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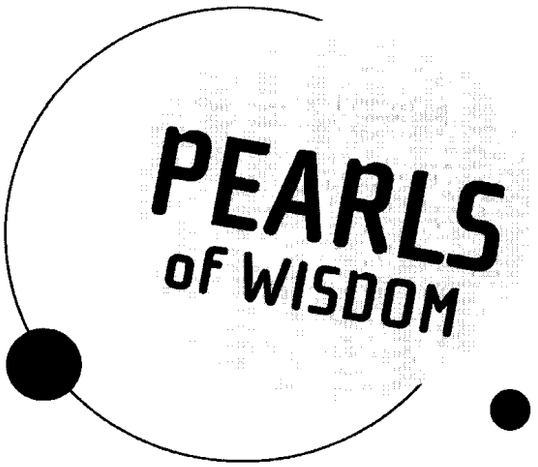
Michael Zevitz



Cardiology
BOARD REVIEW

Second Edition

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DEDICATION

To my wife Joan, the love of my life, and to my children
Erica and Laurel, who have each, in their own way,
taught me to give it my all in everything that I do.

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INTRODUCTION

Congratulations! *Cardiology Board Review: Pearls of Wisdom*, Second Edition, will help you learn some Cardiology. Originally designed as a study aid to improve performance on the Cardiovascular Disease Written Boards/Recertification. This book is full of useful information. While intended for Cardiology specialists, we have learned that this unique format is also useful for Cardiology Fellows, as well as housestaff and medical students rotating through Cardiology. A few words are appropriate discussing intent, format, limitations, and use.

Since *Cardiology Board Review* is primarily intended as a study aid, the text is written in rapid-fire question/answer format. This way, readers receive immediate gratification. Moreover, misleading or confusing "foils" are not provided. This eliminates the risk of erroneously assimilating an incorrect piece of information that makes a big impression. Questions themselves often contain a "pearl" intended to reinforce the answer.

Additional "hooks" may be attached to the answer in various forms, including mnemonics, visual imagery, repetition, and humor. Additional information not requested in the question may be included in the answer. Emphasis has been placed on distilling trivia and key facts that are easily overlooked, that are quickly forgotten, and that somehow seem to be needed on board examinations.

Many questions have answers without explanations. This enhances ease of reading and rate of learning. Explanations often occur in a later question/answer. Upon reading an answer, the reader may think, "Hmm, why is that?" or, "Are you sure"? If this happens to you, go check! Truly assimilating these disparate facts into a framework of knowledge absolutely requires further reading on the surrounding concepts.

Information learned in response to seeking an answer to a particular question is retained better than information that is passively observed. Take advantage of this! Use *Cardiology Board Review* with your preferred source texts handy and open. This book does have limitations. We have found many conflicts between sources of information. We have tried to verify in several references the most accurate information. Some texts have internal discrepancies further confounding clarification.

Cardiology Board Review risks accuracy by aggressively pruning complex concepts down to the simplest kernel; the dynamic knowledge base and clinical practice of Cardiology is not like that! Furthermore, new research and practice occasionally deviates from that which likely represents the correct

answer for test purposes. This text is designed to maximize your score on a test. Refer to your most current sources of information and mentors for direction for practice.

Cardiology Board Review is designed to be used, not just read. It is an *interactive* text. Use a 3 x 5 card and cover the answers; attempt all questions. A study method we recommend is oral, group study, preferably over an extended meal or pitchers. The mechanics of this method are simple and no one ever appears stupid. One person holds the book, with answers covered, and reads the question. Each person, including the reader, says "Check" when he or she has an answer in mind. After everyone has "checked" in, someone states his/her answer. If this answer is correct, on to the next one; if not, another person says their answer or the answer can be read. Usually, the person who "checks" in first gets the first shot at stating the answer. If this person is being a smarty-pants answer-hog, then others can take turns. Try it, it's almost fun! *Cardiology Board Review* is also designed to be re-used several times to allow, dare we use the word, memorization. Open round bullets are provided for any scheme of keeping track of questions answered correctly or incorrectly.

We welcome your comments, suggestions and criticism. Great effort has been made to verify these questions and answers. Some answers may not be the answer you would prefer. Most often this is attributable to variance between original sources. Please make us aware of any errors you find. We hope to make continuous improvements and would greatly appreciate any input with regard to format, organization, content, presentation, or about specific questions. We also are interested in recruiting new contributing authors and publishing new textbooks. We look forward to hearing from you! Study hard and good luck!

M.E.Z.

TABLE OF CONTENTS

PHYSICAL EXAMINATION OF THE HEART AND CIRCULATION

❍ **How many phases does the jugular venous pulse have?**

Three, if the patient is in sinus rhythm.

❍ **What is hepatojugular reflux and what is its significance?**

When there is right ventricular failure, sustained compression of the abdomen will cause the central venous pressure to rise. The venous neck pulses will become more prominent and their level will ascend in the neck. This is a characteristic sign of congestive heart failure, the most common cause of increased level of venous pressure in the neck veins and of exaggerated venous pulses.

❍ **What is the effect of changing posture on carotid arterial pulses?**

Carotid pulses are relatively unaffected by changing posture.

❍ **What is the normal ascendancy of jugular venous pulses?**

With the patient's thorax and head elevated at 45 degrees from the horizontal, the venous pulses should ascend no more than 1 or 2 cm above the level of the manubrium sterni.

❍ **What is the significance of jugular venous distention?**

Jugular venous distention is a clinical measure of central venous pressure and right atrial pressure. For each centimeter of venous pulse ascension, greater than 2 cm above the manubrium sterni, this represents approximately 1 mmHg of increased pressure in the right atrium. Since the normal right atrial pressure ranges from 6-12 mmHg, a jugular venous pulse of 5 cm above the clavicle would represent a right atrial pressure of approximately 15 mmHg.

❍ **What other conditions, besides congestive heart failure, does a positive hepatojugular reflux occur?**

Constrictive pericarditis, inferior vena caval obstruction, severe tricuspid regurgitation, cardiac tamponade, massive pulmonary embolus, and superior vena cava syndrome.

❍ **What is the *a* wave of the venous pulse caused by?**

The "a" wave of the venous pulse is caused by atrial contraction. It is absent in atrial fibrillation, and in atrial flutter, may be replaced by rapid smaller oscillations which occur approximately 300 times per minute.

❍ **What is the *c* wave of the venous pulse?**

This is still in dispute, but is felt to be the result of the bulging of the tricuspid valve at the beginning of ventricular systole. It may also be augmented by the underlying carotid arterial pulse.

❍ What is the *v* wave of the venous pulse?

The *v* wave is a passive filling wave as blood from the periphery enters the atrium in the latter part of ventricular systole. Large V waves occur in severe mitral regurgitation, severe mitral stenosis, severe right-to-left shunts (Eisenmenger's syndrome) and in severe aortic stenosis with marked CHF.

❍ What is the x descent?

The x descent is produced by atrial diastole.

❍ What is the y descent?

The y descent occurs on opening of the tricuspid valve and filling of the right ventricle from the right atrium.

❍ What conditions result in a large "a" wave?

Any condition that results in pulmonary hypertension that is transmitted back to the right ventricle and right atrium. These conditions include severe mitral regurgitation, cor pulmonale, pulmonary embolism and severe dilated cardiomyopathy. Other conditions include tricuspid stenosis, tricuspid atresia and large atrial septal defects. Certain arrhythmias can also result in large "a" waves. These include complete AV block, AV dissociation, and atrial and nodal extrasystoles. These arrhythmias produce *irregular* cannon "a" waves, as opposed to the *regular* large "a" waves of the other above-mentioned conditions.

❍ What is the significance of large c-v waves?

It is a sign of significant tricuspid regurgitation. They may also occur in the presence of atrial fibrillation in the absence of tricuspid regurgitation.

❍ What is Kussmaul's sign and what is its significance?

Kussmaul's sign is when there is jugular venous distention on inspiration, rather than the expected fall in venous pulse during inspiration. While it is not diagnostic of constrictive pericarditis, it occurs very commonly in constrictive pericarditis and uncommonly in pericardial tamponade, a feature that helps to clinically differentiate the two conditions. Kussmaul's sign can also occur in congestive heart failure.

❍ What other abnormality occurs in constrictive pericarditis and what other conditions can it occur in?

A prominent y descent. A prominent x descent is also occasionally found. Again, a prominent y descent is not diagnostic of constrictive pericarditis, but it is a prominent feature in the disorder and is uncommon in cardiac tamponade.

❍ What conditions are bounding arterial pulses found?

1. anxiety
2. aortic insufficiency
3. patent ductus arteriosus, the commonest cause in children
4. left-to-right intracardiac shunts such as sinus of Valsalva aneurysm with rupture into the right heart or coronary arteriovenous fistula
5. thyrotoxicosis
6. severe anemia
7. hyperkinetic heart syndrome
8. beriberi
9. systemic AV fistula

10. complete AV block
11. severe peripheral vascular disease
12. hypertrophic cardiomyopathy, particularly of the obstructive type

❍ **What is the significance of pulsus bisferiens?**

It is characterized by a double systolic impulse and is most prominent over the carotid artery. It is most common in combined aortic stenosis and insufficiency, but can be seen in patients with isolated aortic insufficiency and obstructive hypertrophic cardiomyopathy.

❍ **What is pulsus tardus and what is its significance?**

Pulsus tardus is a delayed, slow carotid upstroke that is typically found in severe aortic stenosis.

❍ **What is pulsus paradoxus and what conditions is it found in?**

Pulsus paradoxus is an exaggerated inspiratory fall in blood pressure during quiet breathing. When the inspiratory fall in systolic blood pressure exceeds 8-10 mmHg, it is abnormal. It occurs in constrictive pericarditis in a third to one-half of cases. It occurs in an overwhelming majority of cases of cardiac tamponade. It also occurs in asthma and emphysema, and rarely in cardiomyopathy.

❍ **Which valve closes first in the cardiac cycle in a normal patient, the mitral valve or tricuspid valve?**

The mitral valve.

❍ **What conditions cause a loud first heart sound (S1)?**

Mitral stenosis (unless very severe), short PR interval, exercise, tachycardia, anemia and hyperthyroidism.

❍ **What conditions cause a faint first heart sound (S1)?**

Very severe mitral stenosis (virtually immobile valve leaflets, mitral insufficiency, 1° AV block, and severe hypertension.

❍ **What conditions is there wide splitting of the second heart sound?**

Right bundle branch block, pulmonic stenosis and atrial septal defect (due to late closure of the pulmonic valve), and mitral insufficiency and ventricular septal defect (due to early closure of the aortic valve).

❍ **What condition causes fixed splitting of the second heart sound?**

Atrial septal defect.

❍ **What conditions cause paradoxical splitting of the second heart sound?**

Left bundle branch block, aortic stenosis, patent ductus arteriosus, obstructive hypertrophic cardiomyopathy and occasionally during myocardial ischemia.

❍ **What conditions cause narrow splitting of the second heart sound?**

Right-to-left intracardiac shunt with right heart failure (Eisenmenger's complex).

❍ **What is an opening snap and what is the significance of the time between the second heart sound and the opening snap?**

An opening snap is heard in 90% of patients with mitral stenosis and is a sharp, high-pitched closure sound heard best at the apex, after the second heart sound. The shorter the duration between the second heart sound and the opening snap, the more severe the mitral stenosis and the higher the left atrial pressure.

❍ **What is the murmur of aortic stenosis?**

A systolic ejection, crescendo-decrescendo murmur, heard best at the apex and aortic area, radiating to the carotids and unchanged by respiration. The murmur increases in intensity with increased inotropy, increased preload and increased afterload.

❍ **What is the murmur of mitral stenosis?**

A low-pitched diastolic rumble with an opening snap, best heard at the apex.

❍ **What is the murmur of aortic regurgitation?**

A decrescendo, high-pitched diastolic murmur heard best at the lower left sternal border, starting almost with the second heart sound.

❍ **What is the murmur of mitral regurgitation?**

A holosystolic, high-pitched murmur that starts with the first heart sound and continues through the second heart sound, best heard at the apex and radiates either to the axilla or lower left sternal border.

❍ **What is the murmur of mitral valve prolapse?**

A mid-systolic high-pitched murmur best heard at the apex and left sternal border, accompanied by one or more systolic clicks in half the cases.

❍ **What is a pericardial friction rub and what does it sound like?**

A pericardial friction rub is a high-pitched, scratchy, almost sandpaper-like sound with two or three components, occurring in both systole and diastole, that occurs in pericarditis, and is best heard with the patient leaning forward or lying prone in deep expiration. Pericardial friction rubs may disappear and return within minutes.

CARDIAC HEMODYNAMICS AND FUNCTION

❍ **What is the significance of large pulmonary V waves on the pulmonary capillary wedge tracing?**

Abnormally large V waves, greater than 10 mmHg greater than the mean pulmonary wedge pressure, represent filling of the left atrium during systole against an abnormally large left atrial pressure. It is most commonly found in mitral regurgitation, but can also be seen in mitral stenosis, congestive left ventricular failure, ventricular septal defects, Eisenmenger's complex, and, in rare instances, severe aortic regurgitation.

❍ **What is the arteriovenous difference?**

Arteriovenous difference is the extraction of oxygen from the circulation across a given organ or tissue.

❍ **What is the extraction reserve?**

Extraction reserve is the factor by which the AV difference can increase at a constant blood flow.

❍ **What is the arterial oxygen saturation in a normal human? Venous saturation?**

The arterial saturation in a normal human is 95%. The venous saturation in a normal human is around 75%, but differs slightly, depending on where you measure.

❍ **What is the normal AV difference for oxygen in man?**

40mL per liter of blood.

❍ **What is the normal extraction reserve for oxygen?**

Three. This means that, given adequate metabolic demand, the body's tissues can extract three times the AV difference for oxygen, or 120mL per liter of blood. This also means that oxygen extraction increases as cardiac output falls until AV oxygen difference has tripled and cardiac output has fallen to one-third of its normal value. Thereafter, further reduction of cardiac output will result in tissue hypoxia, anaerobic metabolism, acidosis, and eventually, circulatory collapse.

❍ **What is the normal cardiac output in an adult human?**

Approximately 4-6 L/min, depending on numerous factors such as body size, metabolic rate, posture, age, body temperature, anxiety, environmental heat and humidity and a host of other factors.

❍ **What is the most accepted method of expressing cardiac output?**

Cardiac index. Cardiac index is the cardiac output divided by the body surface area in square meters.

❍ **What is the Fick method of determining cardiac output?**

Cardiac output = measured oxygen consumption/AV oxygen difference. In actual practice, the rate at which oxygen is taken up from the lungs is not measured, but rather the uptake of oxygen from room air is measured. Furthermore, the AV oxygen difference is not measured directly, but oxygen saturations of blood taken from the pulmonary artery and systemic arterial blood are sampled. The saturations are respectively converted to oxygen contents by multiplying the oxygen saturation percentage and a theoretic oxygen carrying capacity (patient's hemoglobin x 13.6). The difference in arterial oxygen content and pulmonary artery oxygen content is the AV oxygen difference.

❍ **When is the pulmonary venous blood oxygen saturation not approximated accurately by the systemic arterial oxygen saturation?**

When there is a right-to-left intracardiac shunt.

❍ **When do intracardiac shunts become physiologically important?**

When the pulmonary blood flow exceeds 1.5 to 2 times the systemic flow.

❍ **Which method of calculating cardiac output is more accurate and reliable, Fick or thermodilution method?**

Fick. Thermodilution method is easier to perform, but is prone to significant overestimation of cardiac output at low-flow, low cardiac output states.

❍ **What is the formula for estimation of systemic vascular resistance?**

SVR = (mean systemic arterial pressure – mean right atrial pressure) x 80/cardiac output.

❍ **What is the formula for estimation of pulmonary vascular resistance?**

PVR = (mean pulmonary artery pressure – mean left atrial pressure) x 80/pulmonary blood flow. Pulmonary blood flow is assumed to be equal to the cardiac output unless there is a shunt between the pulmonary and systemic circulations or an intracardiac shunt.

❍ **What is the Gorlin formula for the calculation of a stenotic aortic valve area?**

Aortic valve area (cm^2) = (cardiac output/heart rate) x systolic ejection period/44.3 x square root of mean aortic valve gradient.

❍ **What is the Gorlin formula for the calculation of a stenotic mitral valve area?**

Mitral valve area (cm^2) = (cardiac output/heart rate) x diastolic filling period/37.7 x square root of mean gradient across mitral valve.

❍ **What is the Hakki formula?**

It is a simplified valve formula that cancels out the Gorlin equation constant, systolic ejection period or diastolic filling period and the heart rate. It closely approximates the valve area calculated by the Gorlin formula.
Valve area (cm^2) = cardiac output/square root of the mean gradient.

❍ **What is the normal value for systemic vascular resistance?**

800-1400 dynes-sec-cm^{-5}.