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FOR PATIENTS WITH HEART DISEASE

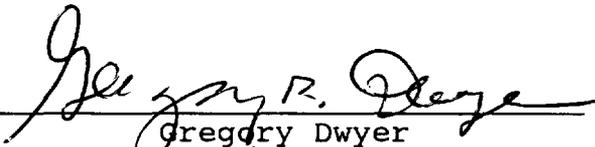
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EXERCISE TEST TERMINATION
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INTRODUCTION

Exercise testing of patients with known heart disease may be conducted to assess the adequacy of conventional therapy, the overall prognosis for a patient, and to provide guidelines for an appropriate level of daily activity (Skinner, p. 211). For cardiac patients, the exercise test results are not for diagnosis of heart disease, but are used to determine the functional significance of the disease (Skinner, p. 216).

There is concordance among exercise test clinicians that symptom-limited maximal exercise testing should be elected over sub-maximal exercise testing in the cardiovascular assessment of coronary heart disease patients (Skinner, p. 214). Symptom-limited maximal testing is especially favored when the purpose of the test is to determine a patients exercise capacity. Sub-maximal testing is not of a great deal of value to clinicians when testing heart disease patients because these patients maximal, or peak, heart rates can not be accurately estimated. Peak heart rates in patients with disease are generally lower than healthy people of the same age. The standard deviation for maximal heart rates in heart patients is more than double the 9-11 beats per minute in healthy individuals (Skinner, p. 214).

For some patients, certain contraindications to exercise testing may apply. For those, the benefit of testing may be overshadowed by the risks it may present. These contraindications must be addressed by a physician before actual testing may occur. A table of contraindications may be found in

Appendix A. It should be noted that some contraindications may not apply where a patient is being tested for specific reasons. These reasons may include a recent myocardial infarction, surgical procedure, or an effort by physicians to determine appropriate medical prescription (ACSM, p. 58).

Symptom-limited maximal testing is very much called for in heart disease patients. The concept of symptom-limited maximal testing is based upon the notion that a patient will continue a monitored bout of exercise testing until the patient must stop. Reasons a patient would stop performing an exercise test include fatigue, or symptoms and/or signs indicate that further testing is not warranted. Exercise test termination criteria varies according to three things: clinical status of the patient, the primary purpose of the test, and the general test environment (Skinner, p. 214). In a patient who recently had a myocardial infarction, a more conservative interpretation of the test termination criteria should be employed (Skinner, p. 214). If the purpose of the test is to authorize a patient to return to a highly demanding job, or to participate in a high level of exercise, more aggressive test interpretation should take place (Skinner, p. 215). Finally, a very liberal attitude may be employed in a medical center with experienced clinicians and nearby medical facilities (Skinner, p. 215).

Patients with disease are often prescribed medications to care for their respective diseases. It is the clinicians job to be informed of the patients medical history (ACSM, p. 150). By

knowing all the details, a clinician can give a more accurate and safe exercise prescription. Medications can give false positive or negative test results, and can alter physiological responses to exercise.

Sometimes, exercise tests may need to be terminated by the exercise test technician based on signs or symptoms provoked in the individual by an exercise test. Symptom-limited maximal exercise testing of patients with heart disease should be terminated when the patient demonstrates significant fatigue, or signs and symptoms indicate the test should not be continued. Further diagnostic evaluation of the patient is warranted if symptoms or signs indicate the test should be discontinued (ACSM, p. 126). Continuing testing after test termination has been attained will not provide any additional useful information for the clinician, and may endanger the health of the patient by increasing their risk of medical complications. The following is an explanation of exercise test termination criteria in patients with known heart disease (Skinner, p. 215).

SYMPTOMS

Symptoms indicating the termination of an exercise test is the most subjective category of exercise test termination criteria. This category of criteria is heavily regulated by patient input. The patients own perception of how they feel should be questioned by the clinician frequently during the exercise test. It is the clinicians duty to evaluate the

patients input, and make appropriate decisions based on this input. The conditions associated in this area of exercise test termination criteria are angina, lightheadedness, dyspnea, fatigue, muscle pain, and nausea (Skinner, p. 215).

The patient may indicate chest pain during the exercise test. This chest pain, or angina pectoris, may be defined as a crushing, heavy feeling in the center of the chest, and may include pain down the left arm, neck, or jaw (ACSM, p. 26). Increasing angina described as severe, or the most severe pain ever felt by the patient indicates a termination of the exercise test (Skinner, p. 215). The pain indicated by the patient in this situation correlates to a grade 3 or 4 on the angina scale, shown here (ACSM, p. 73):

Angina Scale	
1+	light, barely noticeable
2+	moderate, bothersome
3+	severe, very uncomfortable
4+	most severe pain ever experienced

Angina may indicate ischemia, and may be present along with ECG signs of ST segment depression and evidence of a myocardial infarction. Other signs, such as dizziness, ataxia, nausea, vomiting, and impaired consciousness may also be present (Nieman, p. 92).

Severe dyspnea, or shortness of breath, indicated by the patient also calls for exercise test termination (Skinner, p. 215). Some high grades of dyspnea may be evident to the clinician. The following dyspnea scale may be used by the clinician to determine the degree of dyspnea (ACSM, p. 73):

Dyspnea Scale	
+1	mild, not noticeable to the clinician
+2	mild, some difficulty, noticeable
+3	moderate difficulty, can continue
+4	severe difficulty, patient can't continue

Additional symptomatic signals of exercise test termination are fainting/lightheadedness, severe fatigue, severe skeletal muscle pain, and nausea/vomiting (Skinner, p. 215).

Lightheadedness and nausea may indicate ischemia and be accompanied by ischemic ECG signals (Nieman, p. 92). Severe fatigue and skeletal muscle pain make it difficult for patients to simply perform the test, thus, they contraindicate further progress of the test.

CLINICAL SIGNS

Clinical signs indicating that an exercise test should be

terminated are indications by the patient that will be visible to the clinician. These physical signs may dictate to the clinician that the patient cannot continue the test.

These clinical signs are included in the following table (Skinner, p. 215):

CLINICAL SIGNS
Pallor
Cold, moist skin
Cyanosis
Staggering gait ataxia
Confusion
Blank stare

Clinical signs for exercise termination may indicate low cardiac output states. These signs may be accompanied by low blood pressure, or hypotension, and dizziness. Electrocardiograph signs that may be present are arrhythmias, tachycardia, bradycardia, premature atrial contractions, and premature ventricular contractions (Nieman, p. 92).

ELECTROCARDIOGRAM SIGNS

Ischemia

Ischemia is a condition in which the oxygen demands of the myocardium exceed the oxygen supply to the myocardium, because of inadequate myocardial blood flow (ACSM, p. 25). This situation

Mobitz Type II is less common than Type I. Mobitz Type II is characterized by an abruptly dropped QRS complex with no change to the PR intervals. The QRS complexes may also be prolonged and widened (Johnson & Swartz, p. 63). This type of block is more serious than Type I because it may be a predecessor to third degree atrioventricular block (complete heart block).

Third degree atrioventricular block is a serious condition in which atrial impulses are not transmitted to the ventricles. On ECG tracings, this condition will display atrial and ventricular rates which are not connected. This condition is called atrioventricular dissociation. Third degree atrioventricular block is very serious because the ventricular rate, controlled by the AV node in this condition, is too slow to effectively pump blood through the cardiovascular system (Johnson & Swartz, p. 64).

Bundle branch blocks are abnormalities in conduction that disrupt the normal route of ventricular depolarization. This disruption will cause a prolonged QRS complex, and an abnormal QRS morphology (Johnson & Swartz, p. 67). The following is a table of ECG indications of bundle branch blocks (Dwyer, p. 18):

Right Bundle Branch Block

- QRS wider 0.12 seconds
- R, R', or M pattern in V1
- right axis deviation
- deep S waves in V6
- T wave inversion in V1-V3

Left Bundle Branch Block

- QRS wider 0.12 seconds
- wide notched R wave in V6 and I
- wide QS wave in V1
- T wave inversion in V6 and I
- absence of Q waves in V6 and I
- approximately 50% of all LBBB have left axis deviation

Right bundle branch block is usually fixed, but may be intermittent at rapid heart rates. It is not uncommon and can be seen in healthy or older individuals (Dwyer, p. 19).

Left bundle branch block is more serious, and can also be fixed or intermittent. It is usually a sign of organic heart disease, and it can be seen in individuals with hypertension, or valvular anomalies. Left bundle branch block is also serious because the presence of it makes the determination of ischemic changes, and myocardial infarction, on the ECG impossible (Dwyer, p. 19). The different conduction disturbances are shown in appendix B.

Supraventricular Arrhythmias Occurring With Exercise

There are two types of supraventricular arrhythmias to be discussed: atrial fibrillation, and supraventricular

tachycardia.

Atrial fibrillation is characterized by the absence of P waves. The P waves are not present because the atria are contracting 400 to 500 times per minute. These numerous contractions are weak and incomplete, and a wavy and undulating baseline made up of F waves may be seen (Dwyer, p. 24). Ventricular rates are generally between 120-200 beats per minute, and R-R intervals and QRS complexes may appear irregular. Atrial fibrillation may be serious because of a decreased cardiac output, and a tendency for the static blood in the atria to begin clotting. The risk of the blood clot, or thrombus, to pass into the circulatory system is real.

Supraventricular, or atrial, tachycardias are a group of arrhythmias that occur above the ventricles. Atrial tachycardia is a run of three atrial premature contractions in a row. Atrial premature contractions are characterized by P waves that fall early in the cardiac cycle, and are different in configuration. The term paroxysmal is used to describe atrial tachycardia because of its sudden onset and termination. In atrial tachycardia, the ventricular rate will generally fall between 150-250 beats per minute. Although the QRS complex will not generally be affected, P waves will occasionally superimpose on T waves (Johnson & Swartz, p. 36). Supraventricular tachycardias are not generally serious and can be caused by a variety of things including emotions, stress, stimulants, or fatigue (Dwyer, p. 25). Atrial arrhythmias are illustrated in appendix B.

Ventricular Arrhythmias

Ventricular arrhythmias are caused by ectopic impulses, that cause the normal route of depolarization to be bypassed, and prevents the simultaneous depolarization of the ventricles (Johnson & Swartz, p. 47). This category of arrhythmias includes ventricular premature contractions, ventricular tachycardia, and ventricular fibrillation.

Ventricular premature contractions fall early in the cardiac cycle. They are shown on the electrocardiogram by early, wide QRS complexes greater than or equal to 0.12 seconds. This condition may frequently include a full compensatory pause, which is signified by the duration of two cardiac cycles with the ventricular premature contraction; the same in length as two normal cardiac cycles. Another event that may be seen during a ventricular premature contraction is a fusion beat. This is a "fusion" of a normal beat and a ventricular premature contraction beat. Ventricular premature contractions are the most common of all arrhythmias. An occasional ventricular premature contraction is normal in everyone. They are considered serious when they occur frequently, in greater than 30% of all complexes.

Ventricular tachycardia is a run of ventricular premature contractions; three or more in a row. (Johnson & Swartz, p. 52). The characteristics of ventricular tachycardia are shown here:

- bizarre, wide QRS complex wider than 0.12 seconds
- atrioventricular dissociation
- regular ventricular rate at 140-200 beats per minute

- possible fusion beats

- possible capture (Dressler) beats (normal QRS complex in a run of ventricular premature contractions)

Ventricular tachycardia may be serious because the rapid ventricular rate does not allow adequate filling time of the ventricles, thus cardiac output is decreased. This hypotension can lead to cardiac arrest (Johnson & Swartz, p. 54).

Ventricular fibrillation is characterized by no recognizable P waves, QRS complexes, or T waves. This condition is often present in individuals who are at high risk for heart disease, or have heart disease (Johnson & Swartz, p. 55). This condition is serious, and may signal genetic conduction abnormalities.

Cardioversion, or defibrillation, is necessary in treatment of ventricular fibrillation because of the potential of cardiac arrest or sudden death (Dwyer, p. 27). The various ventricular arrhythmias are shown in appendix B.

MEDICATIONS

Patients with heart disease are frequently prescribed medications to manage their respective conditions. These medications may alter cardiorespiratory and/or metabolic responses to the exercise test. The exercise test technician should be aware of any patients' medication history before testing (ACSM, p. 150).

Exercise testing is most efficient when a patient is taking

their prescribed medicine. It is advisable for a patient to have a new exercise test administered with a dramatic change in medication prescription (ACSM, p. 150). Classes of medications that may alter exercise testing are nitrates, beta-blockers, calcium channel blockers, vasodialators, and digitalis (Dwyer, p. 31).

Nitrates

Nitrates are a popular type of medication to relieve angina. These medications may elicit post exercise hypotension, and may increase resting and exercise heart rates (Dwyer, p. 32). Ischemia during exercise may be prevented or delayed due to this medication. The exercise capacity of patients taking nitrates may increase in patients with angina, or be unaffected in patients without angina. In patients with congestive heart failure, exercise capacity may increase, or not be affected (ACSM, p. 276).

Beta-Blockers

The most commonly used heart medications are beta-blockers. They relieve angina and hypertension and are used for patients of congestive heart failure. Because beta-blockers block the sympathetic receptor on the heart, heart rate and blood pressure is lowered. Beta-blockers may also cause fatigue (Dwyer, p. 32). Despite these factors, symptom-limited maximal testing can still be used for exercise prescription. Of clinical value during testing is the intensity level or heart rate at the onset of symptoms (Skinner, p. 217). In patients with angina, beta-

blockers will increase exercise capacity, but in patients without angina, exercise capacity will decrease or remain unchanged (ACSM, p. 276). Another effect of beta-blockers is to delay the onset of or prevent ischemia (ACSM, p. 276).

Calcium Channel Blockers

Calcium channel blockers are a class of medications to help relieve angina, hypertension, and congestive heart failure. Different calcium channel blockers produce different effects. The generic medication Nifedipine may elicit different side effects than most other types of calcium channel blockers. Nifedipine will increase resting and exercise heart rates, while other types of calcium channel blockers will decrease resting and exercise heart rates.

Some general effects of all calcium channel blockers are a decrease in both resting and exercise blood pressure. Calcium channel blockers may delay or prevent ischemia, and increase exercise capacity of patients with angina (ACSM, p. 276).

Vasodilators

Vasodilators are not widely used medications. The primary purpose of this drug is to relieve hypertension (Dwyer, p. 32). There are three categories of vasodilators; these are peripheral, alpha-adrenergic blockers, and anti-adrenergic agents without selective blockade of peripheral receptors.

Peripheral vasodilators may cause an increase in resting and exercise heart rates, and a decrease in blood pressure. Exercise capacity probably will not change, except in patients with

congestive heart failure, and then it may increase (ACSM, p. 276).

Alpha-adrenergic blockers will not have many side effects. One effect they will have though are to decrease resting and exercise blood pressure (ACSM, p. 276).

Alpha-adrenergic agents without selective blockade of peripheral receptors will decrease or unaffected rest and exercise heart rates. Blood pressure may decrease, and exercise capacity will probably remain unchanged (ACSM, p. 276).

Digitalis

Digitalis is the oldest cardiovascular medication prescribed, and it is used for patients of congestive heart failure (Dwyer, p. 34). Heart rate may decrease in patients with atrial fibrillation while taking this medication. Electrocardiograph changes include non-specific ST-T wave changes at rest. When exercising, ST segment depression may occur (ACSM, p. 276). Digitalis may cause a lot of difficulty when interpreting exercise tests. The ECG cannot be interpreted when there are ST segment changes while on digitalis. If ischemia is a likely risk, and must be documented, the drug should be discontinued for three weeks, and the exercise test performed after that time. However, if the ECG shows a normal ST segment, it should be interpreted as normal, or negative (Skinner, p. 217).

A list of generic medication names for each class of medications can be found in appendix C.

CONCLUSION

Two additional termination criteria exist; they are patient requests to stop the exercise test, and the ECG monitoring system fails (Skinner, p. 215). As trivial as these may sound, to continue testing after these endpoints is not ethical, and could endanger the health of the patient.

In testing patients with heart disease, the clinician will encounter various degrees of dysfunction. The clinician is to determine the degree of impairment, and provide a prognosis for the patient including such events as reinfarction, cardiac arrest, heart failure, and the patients functional capacity (ACSM, p. 122).

The prognosis derived from exercise testing will be used by the clinician to determine the levels of exercise training, type of training best suited for the patient, intensity of training, and the degree of medical supervision appropriate for the patient (ACSM, p.122).

When testing patients with known heart disease, all test termination criteria should be evaluated. There is occasionally a tendency for exercise test technicians to focus only on one or two signs or symptoms, and ignore equally significant others (Skinner, p. 215). Comprehensive monitoring of patients will increase the reliability and clinical value of exercise test results, and will help to minimize complications resulting from the testing (Skinner, p. 216). The more severe the case of the disease a patient has, the more attention should be given to each

of the signs or symptoms elicited in a patient by the exercise
test (Skinner, p. 216).

APPENDIX A

Absolute Contraindications to Exercise Testing

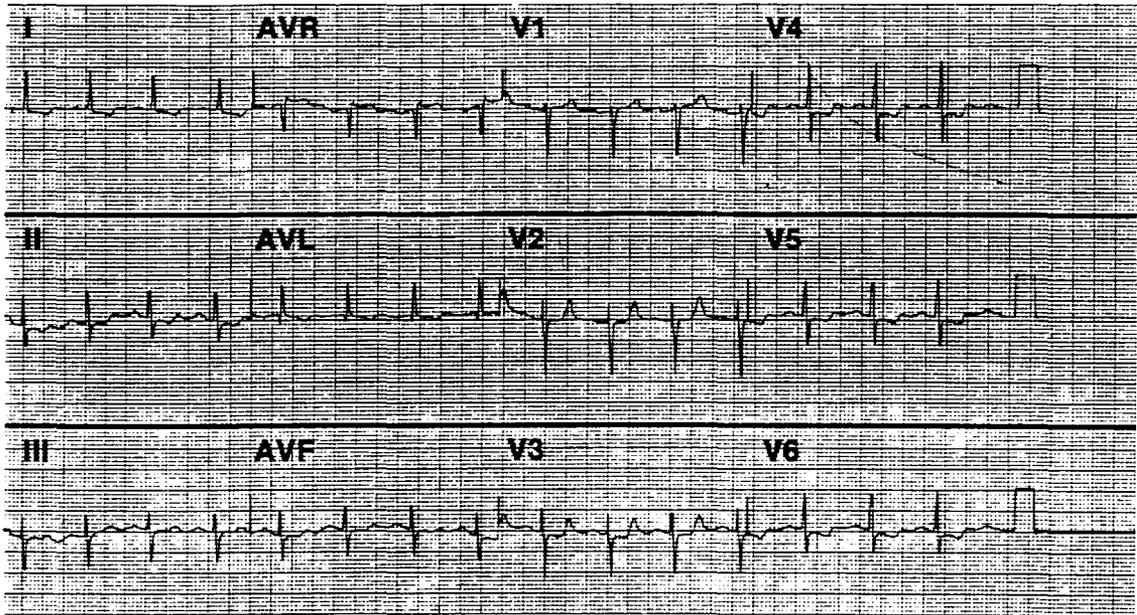
- *recent ECG change indicating infarction or an acute cardiac event
- *recent complicated myocardial infarction
- *unstable angina
- *uncontrolled ventricular dysrhythmia
- *atrial dysrhythmia compromising cardiac function
- *third degree atrioventricular block
- *acute congestive heart failure
- *severe aortic stenosis
- *dissecting aneurysm
- *myocarditis or pericarditis
- *thrombophlebitis or intracardiac thrombi
- *recent systemic or pulmonary embolus
- *acute infection
- *psychosis

Relative Contraindications to Exercise Testing

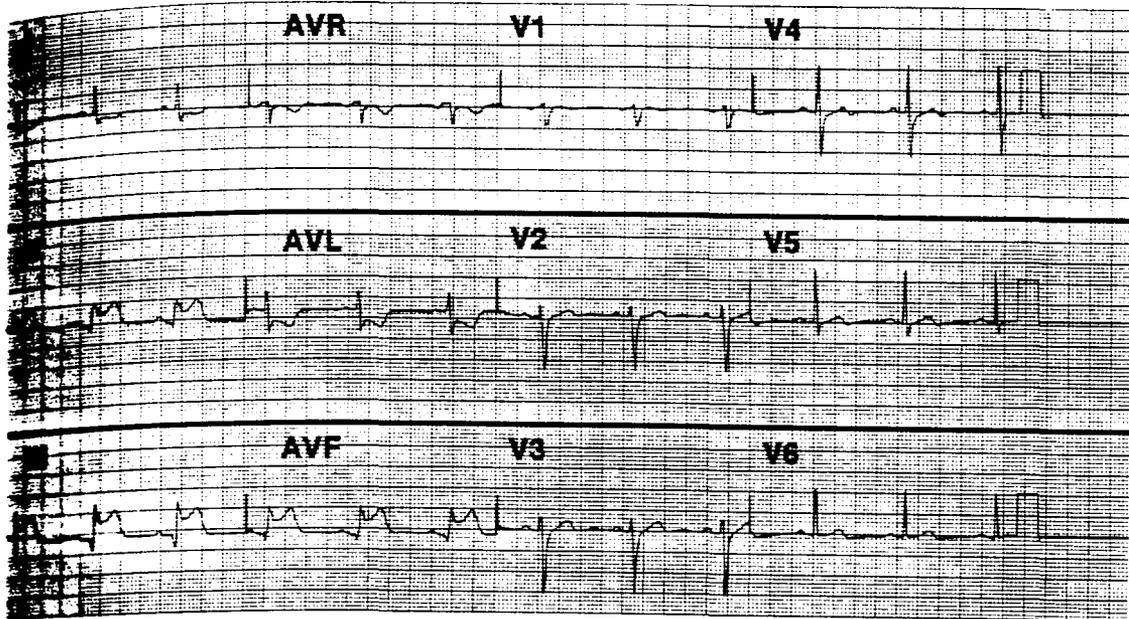
- *resting diastolic blood pressure >120 mm Hg or, resting systolic blood pressure >200 mm Hg
- *moderate valvular heart disease
- *hypokalemia, hypomagnesemia
- *fixed-rate pacemaker (rare)
- *frequent or complex ventricular ectopy
- *ventricular aneurysm
- *cardiomyopathy
- *uncontrolled metabolic disease
- *chronic infectious disease
- *neuromuscular, musculoskeletal, or rheumatoid disorders worsened by exercise
- *advanced or complicated pregnancy

(ACSM, p. 59)

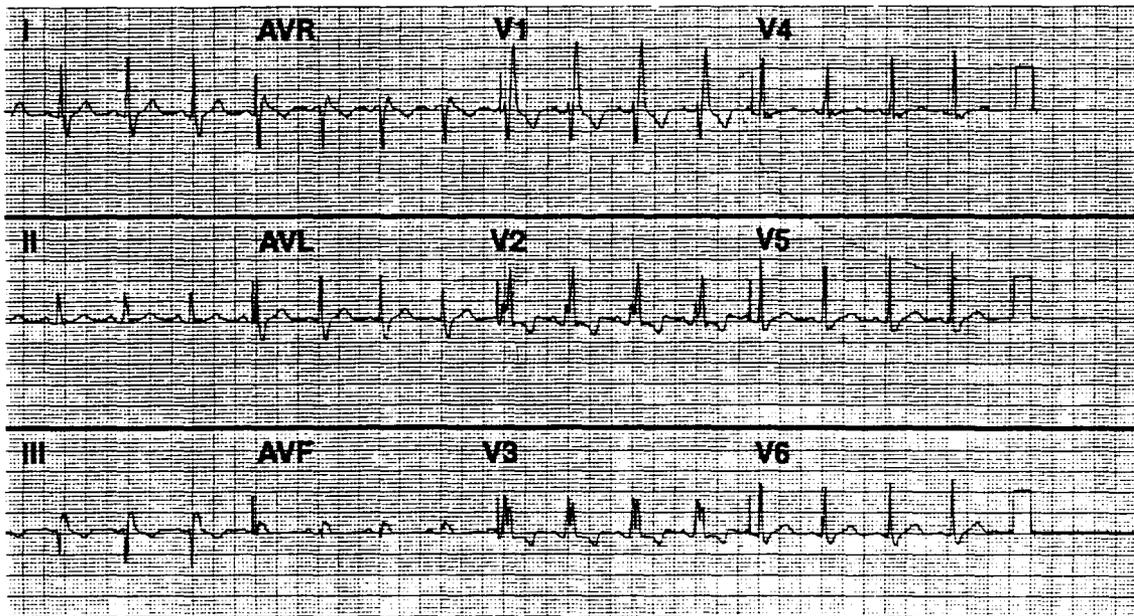
APPENDIX B



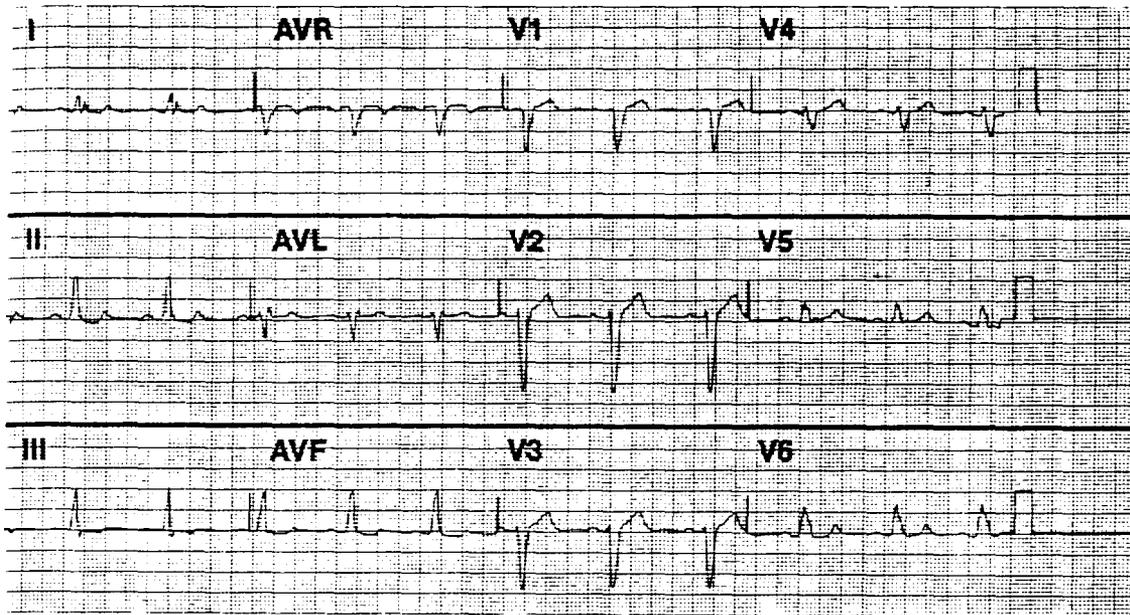
ischemia



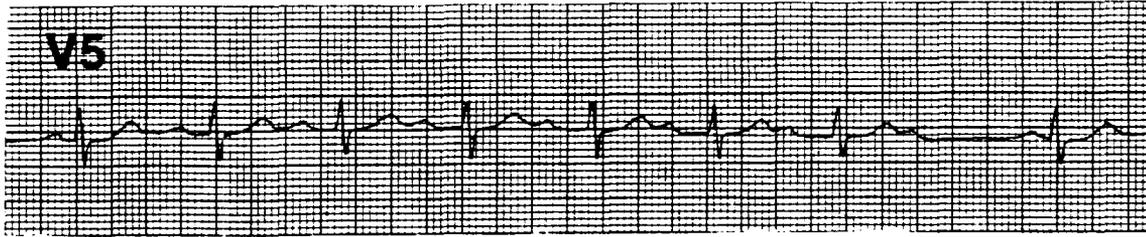
injury



right bundle branch block



left bundle branch block



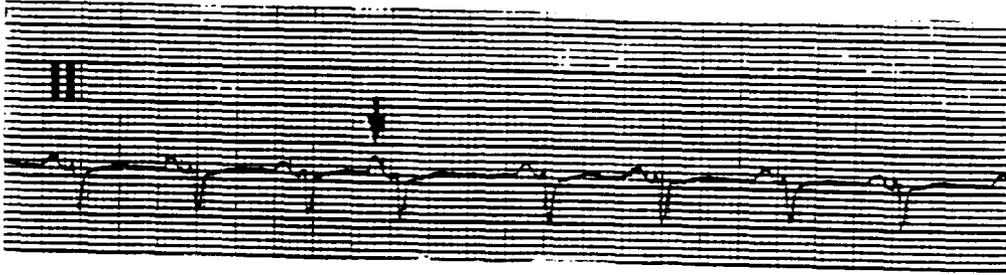
second degree atrioventricular block- Type I



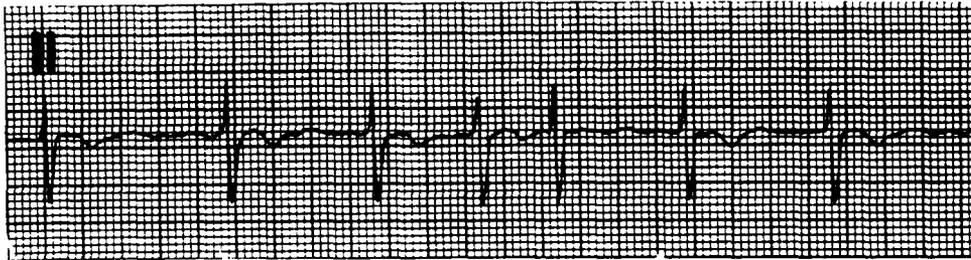
second degree atrioventricular block- Type II



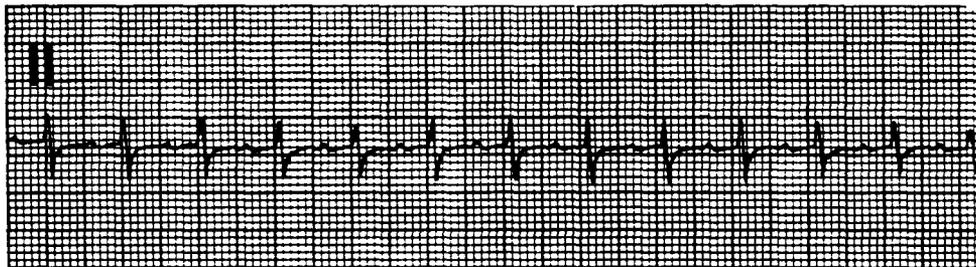
third degree atrioventricular block



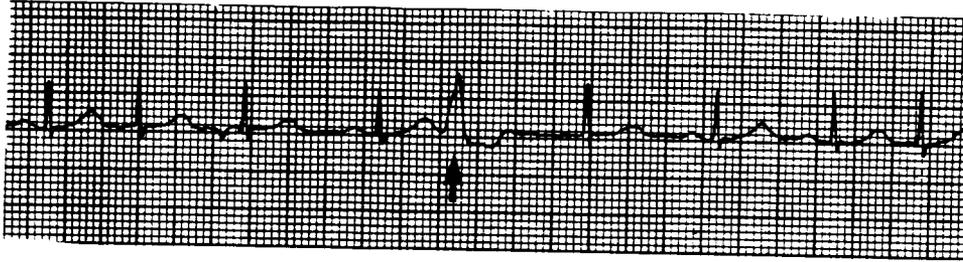
premature atrial contraction



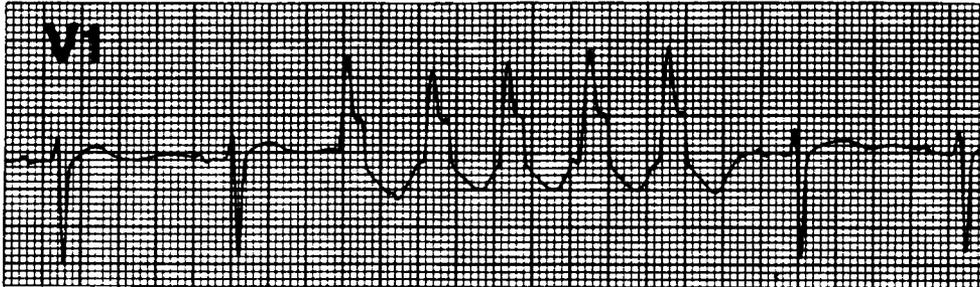
atrial fibrillation



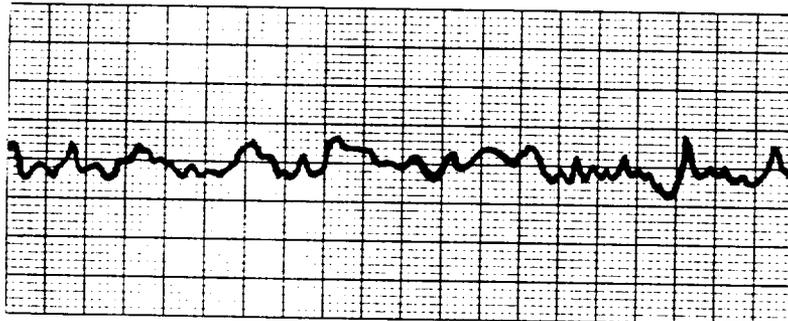
supraventricular tachycardia



ventricular premature contraction



ventricular tachycardia



ventricular fibrillation

APPENDIX C

Medication Names

CLASS	GENERIC NAME
*Nitrates	*Isosorbide dinitrate *Nitroglycerin
*Beta-Blockers	*Acebutolol *Atenolol *Metoprolol *Wadolol *Pindolol *Propranolol *Timolol
*Calcium Channel Blockers	*Diltiazem *Nifedipine *Nitrendipine
*Vasodialators	*Nonadrenergic *Hydralazine *Minoxidil *Prazosin *Terazosin *Clonidine *Guanabenz *Guanethidine *Guanfacine *Methyldopa *Reserpine
*Digitalis	*Digoxin

(ACSM, p. 273-274)

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