerebral hemorrhage

ICU	Intensive care unit
IE	Infective endocarditis
INR	International normalization ratio
ISHLT	International Society for Heart and Lung Transplantation
IU	International units
IV	Intravenous
IVC	Inferior vena cava
IVUS	Intravascular ultrasound
JVD	Jugular venous distention
JVP	Jugular venous pressure
LA	Left atrium
LAD	Left anterior descending
LAO	Left anterior oblique
LBBB	Left bundle branch block
LCA	Left coronary artery
LCX	Left circumflex
LDL	Low-density lipoprotien
LIMA	Left internal mammary artery
Lp(a)	Lipoprotein a
LSB	Left sternal border
L-TGA	Levo transposition of the great arteries
LV	Left ventricle/Left ventricular
LVAD	Left ventricular assist device
LVEDP	Left ventricular end diastolic pressure
LVH	Left ventricular hypertrophy
LVOT	Left ventricular outflow tract
MACE	Major adverse cardiac event
MADIT-II	Multicenter Automatic Defibrillator Implantation Trial II
MASS	Medicine, Angioplasty, or Surgery Study
MCA	Middle cerebral artery
mCi	milli Curies
MELLITUS	Optimal Management of Multivessel Disease
MET	Metabolic equivalent
MI	Myocardial infarction
MIRACLE	Multicenter InSync Randomized Clinical Evaluation
MPI	Myocardial perfusion imaging
MR	Mitral regurgitation
MRI	Magnetic resonance imaging
MS	Mitral stenosis
MUGA	Multiple gated acquisition/Multigated image acquisition analysis
MUSTT	Multicenter Unsustained Tachycardia Trial
MV	Mixed venous
MVA	Mitral valve area
MVR	Mitral valve replacement
NCEP	National Cholesterol Education Panel
NO	Nitrous oxide/Nitric oxide
NOS	Nitric oxide synthetase
NPH	Neutral Protamine Hagedorn
NRAF	National Registry of Atrial Fibrillation
NSAID	Nonsteroidal anti-inflammatory medication
NSTEMI	Non-ST elevation myocardial infarction

NTG	Nitroglycerine
NYHA	New York Heart Association
OM	Obtuse marginal
PA	Pulmonary artery
PABV	Percutaneous aortic balloon valvulotomy
PAF	Paroxysmal atrial fibrillation
PAH	Pulmonary artery hypertension
PAI-1	Plasminogen activator inhibitor 1
PAP	Pulmonary artery pressure
PCI	Percutaneous coronary intervention
PCWP	Pulmonary capillary wedge pressure
PET	Positron emission tomography
PFO	Patent foramen ovale
PMBV	Percutaneous mitral balloon valvotomy
PTCA	Percutaneous transluminal coronary balloon angioplasty/Percutaneous transluminal coronary angioplasty
PVC	Premature ventricular contraction
QTc	Corrected QT interval
RA	Right atrium
RAO	Right anterior oblique
RCA	Right coronary artery
REACT	Rescue Angioplasty Versus Conservative Treatment or Repeat Thrombolysis
REM	Rapid eye movement sleep
RF	Regurgitant fraction
RV	Right ventricle/Right ventricular
RVOT	Right ventricular outflow tract
RVSP	Right ventricular systolic pressure
SCD-HeFT	Sudden Cardiac Death in Heart Failure Trial
SEM	Systolic ejection murmur
SEP	Systolic ejection period
SHOCK	Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock
SIRIUS	Sirolimus-coated stent in treatment of de novo coronary artery lesions
SISR	Sirolimus Eluting Stents Versus Vascular Brachy Therapy for In-Stent Restenosis
SL NTG	Sublingual nitroglycerine
SR	Sarcoplasmic reticulum
STEMI	ST elevation myocardial infarction
SV	Stroke volume
SVC	Superior vena cava
SVT	Supraventricular Tachycardia
TD CO	Thermodilution cardiac output
TEE	Transesophageal echocardiogram/Transesophageal echocardiography
TGA	Transposition of the great arteries
TICM	Tachycardia-induced cardiomyopathy
TID	Three times daily
TIMI	Thrombolysis in myocardial infarction
TMET	Treadmill exercise test
TnI	Troponin I
TnT	Troponin T
tPA	Tissue plasminogen activator
TR	Tricuspid regurgitation
TTE	Transthoracic echocardiogram/Transthoracic echocardiography

TTP	Thrombotic thrombocytopenic purpura
TV	Total volume
TVI	Time-velocity integral
TVR	Tricuspid valve replacement
US	Ultrasound
VA	Veterans Administration
VANQWISH	Veterans Affairs Non-Q-Wave Infarction Strategies in Hospital
VF	Ventricular fibrillation
VLDL	Very low-density lipoprotein
VSD	Ventricular septal defect
VT	Ventricular tachycardia
vWF	von Willebrand factor
WBC	White blood cell count
XRT	Radiation therapy

Mayo Clinic Normal Blood Values

Acid base balance	
pH, venous	7.32–7.42
pCO_2, venous	41–51 torr
Std bicarbonate	21.3–24.8 mEq/L
pO_2, arterial	80–90 torr
Activated partial thromboplastin time	21–33 sec
Amiodarone	1.5–2.5 µg/mL (therapeutic range)
Desethylamiodarone	1.5–2.5 µg/mL (therapeutic range)
Angiotensin-converting enzyme	7.0–46.0 U/L
Atrial natriuretic factor	≥2 M: 20–77 pg/mL
C-reactive protein, high sensitivity	≤3 mg/L
Calcium, total	Male: ≥22 Y: 8.9–10.1 mg/dL Female: ≥19 Y: 8.9–10.1 mg/dL
Catecholamines, fractionation	
Norepinephrine	Supine: 70–750 pg/mL Standing: 200–1700 pg/mL
Epinephrine	Supine: 0–110 pg/mL Standing: 0–140 pg/mL
Dopamine	Supine: <30 pg/mL Standing: <30 pg/mL
Chemistry group	
Sodium	135–145 mEq/L (same in children age 1 and older)
Potassium	3.6–4.8 mEq/L (higher in children age 1–16)
Calcium	8.9–10.1 mg/dL (higher in children age 1 and older)
Phosphorus	2.5–4.5 mg/dL (higher in children age 1 and older)
Protein, total	6.3–7.9 g/dL (same in children age 1 and older)
Glucose	70–100 mg/dL (same in children age 1 and older)
Alkaline phosphatase	Male: 98–251 U/L (higher in children) Female: 17 Y–23 Y: 114–312 U/L 24 Y–45 Y: 81–213 U/L 46 Y–50 Y: 84–218 U/L 51 Y–55 Y: 90–234 U/L 56 Y–60 Y: 99–257 U/L

	61 Y–65 Y:	108–282 U/L
	≥66 Y:	119–309 U/L
	(higher in children)	
AST (GOT)	Male:	
	12–31 U/L (higher in children)	
	Female:	
	≥14 Y:	12–31 U/L (higher in children)
Bilirubin, total	0.1–1.0 mg/dL (lower in children)	
Bilirubin, direct	0–0.3 mg/dL	
Uric acid	Male: 4.3–8.0 mg/dL	
	Female: 2.3–6.0 mg/dL	
Creatinine	Male: 0.9–1.4 mg/dL	
	Female: 0.7–1.2 mg/dL	
Albumin	3.5–5.0 g/dL (same in children age 1 and older)	

Cholesterol

Total	Desirable:	<200 mg/dL
	Borderline high:	200–239 mg/dL
	High:	≥240 mg/dL
Low-density cholesterol (LDL)	Optimal:	<100 mg/dL
	Low Risk:	100–129 mg/dL
	Borderline high:	130–159 mg/dL
	High:	160–189 mg/dL
	Very high:	≥190 mg/dL
High-density cholesterol (HDL)	Low HDL:	<40 mg/dL
	Normal:	40–60 mg/dL
	Desirable:	>60 mg/dL

CK-MB ≤6.2 ng/mL

Cyclosporine 100–400 ng/mL

D-dimer

D-dimer, P	<301 ng/mL
D-dimer, P, manual	<250 µg/L

Digoxin 0.5–2.0 ng/mL

Hematology group (adult)

	Male	Female	Units
Hemoglobin	13.5–17.5	12.0–15.5	g/dL
Hematocrit	38.8–50.0	34.9–44.5	%
Erythrocytes	4.32–5.72	3.90–5.03	$\times 10^{12}$/L
MCV	81.2–95.1	81.6–98.3	fL
Leukocytes	3.5–10.5	3.5–10.5	$\times 10^{9}$/L
Neutrophils	1.7–7.0	1.7–7.0	$\times 10^{9}$/L
Lymphocytes	0.9–2.9	0.9–2.9	$\times 10^{9}$/L
Monocytes	0.3–0.9	0.3–0.9	$\times 10^{9}$/L
Eosinophils	0.05–0.50	0.05–0.50	$\times 10^{9}$/L
Basophils	0–0.3	0–0.3	$\times 10^{9}$/L
Platelet count	150–450	150–450	$\times 10^{9}$/L

Homocysteine
Total ≤13 µmol/L

Lidocaine 2–5 µg/mL (therapeutic range)

Metanephrine, fractionated, free
Normetanephrine, free <0.90 nmol/L
Metanephrine, free <0.50 nmol/L

Mexiletine 0.75–2.00 µg/mL (therapeutic range)

Procainamide
Procainamide 4–8 µg/mL (therapeutic range)
N-Acetyl procainamide <30 µg/mL (therapeutic range)
Procainamide + NAPA ≤30 µg/mL (therapeutic range)

Propafenone 0.5–2.0 µg/mL (therapeutic range)

Propranolol 50–100 ng/mL (therapeutic range)

Prothrombin time 8.4–12.0 sec
INR INR = International Normalized Ratio for monitoring stable warfarin anticoagulation
Suggested INR therapeutic ranges*

Intensity	
Standard	Higher**
2.0–3.0	2.5–3.5

*Target INR should be individualized.
Occasionally, INR range 3.0–4.5 may be appropriate.
**Higher intensity INR: Mechanical heart valve, etc.

Quinidine 2.0–5.0 µg/mL (therapeutic range)

Renin
Sodium depleted upright
18–39 Y: Mean = 10.8
Range = 2.9–24.0 ng/mL/h
≥40 Y: Mean = 5.9
Range = 2.9–10.9 ng/mL/h
Sodium replete upright
18–39 Y: Mean = 1.9
Range = ≤0.6–4.3 ng/mL/h
≥40 Y: Mean = 1.0
Range = <0.6–3.0 ng/mL/h

Sedimentation rate
Male: 0–22 mm/1h
Female: 0–29 mm/1h

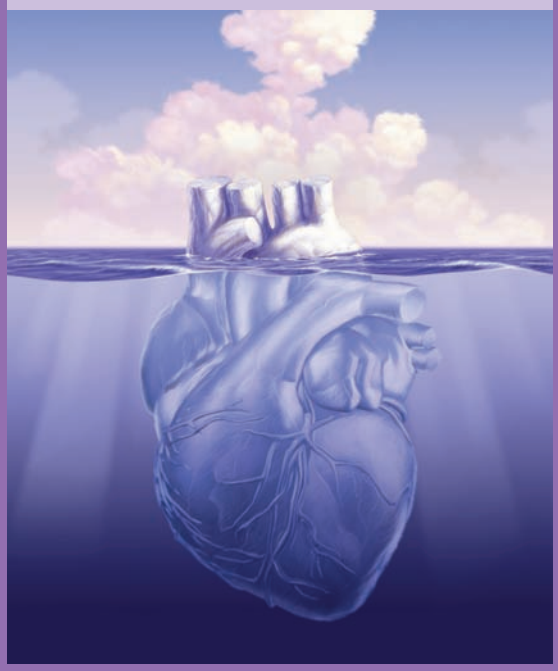
Sirolimus 4.0–20.0 ng/mL

Thyroid-stimulating hormone (sTSH)	0.30–5.0 mIU/L
Thyroxine, total	Male: 5.0–12.5 µg/dL Female: 5.0–12.5 µg/dL
Triiodothyronine (T3)	80–180 ng/dL
Troponin T	≤0.03 ng/mL

SECTION I

Cardiac Electrophysiology

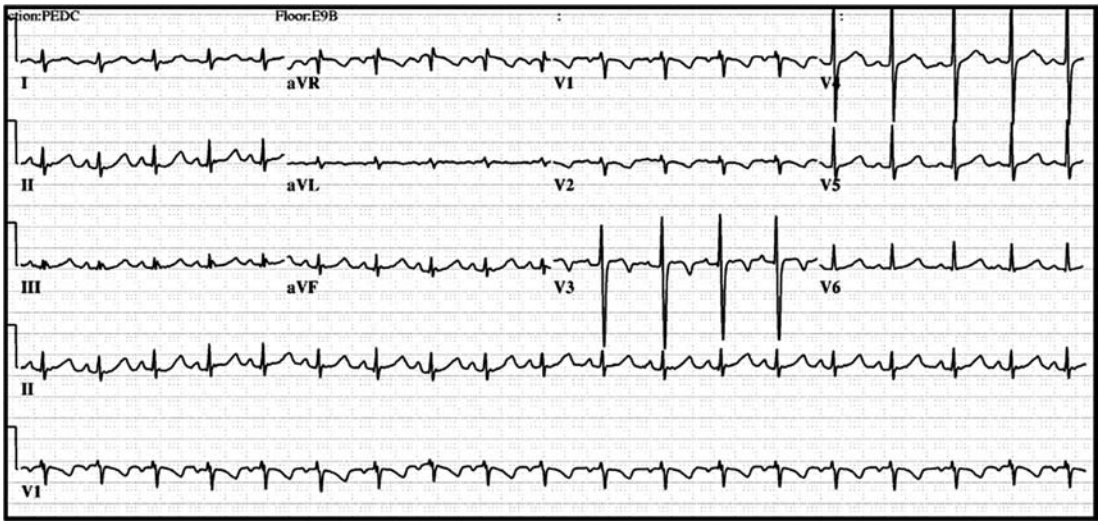
T. Jared Bunch, MD



Questions

1. A 16-year-old female was admitted to the coronary care unit after an aborted sudden cardiac death. The patient was awakened to answer a telephone call and suddenly collapsed. The fall was witnessed and a rapid 911 call allowed the paramedics to arrive within 5 minutes. The patient was in VF and was successfully defibrillated with one shock. She remained comatose and was intubated and transported to the hospital.

On physical exam she was intubated and withdrew to painful stimuli. Her pupils were dilated, but reactive to light symmetrically. Her past medical history is remarkable for 3 brief fainting episodes. She was not using any prescription medication. The mother denied knowledge of substance abuse. Her family history is notable for a sister who died suddenly at the age of 20.



What is the most likely diagnosis at this time?

a. HCM
b. Brugada syndrome
c. Idiopathic VF
d. RVOT tachycardia
e. Long QT syndrome

2. Based upon the above patient presentation what subtype of long QT syndrome is expected?

a. Long QT syndrome 1
b. Long QT syndrome 2
c. Long QT syndrome 3
d. Jervell and Lange-Nielsen syndrome
e. Timothy syndrome

Answers to this section start on page 35.

3. Within the first 24 hours of hospitalization the patient recovers quickly until there are no apparent neurologic deficits. She provides no additional history and reports no symptoms prior to the cardiac arrest. What is the next step in her management?

   a. Left cardiac sympathetic denervation
   b. Dual-chamber permanent pacemaker
   c. Amiodarone
   d. Single-chamber ICD
   e. Atenolol

4. What is the most common mechanism involved in clinically important cardiac arrhythmias?

   a. Triggered activity
   b. Abnormal automaticity
   c. Reentry
   d. Early afterdepolarizations
   e. Parasystole

5. Torsades de pointes is characterized by all of the following **except:**

   a. Results from triggered activity (early afterdepolarizations) that occurs during phase 2 or 3 of the cardiac action potential
   b. Prolonged QT interval
   c. Exacerbation by bradycardia with short-long coupling intervals
   d. Polymorphic VT
   e. Often provoked during amiodarone administration

6. Which one of the following currents is responsible for maintaining stable resting membrane potential in the atrial and ventricular cells?

   a. I_f
   b. I_{Na}
   c. I_{Kl}
   d. I_K
   e. I_{Ca}

7. The I_{KATP} is a potassium channel that is inhibited by physiologic intracellular concentrations of ATP. How is this channel activated?

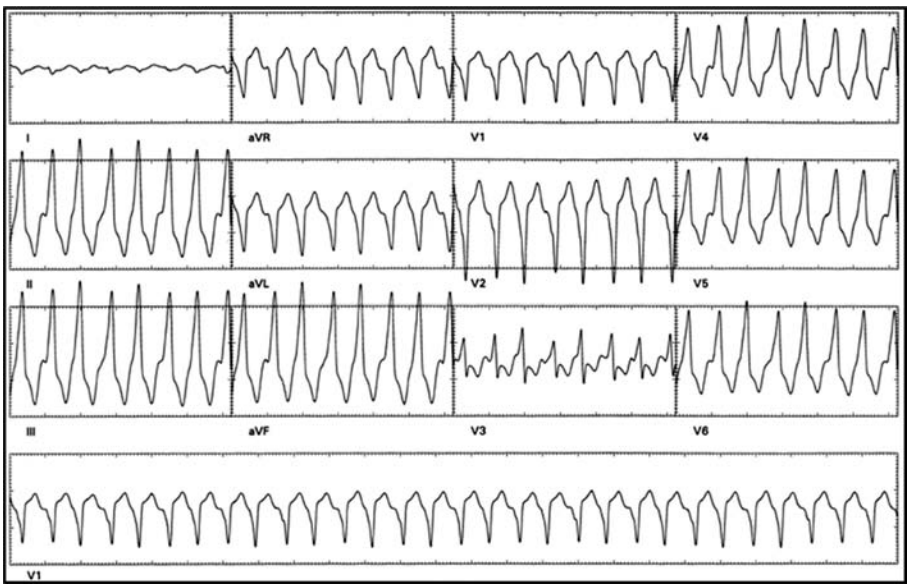
   a. A consequence of I_f activation that enhances pacemaker activity
   b. Physical opening of the channel pore by the N-terminal portion of the channel
   c. Chemical ligand binding in response to depletion of ATP from ischemia
   d. Conformational changes in channel structure
   e. The channel is only inhibitory and is not activated

8. The sinus node is predominantly characterized by depolarization in which phase of the action potential?

   a. Phase 0
   b. Phase 1
   c. Phase 2
   d. Phase 3
   e. Phase 4

9. A 26-year-old man is referred to the arrhythmia clinic for evaluation of exercise-induced palpitations. He denies presyncope or syncope during these episodes. He had no other significant medical history. He has no family history of cardiomyopathy, arrhythmia, or sudden death. An ECG, echocardiogram, and 24 hour ambulatory Holter monitor were all within normal limits.

During TMET, the wide complex tachycardia was induced. The 12 lead ECG is shown. The patient reports palpitations without lightheadedness.



ECG provided by Dr. John D. Day

What is the most likely clinical diagnosis?

a. RVOT tachycardia
b. Wolff-Parkinson-White syndrome
c. Atrial flutter with rapid ventricular response
d. Sinus tachycardia with aberrancy
e. Scar-mediated VT

10. What treatment should be considered for this patient?

a. ICD
b. Beta blocker
c. Digoxin
d. Referral for catheter ablation of a ventricular arrhythmogenic focus
e. Referral for catheter ablation of the caval-tricuspid isthmus

11. Which one of the following antiarrhythmic agents does **not** prolong the QT interval?

a. Quinidine
b. Lidocaine
c. Sotalol
d. Procainamide
e. Ibutilide

12. Which one of the following antiarrhythmic agents has the **least** effect on slowing conduction through the AV node?

a. Calcium channel blockers
b. Beta blockers
c. Amiodarone
d. Lidocaine
e. Sotalol

13. Which of the following antiarrhythmic agents may promote AF?

a. Adenosine
b. Quinidine
c. Propafenone
d. Amiodarone
e. Atenolol

14. Which one of the following antiarrhythmic agents is **least** likely to cause torsades de pointes?

a. Quinidine
b. Procainamide
c. Flecainide
d. Ibutilide
e. Sotalol

15. All of the following statements regarding the AV node are true **except:**

a. Conduction through the node displays decremental behavior
b. It is positioned in the subendocardium at the base of the triangle of Koch
c. It is composed of nodal cells and transitional cells
d. It is a right atrial structure

16. In which of the following tissues is the upstroke of the action potential generated by ingoing calcium currents?

a. Atrial
b. AV node
c. His-Purkinje
d. Ventricular

17. Conduction velocity is most rapid in which tissue?

a. Atrial
b. AV node
c. His-Purkinje
d. Ventricular

18. Repolarization of the myocardial cells is determined mostly by which current?

a. Outgoing sodium
b. Ingoing calcium
c. Outgoing potassium
d. Ingoing chloride
e. Ingoing sodium

19. All of the following statements regarding AV nodal cells are true **except:**

a. The resting membrane potential is typically −80 to −90 mV
b. The activation threshold ranges between −30 and −40 mV
c. The upstroke of the action potential is carried by inward calcium current
d. Conduction in the AV node proceeds at a velocity of 0.01 to 0.1 m/sec

20. Vagal stimulation in each of the following tissue types changes the action potential duration **except** in which cardiac structure?

a. AV node
b. His-Purkinje system
c. Ventricular myocardium
d. Atrial myocardium

21. Early afterdepolarizations are favored by:

a. High potassium concentrations
b. Type III antiarrhythmic drugs
c. Fast underlying HR
d. Increased magnesium concentrations

22. The underlying arrhythmia mechanism most likely present in digitalis toxicity is:

a. Reentry
b. Delayed afterdepolarizations
c. Enhanced automaticity
d. Early afterdepolarizations

23. Which of the following contain the normal A–H and H–V intervals?

a. 40–80 msec, 35–60 msec
b. 60–120 msec, 35–60 msec
c. 60–120 msec, 25–50 msec
d. 60–100 msec, 60–80 msec

24. Patients with the Wolff-Parkinson-White syndrome typically show each of the following features **except:**

a. A wide QRS complex during normal sinus rhythm
b. A narrow complex SVT
c. A delta wave on the surface QRS
d. A long H–V interval on the His-bundle recording

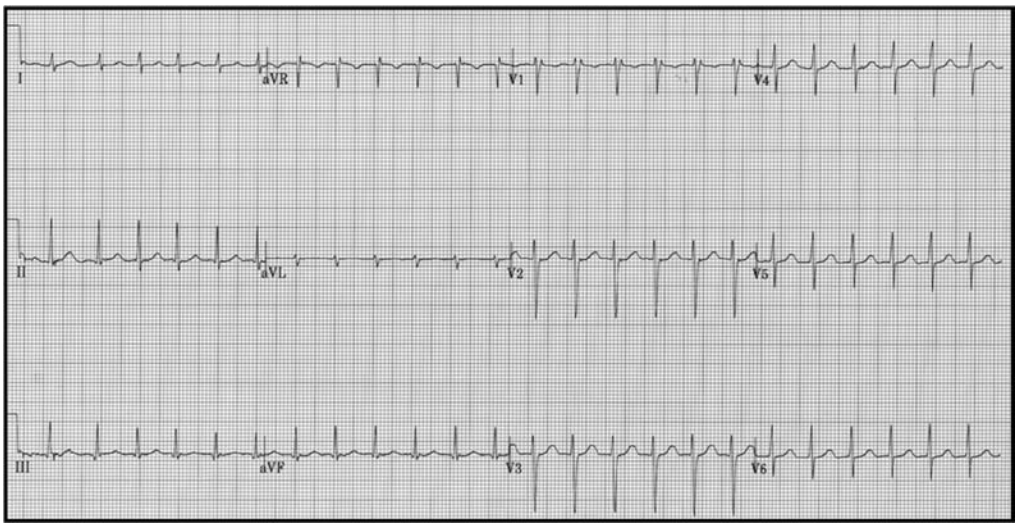
25. Prerequisite conditions of the reentrant arrhythmia include all of the following **except:**

a. Two functionally distinct conducting pathways
b. An anatomical obstacle around which the impulse reenters
c. Unidirectional block in one pathway
d. Slow conduction via one pathway with return via the second

26. Antidromic reciprocating tachycardia in a patient with Wolff-Parkinson-White refers to:

- **a.** AV conduction proceeding via the normal AV conduction system with return via the accessory pathway
- **b.** AV conduction via the accessory pathway with return via the normal ventriculoatrial conduction system
- **c.** AVNRT with additional conduction via the accessory pathway
- **d.** None of the above

27. A 24-year-old female presents with recurrent palpitations. There is no pattern to what triggers the arrhythmia, but she is typically able to terminate it by performing a Valsalva-type maneuver. She has no significant past medical history. She denies alcohol or illicit drug use. There is no family history of arrhythmia, sudden death, or cardiomyopathy. The baseline ECG and echocardiogram are normal. The following ECG was obtained when the patient presented to the ED with persistent palpitations.



What is the most likely diagnosis based upon the clinical history and ECG?

- **a.** Antidromic reciprocating tachycardia
- **b.** Atrial flutter with rapid ventricular response
- **c.** Inappropriate sinus tachycardia
- **d.** AVNRT
- **e.** His-Purkinje extrasystoles

28. Patients with the tachycardia in Question 27 usually have:

- **a.** Dual AV nodal physiology
- **b.** A concealed accessory pathway
- **c.** Retrograde atrial activation spreading from the free wall of the AV groove to the septum
- **d.** A wide QRS complex during tachycardia that narrows at lower HR
- **e.** Structural heart disease

29. The most common mechanism of arrhythmia in sustained VT is:

- **a.** Sympathetically facilitated enhanced automaticity
- **b.** Reentry involving ventricular myocardium
- **c.** Triggered automaticity arising from early afterdepolarizations
- **d.** Reflection of propagated impulses

30. A 54-year-old man is referred to you due to an enlarged cardiac silhouette discovered on routine chest X-ray as part of his employment physical exam. He reports no known past medical history. Although he denies symptoms of overt heart failure, he states that he tends to become short of breath with strenuous activity—a symptom that he felt was due to lack of exercise.

On physical examination he has a displaced apical impulse and a third heart sound. An ECG shows sinus rhythm with a LBBB. An echocardiogram discloses global LV dysfunction with an EF of 25% and mild functional mitral valve regurgitation. Coronary angiography is normal. A 24-hour Holter monitor shows 35,000 PVCs and 85 runs of nonsustained VT, 3 to 9 beats in duration.

What is the next appropriate test?

a. EP study
b. RV biopsy
c. Serum ferritin
d. Signal average ECG
e. No further testing is required; schedule the patient to receive an ICD

31. All of the following clinical characteristics are associated with cardiogenic syncope and should prompt referral for an invasive EP study **except:**

a. Age >65 years
b. History of CHF
c. Bundle branch block
d. History of ventricular arrhythmias
e. Recurrent unexplained falls in a 70-year-old patient

32. A 38-year-old man underwent radiofrequency ablation in the RA for medically refractive symptomatic atrial tachycardia. He was dismissed on aspirin 325 mg/day. Six days following the procedure he developed left-sided persistent chest pain and mild dyspnea. His exam is notable only for tachycardia with a HR of 110 bpm. An ECG discloses sinus tachycardia. What is the next most appropriate test to request?

a. Echocardiogram
b. CT scan
c. Coronary angiography
d. Arterial blood gas, D-Dimer
e. Ventilation perfusion scan

33. All the following are true about head-up tilt testing **except:**

a. The test should be performed at 60 to 80 degrees
b. Sensitivity and specificity of the test are approximately 80%
c. A vasodepressor response occurs most often in patients younger than 60
d. In patients without structural heart disease, it can provide a diagnosis in approximately 60% of them
e. A cardioinhibitory response tends to be infrequent in older patients

34. The arrhythmic substrate **least** likely to be definitely ruled out with a negative EP study is:

a. Sinus node dysfunction
b. Severe His-Purkinje disease
c. Accessory bypass tract
d. VT in a patient with ischemic cardiomyopathy
e. AVNRT

35. An active 78-year-old woman with recurrent syncope has an EP study. With atrial pacing at 150 bpm for 30 sec, a 7-sec atrial pause occurs when the pacing ceases. Her baseline examination and echocardiogram are all within normal limits. ECG shows sinus rhythm with first degree AV block. What is the next appropriate management step?

a. Implant a VVI single-chamber permanent pacemaker
b. Implant a dual-chamber ICD
c. Implant a DDDR dual-chamber rate responsive pacemaker
d. Implant an AAI single-chamber permanent pacemaker
e. Medical management with atropine

36. Programmed ventricular stimulation is an important tool in risk assessment in patients with CAD for which of the following patient subsets?

a. An EF of 30% to 35% and the presence of nonsustained VT
b. An EF of 35% to 40% and the presence of nonsustained VT
c. An EF of 30% to 35% and an abnormal signal averaged ECG
d. An EF of 35% to 40% and a history of cardiac arrest

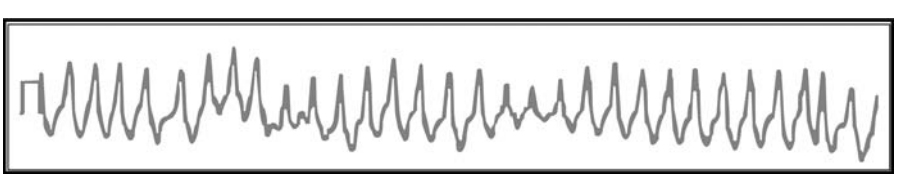
37. All of the following examples are considered positive responses to a drug in a patient with an expected cardiac channelopathy **except:**

a. A decreased QT interval with lidocaine in a patient suspected to have long QT3
b. An increased QT interval with epinephrine in a patient suspected to have long QT1
c. Abnormal ST-T changes in leads V1–V2 with procainamide in a patient suspected to have Brugada syndrome
d. An increased QT interval with notched T waves with epinephrine in a patient suspected to have long QT2
e. An increased QT interval with ajmaline in a patient suspected to have long QT4

38. Acute success rates for ablation of accessory pathways could be stated as:

a. 50% to 70%
b. 75%
c. 85%
d. 90% to 95%
e. Virtually 100%

39. A 69-year-old woman presents to the ED with palpitations, lightheadedness, and no other symptoms. She denies syncope. She had no additional past medical history. The following rhythm strip is obtained. Her BP is 110/70 mmHg, she is mildly uncomfortable with her palpitations, but otherwise her exam is within normal limits.



Telemetry strip provided by Dr. Paul A. Friedman

What is the next step in her acute and then chronic management?

a. Adenosine and then radiofrequency ablation
b. Lidocaine and then coronary angiogram and EP testing
c. DC cardioversion and then ICD implantation without further testing
d. Procainamide and then radiofrequency ablation
e. Procainamide and then amiodarone

40. The following findings are considered positive results during EP testing **except:**

a. A >3 sec pause, a fall in BP >50 mmHg with symptoms, or syncope with carotid sinus massage
b. A >3 sec asystole, hypotension <60 mmHg, syncope with head up tilt
c. Sinus node recovery time >2 sec
d. A corrected sinus node recovery time >525 sec
e. An H–V interval 55 to 75 msec

41. A patient has a loss of function mutation in KCNQ1. This patient is most likely to have events triggered by:

a. Swimming
b. Doorbells
c. The postpartum period
d. Sleeping

42. Efforts to identify patients with concealed long QT syndrome (genotype positive and resting ECG negative) are improved by which testing and response?

a. Exercise testing with failure to lengthen the QT interval appropriately
b. Paradoxical lengthening of the QT interval with low-dose epinephrine infusion
c. EP testing with induction of polymorphic VT with ventricular extra stimuli
d. No further testing is required in these patients unless they experience syncope

43. Which of the following sports can be played in patients with long QT syndrome?

a. Golf
b. Cricket
c. Bowling
d. Billiards
e. All of the above

44. Each of the following statements about Romano-Ward syndrome is true, **except:**

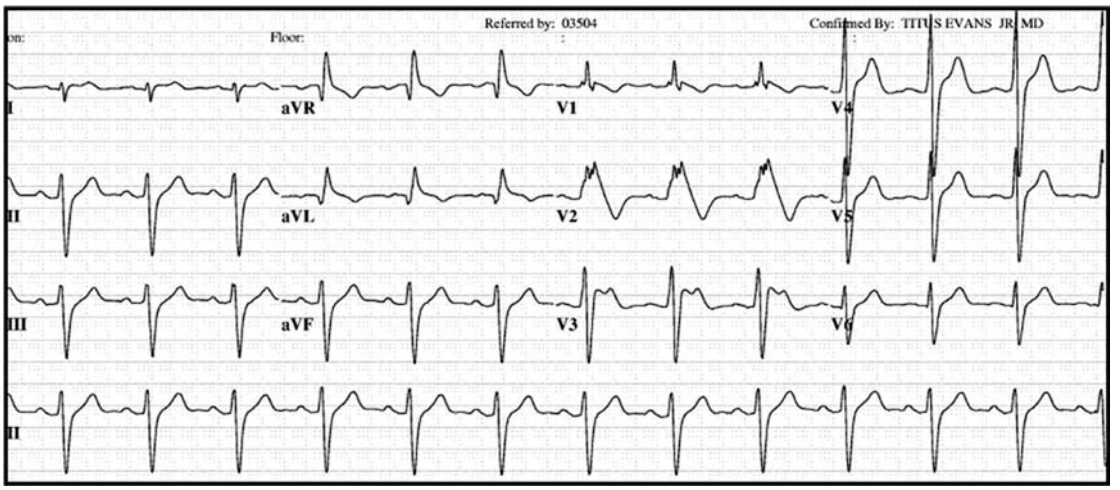
a. It is a heterogeneous disorder involving mutations in different ion channels
b. It is inherited as an autosomal recessive disorder
c. It is associated with sudden cardiac death in young patients
d. It is not associated with congenital deafness
e. It is more frequent than the Jervell and Lange-Nielsen syndrome

45. Treatments of drug-induced prolongation of QT interval and torsades de pointes include all of the following **except:**

a. Withdrawal of the offending agent
b. Correction of electrolyte and acid-base disturbance
c. IV magnesium
d. IV isoproterenol infusion or temporary pacing
e. IV beta blocker

46. A 23-year-old male with no known medical history suddenly collapsed while playing a vigorous game of ultimate Frisbee. His friends immediately started CPR and called 911. The paramedics arrived within 5 minutes and found him in VF. He was defibrillated successfully with one shock with return of spontaneous circulation. He was transported to the hospital for subsequent care.

The following ECG was obtained upon arrival to the hospital:



What is the most likely diagnosis?

a. Short QT syndrome
b. Long QT syndrome
c. Brugada syndrome
d. Catecholaminergic polymorphic VT
e. Timothy syndrome

47. The patient in Question 46 makes a complete neurologic recovery. An echocardiogram is within normal limits. What is the next appropriate step in management?

a. Start a beta blocker and restrict him from participation in competitive sports
b. EP testing with administration of a class 1 antiarrhythmic (flecainide and procainamide) to determine risk of sudden death
c. Exercise testing to assess if his QT shortens appropriately
d. Implant an ICD
e. Implant a dual-chamber pacemaker