NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

# A Case Study on Tachycardia in Sam the Runner

*by*
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## Part I – Heart Rate

A group of runners gathers every week to train for long-distance runs. One member, Sam, pushes herself regularly during training sessions and seems to be enjoying the workouts. She has run a few half marathons in the past and is currently training for a full marathon. Sam is a seemingly healthy 27 year-old female.

One day, all the runners are comparing output from their heart rate, speed, and distance-tracking devices. Sam is slightly alarmed because her max heart rate during distance runs is quite high; it reaches over 200 beats per minute (BPM) and averages in the high 180s–190s (~185 bpm). Sam feels fine during training runs, although she can "feel" the workouts when the group does speed training or runs uphill (breathing becomes a bit difficult and she knows her body is working hard). She has exercise-induced asthma and regularly takes her albuterol inhaler prior to group training runs to relieve the shortness of breath.

### *Questions*

1. What equation is commonly used to calculate max heart rate for a person? Using this equation, what is Sam's max heart rate?
2. According to information from exercise coaches and commonly posted charts in gyms, endurance athlete should be working at about 60–80% of max (see "training zone" in Figure 1). Using the max heart rate from Question 1, at what % of max is Sam working?

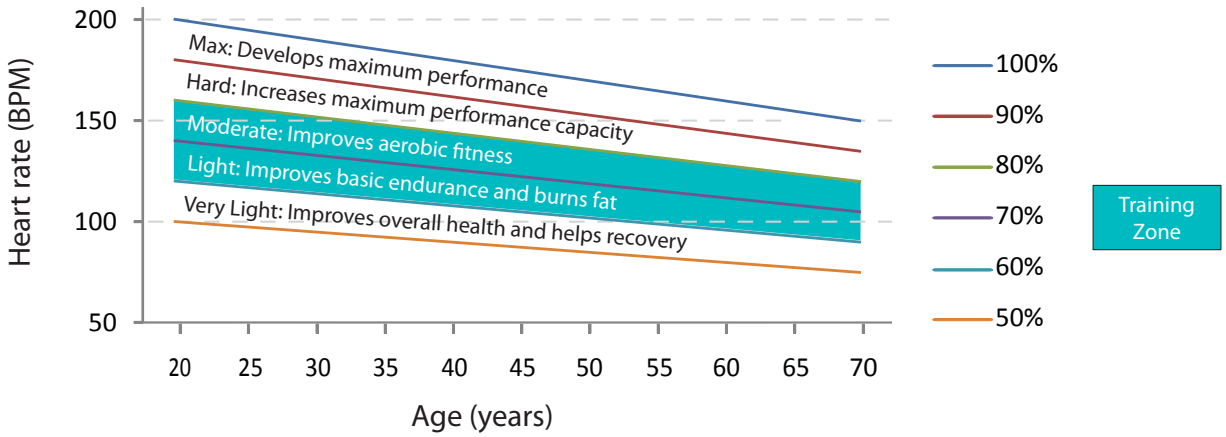


*Figure 1.* Training zone heart rate percentage correlated with age, based on Haskell-Fox model.

3. What are the primary determinants limiting max heart rate in a person? Consider how the heart muscle contracts and how heart rate is determined.
4. Based on what you know about Sam thus far, what might be affecting her heart rate during runs?

## Part II – Albuterol?

After Sam talks to her physician about the heart rate she experiences during running, her physician asks her to stop using her inhaler. She feels this is okay because she only experiences significant breathing difficulty during sprints and she is training for a marathon.

### *Questions*

5. Why does her physician ask her to track her heart rate without the inhaler? What physiological effects does albuterol have? Where in the body does this drug act (target organ/receptor and what does it do intracellularly)?
6. Sam takes her physician's advice and stops using the albuterol inhaler. She tracks her next fast-paced, 13-mile run without the inhaler and gets the data presented (Figure 2 and Table 1). Based on the new information, does it appear that the albuterol was affecting Sam's HR? Why or why not?

*Figure 2.* Sam's run without the inhaler.

*Table 1.* Sam's split data without the inhaler.

| *Split* | *Time* | *Distance miles* | *Elevation Gain* | *Elevation Loss* | *Avg Pace* | *Avg HR* | *Max HR* | *Calories* |
|---|---|---|---|---|---|---|---|---|
| 1 | 07:54.4 | 1 | 69 | 84 | 7:54 | 178 | 207 | 147 |
| 2 | 07:54.4 | 1 | 32 | 44 | 7:56 | 184 | 190 | 151 |
| 3 | 08:03.5 | 1.01 | 0 | 50 | 8:00 | 189 | 194 | 150 |
| 4 | 07:54.9 | 1 | 0 | 0 | 7:57 | 191 | 197 | 148 |
| 5 | 07:56.3 | 1 | 0 | 38 | 7:54 | 190 | 195 | 141 |
| 6 | 08:26.0 | 1.02 | 74 | 52 | 8:17 | 190 | 199 | 142 |
| 7 | 08:11.0 | 1 | 0 | 41 | 8:13 | 187 | 191 | 141 |
| 8 | 08:29.8 | 0.98 | 55 | 33 | 8:39 | 188 | 191 | 150 |
| 9 | 08:54.7 | 1 | 41 | 0 | 8:55 | 188 | 194 | 157 |
| 10 | 08:49.1 | 1 | 43 | 35 | 8:49 | 187 | 194 | 153 |
| 11 | 09:01.5 | 1 | 9 | 33 | 9:02 | 189 | 193 | 152 |
| 12 | 09:12.5 | 1 | 66 | 44 | 9:11 | 190 | 193 | 159 |
| 13 | 09:05.2 | 1 | 57 | 0 | 9:04 | 192 | 197 | 161 |
| 14 | 02:38.6 | 0.32 | 0 | 0 | 8:17 | 196 | 201 | 47 |
| *Summary* | 1:52:31 | 13.32 | 446 | 454 | 8:27 | 188 | 207 | 1,999 |

## Part III – Time for Tests

Sam meets with her physician to talk about why increased HR (also termed tachycardia) might be dangerous. Exercise-induced rapid heart rate is normal, but the level to which Sam's heart rate was rising could signal some other problem.

There are two main types of tachycardia, sinus and ventricular (see Figure 3). Sinus tachycardia is caused by rapid firing of the SA node and results in an increase in heart rate. Causes of sinus tachycardia include: fever, anxiety, some drugs (prescribed or recreational, e.g., alcohol, caffeine, cocaine), emotional distress, fright, stress, strenuous exercise, anemia, hypoxia, increased thyroid activity, heart muscle damage, valve disease, smoking, or hemorrhage.

Ventricular tachycardia is more dangerous. In this scenario, the ventricles are the site of increased heart rate (not the SA node) and this can progress to ventricular fibrillation (uncoordinated, quivering contraction of the ventricle; see Figure 3, bottom), which is a fatal arrhythmia that needs to be converted with defibrillation. Ventricular tachycardia can be caused by lack of oxygen due to obstruction of the coronary artery, cardiomyopathy (enlarged heart), medication, and sarcoidosis (inflammatory disease affecting the skin or other body tissues). Also, a rare congenital issue called Wolff-Parkinson-White syndrome occurs when an extra conduction system between the atria and ventricles exists and this extra electrical communication results in ventricular tachycardia (this shows as a delta wave between the P and QRS on an ECG).

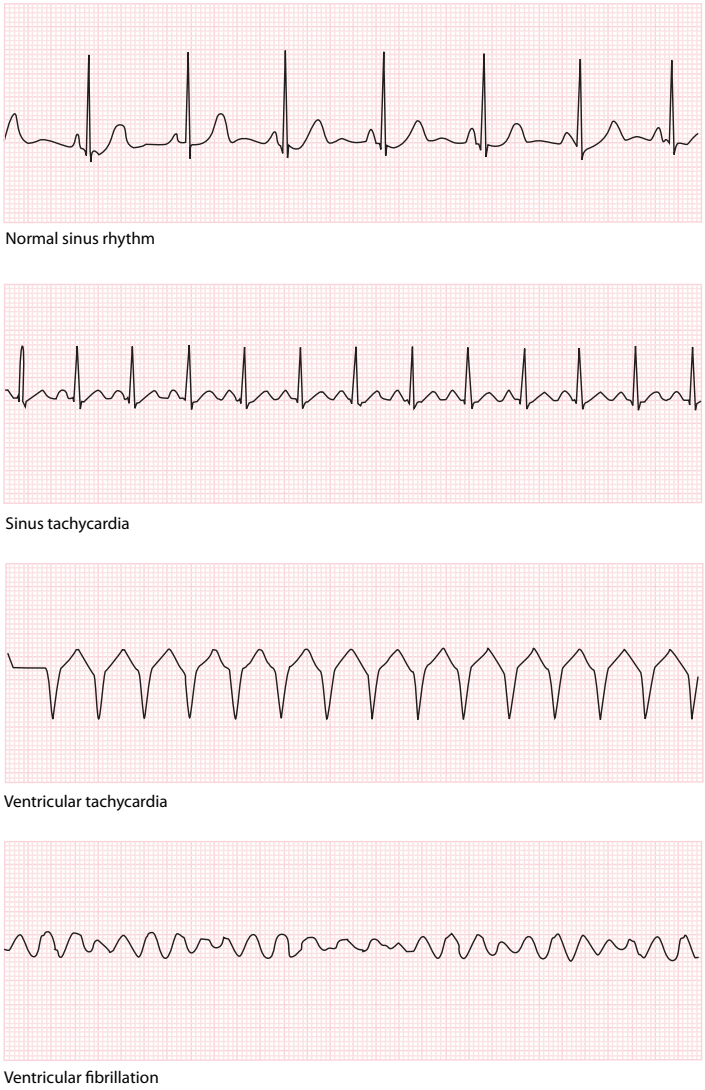


*Figure 3.* Normal sinus rhythm, sinus tachycardia, ventricular tachycardia and ventricular fibrillation ECG output.

Tachycardia is not unique to the factors listed above, and various other diagnoses can cause changes in heart rate. There is an additional condition, catecholaminergic polymorphic ventricular tachycardia (CPVT), which results in an irregular heart rate during exercise (CPVT can present outside of exercise, but sometimes it only presents with exercise). CPVT is an inherited condition and is due to problems with calcium signaling in the cardiac myocytes. (*Note:* this is not an all-inclusive list of conditions/scenarios which can result in tachycardia.)

### *Question*

7. Sam's physician decides to order some tests. Based on what you know so far, which tests might you order? What else might you want to know about Sam?

# Part IV – Results

## *Office Visit*

As a result of Sam's visit with her physician, the following patient history was taken and various tests were performed.

*Patient History:* Sam is a female, 27 yr-old, non-smoker who has a few drinks 1–3 times a week. She is a healthy eater and was a vegetarian until about 6 months ago. She now eats a lot of steamed or sautéed vegetables, whole grain bread with olive oil, and lean meats. Dessert is usually a bit of dark chocolate. After running in the heat she is careful to drink fluids containing electrolytes. She has always exercised and enjoyed endurance running. She has an albuterol inhaler for exercise-induced asthma and has been using the inhaler off and on since high school. She does not take any prescription medication, but she uses Paragard for birth control and has long (7–8 days), heavy menstrual periods each month. Sam does not have a personal history of cardiovascular issues, but other family members have experienced cardiovascular and circulatory problems (maternal aunt, age 58: myocardial infarction, 95% heart blockage leading to a stent in the left anterior descending coronary artery; maternal grandfather, age 75: sudden cardiac death ventricular fibrillation due to arrhythmia leading to defibrillation and pacemaker placement; paternal aunt, age 58: unstable angina due to 95% blockage leading to left anterior descending coronary artery stent placement), there also is a history of breast cancer (maternal grandmother) and Parkinson's disease (paternal grandfather). Sam was not currently menstruating at the time she went to have her tests done; her previous period was ~ 2 weeks prior to her appointment.

*Physician's Visit Notes:*

Sex: Female
Age: 27
Blood Pressure: 110/55
Pulse: 62
Lungs: Clear to auscultation; No crackles or Rhonchi (wheezing sounds)
Temp: 97.2 ºF
Body Weight: 133 lbs
Height: 61 inches
BMI: 25.1

- Underweight = <18.5
- Normal weight = 18.5–24.9
- Overweight = 25–29.9
- Obesity = BMI of 30 or greater

*Tests Ordered:* complete blood count, fasting lipid panel, iron panel, metabolic panel, pregnancy test, thyroid function test, B12 and folate, urinalysis, Bruce Protocol stress test, echocardiogram.

## *Questions*

8. Please use Sam's patient history and the results of her lab tests (patient data listed on the following pages) to answer the following questions:
   a. What is Sam's resting blood pressure? Is this value within the normal range?
   b. What is Sam's resting HR? Is it normal?
   c. Does her issue seem to be continually present or only when she exercises?
   d. Does anything from Sam's complete blood count look unusual? Are any parameters borderline?
   e. Are her total cholesterol, HDL, and LDL blood concentrations within normal ranges? What is her ratio of total cholesterol and HDL ratio and what might this possibly tell you about risk for cardiovascular problems? Are any parameters borderline?
   f. How are her iron, B12 and folate panel results? Are any parameters borderline? What do these parameters reveal about her total health?
   g. What about her metabolic results? Are any parameters borderline?

h. Is she pregnant? How do you know?
i. Does she have a thyroid problem? How do you know?
j. Are her kidneys functioning properly? How do you know?
k. What was Sam's resting HR and BP before the Bruce protocol? At max exercise? During recovery?
l. Based on the ECG printouts, does it appear she has sinus tachycardia or ventricular tachycardia?
m. What is ejection fraction? What are normal values for this measure?
n. Did Sam have a normal ejection fraction?
o. What did the echocardiogram say about Sam's heart valves?
p. Overall, does Sam's heart muscle appear healthy? Explain
q. Would you recommend any lifestyle or dietary changes to Sam?

9. What do you feel is the cause of her elevated heart rate during exercise? What is your diagnosis?

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# Patient Data

NIH Medline was used as a reference for all lab test descriptions

## *Complete Blood Count (CBC)*

*Background:* Used to measure the number of red blood cells (RBC count), the number of white blood cells (WBC count), the platelet count (PLT), the breakdown of the white blood cells (granulocytes, lymphocytes, monocytes), the total amount of hemoglobin (HGB), and the percent of the blood sample composed of red blood cells (HCT). A CBC also tells us the average RBC size (MCV), hemoglobin amount per RBC (MCH), the amount of hemoglobin relative to size of the cell (hemoglobin concentration) per red blood cell (MCHC), and the RBC distribution width (measure of variability in RBC size). A CBC can be used to evaluate RBC production or destruction, test for infections, or detect clotting or blood disorders.

| Test Name | Result | Flag(s) | Reference Range |
|---|---|---|---|
| WBC | 7.2 | | 3.5–10.0 K/uL |
| RBC | 4.45 | | 3.80–5.80 M/uL |
| HGB | 11.2 | | 11.0–16.5 g/dL |
| HCT | 35.4 | | 35.0–50.0 g/dL |
| MCV | 84 | | 80–97 fL |
| MCH | 27.3 | | 26.5–33.5 pg |
| MCHC | 32.3 | | 31.5–35.0 g/dL |
| RDW | 12.8 | | 10.0–15.0 % |
| PLT | 201 | | 150–390 K/uL |
| GRAN% | 67 | | 43–76 % |
| LYM% | 27 | | 17–48 % |
| MON% | 7 | | 3–7 % |
| GRAN# | 4.9 | | 1.2–6.8 K/uL |
| LYM# | 1.90 | | 1.20–3.20 K/uL |
| MON# | 0.4 | | 0.1–0.4 K/uL |

## *Iron Panel*

*Background:* The iron panel is used to measure oxygen carrying capacity, liver function, and nutrition. Various parameters can be recorded in iron panels. Total iron, or serum iron, measures the amount of iron bound to transferrin in the blood (about 30% of iron is bound this way, 65% in Hb, 4% in myoglobin). Iron binding capacity measures the max amount of iron the blood can carry, thus this is an indirect measure of transferrin levels. Percent saturation is how many of the total iron binding sites available are bound to iron (total/capacity). Ferritin stores iron in the tissues and ferritin levels are analyzed as a measure of iron storing ability (the lower the ferritin level, even within the "normal" range, the more likely the patient does not have enough iron).

| Test Name | Result | Flag(s) | Reference Range |
|---|---|---|---|
| IRON, TOTAL | 94 | | 40–175 mcg/dL |
| IRON BINDING CAPACITY | 412 | | 250–450 mcg/dL |
| % SATURATION | 23 | | 15–50 % (calc) |
| FERRITIN | 11 | | 10–154 ng/mL |

## *Comprehensive Metabolic Panel*

*Background:* A group of blood tests which provide information about body metabolism. This is usually performed to measure kidney function, acid/base balance, blood sugar, and electrolytes. For the metabolic panel, patients fast for 8h prior to having blood drawn. BUN (blood urea nitrogen) is determined to check function of kidneys. Creatinine is a breakdown product of creatine (from phosphocreatine—used to store ATP to fuel muscle activity), and is generally a measure of kidney function (high values indicate a kidney problem). Low levels of creatinine can be benign, or can mean a low-protein diet, pregnancy, or liver disease. Men tend to have higher creatinine levels than females due to higher muscle mass. eGFR = estimated glomerular filtration rate (based on creatinine and sodium clearance). BUN/creatinine ratio can be used to determine acute kidney injury or dehydration; both urea and creatinine are freely filtered by the glomerulus, but urea can be reabsorbed in the tubules whereas creatinine excretion remains fairly constant. Albumin is a blood protein made by the kidneys (it helps with the colloid pressure of the blood and keeps it from leaking out of the vessels; also carries other molecules). Globulin (proteins made by liver and immune system) can indicate blood disease. The ratio of albumin/globulin can indicate disease states (e.g., kidney disease, autoimmune disease, leukemias). Alkaline phosphatase is an enzyme and levels can indicate liver disease or bone problems. Bilirubin test checks for liver function. AST = asparate amino transferase, ALT = alanine amino transferase.

| Test Name | Result | Flag | Reference Range |
|---|---|---|---|
| GLUCOSE | 86 | | 65–99 mg/dL (fasting) |
| UREA NITROGEN (BUN) | 10 | | 7–25 mg/dL |
| CREATININE | 0.54 | L | 0.57–1.03 mg/dL |
| eGFR NON-AFR. AMERICAN | >60 | | > OR = 60 mL/min/1.73m2 |
| SODIUM | 140 | | 135–146 mmol/L |
| eGFR AFRICAN AMERICAN | >60 | | > OR = 60 mL/min/1.73m2 |
| BUN/CREATININE RATIO | 19 | | 6–22 (calc) |
| POTASSIUM | 3.9 | | 3.5–5.3 mmol/L |
| CHLORIDE | 105 | | 98–110 mmol/L |
| CARBON DIOXIDE | 26 | | 21–33 mmol/L |
| CALCIUM | 9.5 | | 8.6–10.2 mg/dL |
| PROTEIN, TOTAL | 6.9 | | 6.2–8.3 g/dL |
| ALBUMIN | 4.2 | | 3.6–5.1 g/dL |
| GLOBULIN | 2.7 | | 2.2–3.9 g/dL (calc) |
| ALBUMIN/GLOBULIN RATIO | 1.6 | | 1.0–2.1 (calc) |
| BILIRUBIN, TOTAL | 0.5 | | 0.2–1.2 mg/dL |
| ALKALINE PHOSPHATASE | 46 | | 33–115 U/L |
| AST | 18 | | 10–30 U/L |
| ALT | 14 | | 6–40 U/L |

## *Fasting Lipid Panel*

*Background:* This test measures the amount of cholesterol and triglycerides in your blood. High cholesterol levels do not normally cause symptoms, but they are a risk factor for heart disease and atherosclerosis (as per the American Heart Association, elevated LDL and total cholesterol, and decreased HDL are all risk factors for heart disease). Four main values are recorded: total cholesterol, low-density lipoprotein cholesterol (the "bad" type—think "l" for

"lethal"), high-density lipoprotein (the "good" type—think "h" for "healthy"), and triglycerides. Due to the influence of reproductive hormones, women tend to have higher HDL than men. Sometimes the test includes very-low-density lipoprotein level (VLDL, typically calculated from triglycerides). The cholesterol/HDL ratio is often calculated (this number should be below 5; you want the "good" cholesterol to make up a large proportion of your total cholesterol).

| Test Name | Result | Flag(s) | Reference Range |
|---|---|---|---|
| CHOLESTEROL, TOTAL | 162 | | 125–200 mg/dL |
| HDL CHOLESTEROL | 81 | | > OR = 46 mg/dL |
| TRIGLYCERIDES | 42 | | <150 mg/dL |
| LDL-CHOLESTEROL | 73 | | <130 mg/dL (calc) |
| CHOL/HDLC RATIO | 2.0 | | < OR = 5.0 (calc) |
| Desirable range <100 mg/dL for patients with CHD or diabetes and <70 mg/dL for diabetic patients with known heart disease. | | | |

## *Thyroid Function*

*Background:* This is a basic test for thyroid function. If TSH levels are out of the normal range then a test for T4 will be ordered.

| Test Name | Result | Flag(s) | Reference Range |
|---|---|---|---|
| TSH, 3RD GENERATION W/ REFLEX TO FT4 | 1.00 | | mIU/L |
| Reference Range > or = 20 Years 0.40–4.50<br>Pregnancy Ranges: 1st trimester 0.20–4.70; 2nd trimester 0.30–4.10; 3rd trimester 0.40–2.70 | | | |

## *Pregnancy Test*

*Background:* Following fertilization (sperm joining egg) the blastocyst implants in the uterine lining and specialized cells produce human chorionic gonadotropin (hCG). This peptide binds to luteinizing hormone receptors on the corpus luteum resulting in production of progesterone. Progesterone maintains the uterine lining (without fertilization the corpus luteum regresses and the lining sloughs off), thus sustaining the pregnancy. By about the 7th week, the corpus luteum degenerates because the placenta has taken over progesterone production (hCG levels are high until roughly month 3 of pregnancy).

| Test Name | Result | Flag(s) | Reference Range | Reported Date |
|---|---|---|---|---|
| HCG, TOTAL, QN | <2 | | mIU/mL | < OR = 5, nonpregnant |

## *B12 and Folate*

*Background:* This test is completed to look for anemia. Vitamin B12 is essential for brain and nervous system function. In pernicious anemia (disorder of the gastric parietal cells which normally produce intrinsic factor), the body cannot absorb B12 leading to B12 deficiency (and the body does not make enough blood cells). Folic acid (aka Folate or vitamin B9) is important for many cellular processes, especially during pregnancy when folate is required for spinal cord development and low folate levels can lead to spina bifida in newborns. Folate, Vitamin B12, and iron also interact.

| Test Name | Result | Flag(s) | Reference Range |
|---|---|---|---|
| Vitamin B12 | 644 | | 200–1100 pg/mL |
| Folate, serum | >24.0 | | <3.5 = low; 3.4–5.4 borderline; >5.4 normal |

## *Urinalysis (UADIP – UA DIP w/reflex)*

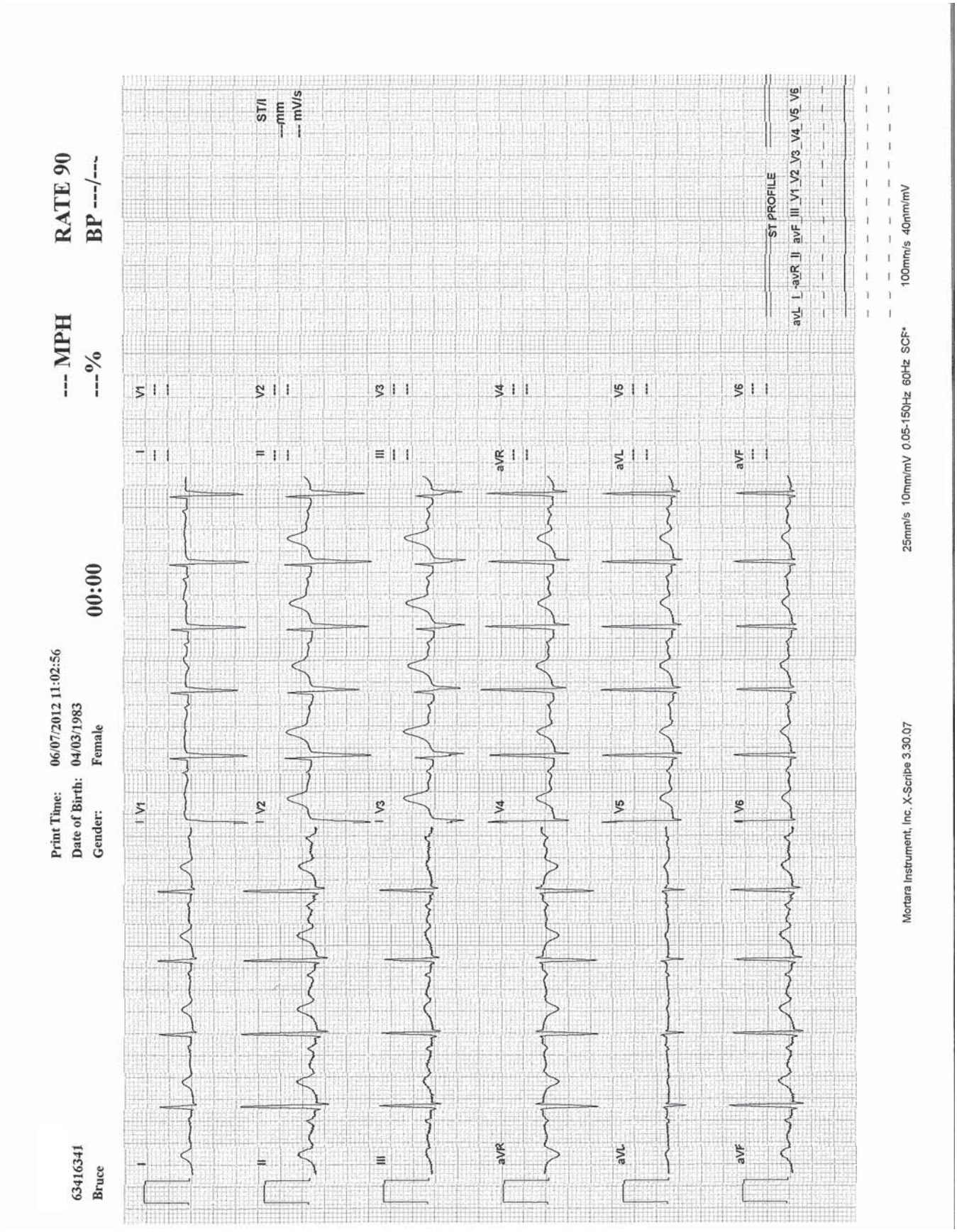
*Background:* Urinalysis is a common lab procedure used for several diagnoses. COL = color; PH = urinary pH; SPGR = specific gravity (measure of concentration, high specific gravity means concentrated urine, low means dilute urine; this is in reference to distilled water which has a specific gravity of 1.00); GLU = glucose; PROT = protein; BIL = bilirubin (the metabolites of bilirubin give urine its color); KET = ketone bodies; BLD = blood; NIT = urinary nitrate; LEUK EST = white blood cells.

| Test Name | Result | Flag(s) | Reference Range |
|---|---|---|---|
| U COL | Yellow | | Yellow |
| U PH | 7.0 | | 5.0–8.0 |
| U SPGR | 1.010 | | 1.005–1.030 |
| U GLU | Negative | | Negative |
| U PROT | Negative | | Negative |
| U BIL | Negative | | Negative |
| U KET | Negative | | Negative |
| U BLD | Negative | | Negative |
| U NIT | Negative | | Negative |
| U LEUK EST | Negative | | Negative |

## *Stress Test (Bruce Protocol) – ECG Results*

*Background:* A treadmill protocol designed by Dr. Robert Bruce to monitor cardiac function during exercise. This test is useful for detecting previous heart damage or to look for signs of arrhythmia or coronary artery disease. "The Bruce protocol is the most widely adopted protocol and has been extensively validated. The protocol has seven stages, each lasting three minutes, resulting in 21 minutes' exercise for a complete test. In stage 1 the patient walks at 1.7 mph (2.7 km) up a 10% incline. Energy expenditure is estimated to be 4.8 METs (metabolic equivalents) during this stage. The speed and incline increase with each stage. A modified Bruce protocol is used for exercise testing within one week of myocardial infarction." – *Exercise Tolerance Testing*, pp. 1084, Hill and Timmis, 2002.

See the following three pages (5–7) for Bruce Results at rest (time 00:00), peak exercise (Peak Exer 12:23), and recovery (07:08 REC).


63416341
Bruce
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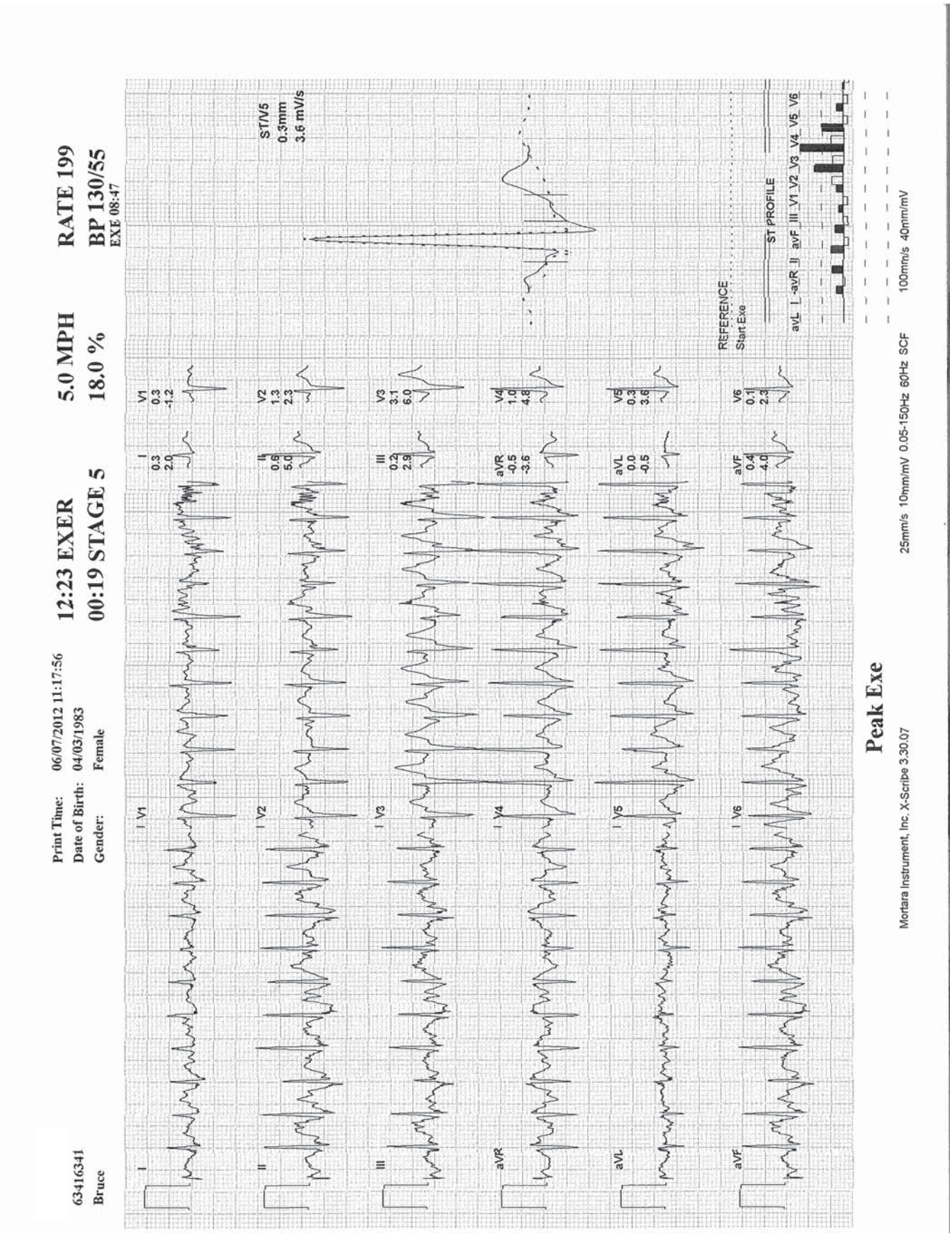
Date of Birth: 04/03/1983
Gender: Female
00:00
--- MPH
---%
RATE 90
BP ---/---
ST/I
---mm
--- mV/s
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
ST PROFILE
avL I -avR II avF III V1 V2 V3 V4 V5 V6
25mm/s 10mm/mV 0.05-150Hz 60Hz SCF* 100mm/s 40mm/mV
Mortara Instrument, Inc. X-Scribe 3.30.07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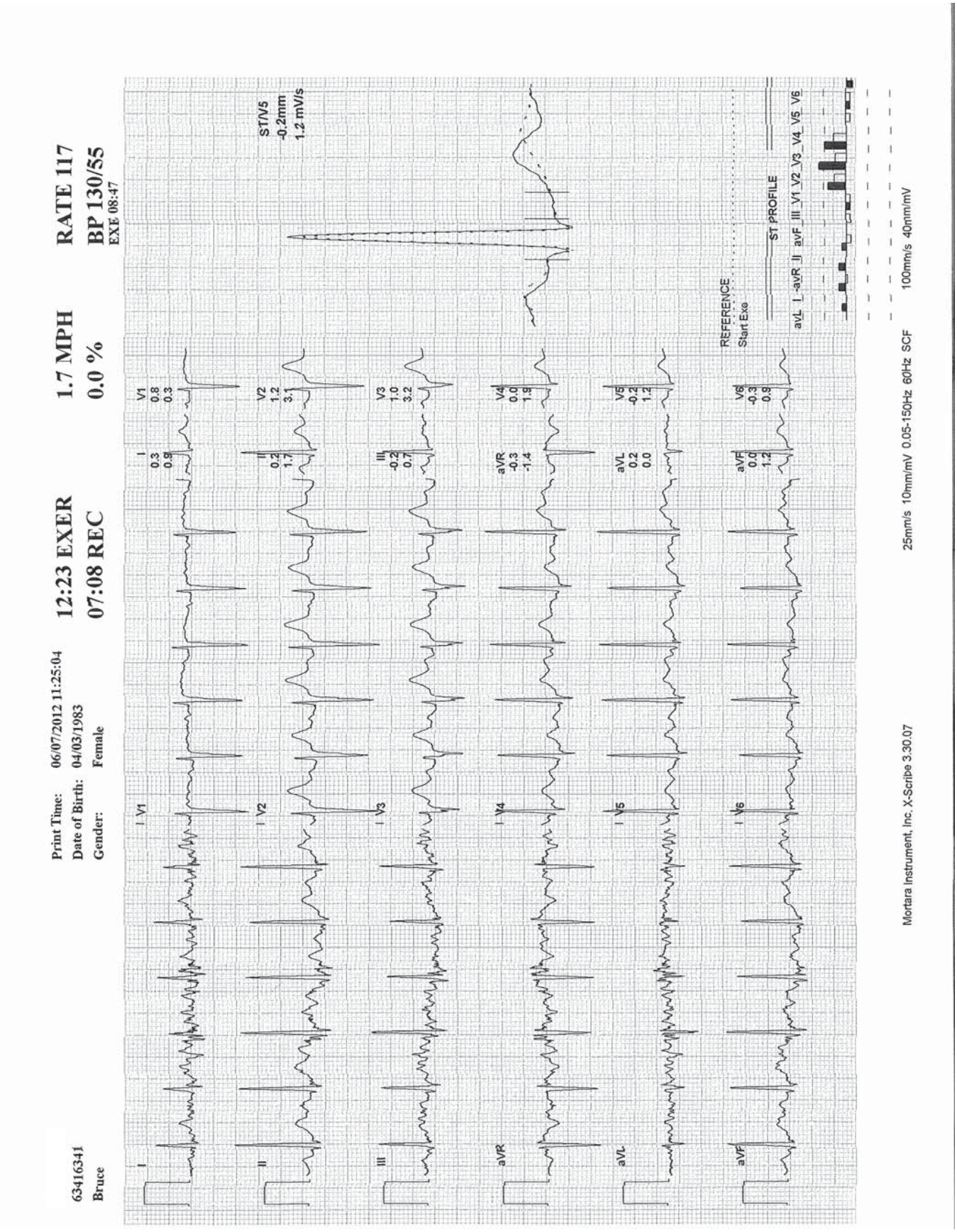
Gender: Female
12:23 EXER
00:19 STAGE 5
5.0 MPH
18.0 %
RATE 199
BP 130/55
EXE 08:47
63416341
Bruce
I V1
I V2
I V3
I V4
I V5
I V6
V1 0.3 -1.2
V2 1.3 2.3
V3 3.1 6.0
V4 1.0 4.8
V5 0.3 3.6
V6 0.1 2.3
I 0.3 2.0
II 0.6 5.0
III 0.2 2.9
aVR -0.5 -3.6
aVL 0.0 -0.5
aVF 0.4 4.0
ST/V5 0.3mm 3.6 mV/s
REFERENCE
Start Exe
ST PROFILE
avL I -avR II avF III V1 V2 V3 V4 V5 V6
Peak Exe
Mortara Instrument, Inc. X-Scribe 3.30.07
25mm/s 10mm/mV 0.05-150Hz 60Hz SCF 100mm/s 40mm/mV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Date of Birth: 04/03/1983
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12:23 EXER
07:08 REC
1.7 MPH
0.0 %
RATE 117
BP 130/55
EXE 08:47
63416341
Bruce
I V1
II V2
III V3
aVR V4
aVL V5
aVF V6
V1 0.8 0.3
V2 1.2 3.1
V3 1.0 3.2
V4 0.0 1.9
V5 -0.2 1.2
V6 -0.3 0.9
I 0.3 0.9
II 0.2 1.7
III -0.2 0.7
aVR -0.3 -1.4
aVL 0.2 0.0
aVF 0.0 1.2
ST/V5
-0.2mm
1.2 mV/s
REFERENCE
Start Exe
ST PROFILE
avL I -avR II avF III V1 V2 V3 V4 V5 V6
Mortara Instrument, Inc. X-Scribe 3.30.07
25mm/s 10mm/mV 0.05-150Hz 60Hz SCF
100mm/s 40mm/mV

## *Echocardiogram*

*Background:* An echocardiogram uses sound waves to create a moving picture of the heart. This procedure produces a picture that is more detailed than an x-ray and does not require radiation exposure. It allows visualization of the heart while it beats; videos and still pictures (Figure 4) can be captured for analysis of valves and structures. This test allows physicians to diagnose, evaluate and/or monitor: abnormal heart values, atrial fibrillation, congenital heart disease, damage to the heart, heart murmurs, pericarditis (infection of the sac surrounding the heart), infection endocarditis (infection of the heart valves), pulmonary hypertension, pumping function, and other some other conditions. Procedure can be a transthoracic echocardiogram (TTE) or a transesophageal echocardiogram (TEE); also called Doppler ultrasound of the heart or surface echo.

*Potential Valve Issues:*

- *Stenosis*—narrowing of the valve.
- *Prolapse*—the displacement of part of the valve flap into the atrium during systole (more common in bicuspid), results in regurgitation of blood.

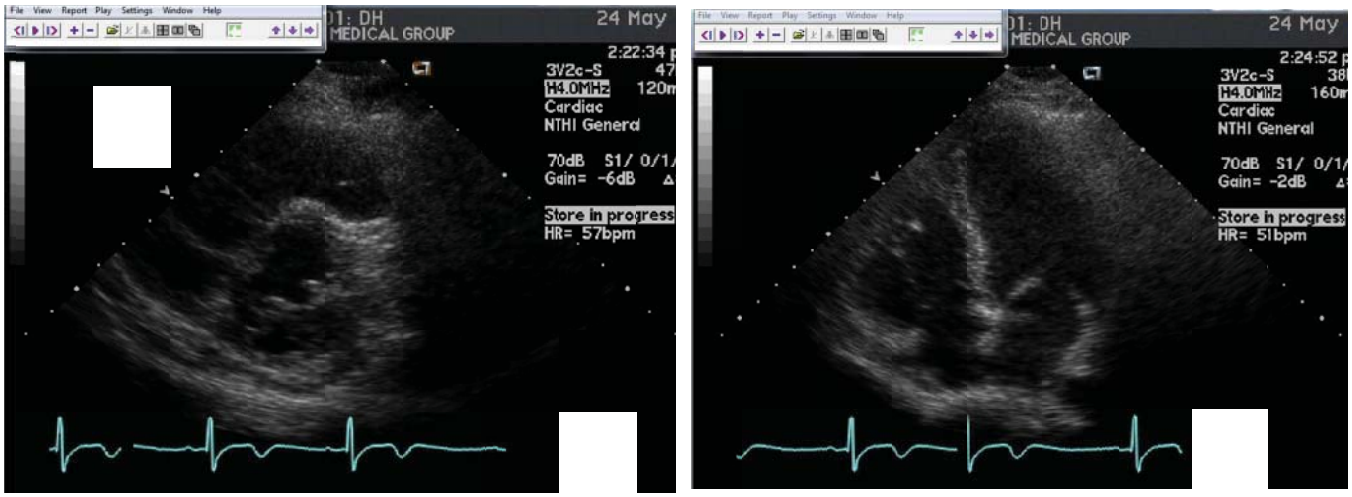


*Figure 4.* Stills from the echocardiogram. Left picture is of the semilunar value, right picture is of the AV valves (apex of heart is toward the top of the screen).

Echocardiogram results and interpretation are presented on page 9 below.

| M-Mode and 2D Dimensions: | Adult Values | Normal Range |
|---|---|---|
| RVDd | 1.1 cm | 0.7 – 2.6 cm |
| IVSd | 0.9 cm | 0.6 – 1.1 cm |
| LVIDd | 4.9 cm | 3.5 – 5.6 cm |
| LVIDs | 3.1 cm | 2.0 – 4.0 cm |
| LVPWd | 0.9 cm | 0.6 – 1.1 cm |
| $A_o$ Root Diam | 2.7 cm | 2.0 – 3.7 cm |
| $A_o$ Ascend Diam | 2.8 cm | 2.0 – 4.0 cm |
| $A_o$ Arch Diam | 2.5 cm | 2.0 – 3.6 cm |
| $A_o$ Cusp Sep | 1.8 cm | 1.5 – 2.6 cm |
| LA:$A_o$ | 1.3 | |
| LA Dimension | 3.6 cm | 2.0 – 4.0 cm |
| EPSS | 0.4 cm | 1.0 cm |
| % FS | 38 % | 30 – 45% |
| % EF M-Mode | 67 % | 50 – 85% |
| % EF Simpson's | 72 % | |

| Doppler Measurements: | Adult Values | Normal Range |
|---|---|---|
| **Mitral Valve** | | |
| Decel Time | 167 msec | 160 – 240 msec |
| Peak E | 0.9 m/s | 0.6 – 1.3 m/s |
| Peak A | 0.4 m/s | 0.3 – 0.6 m/s |
| E to A Ratio | 2.25 | 1.0 – 1.5 |
| Mean PG | 1 mmHg | < 5 mmHg |

| Doppler Measurements: | Adult Values | Normal Range |
|---|---|---|
| **Tricuspid Valve** | | |
| Peak E Velocity | 0.8 m/s | 0.6 – 1.0 m/s |
| Mean PG | 1 mmHg | |
| TR Peak Vel | 2.3 m/s | |
| RAP | 5 mmHg | 2 – 10 mmHg |
| RVSP | 25 mmHg | 18 – 30 mmHg |
| **Pulmonic Valve** | | |
| Peak Velocity | 1.0 m/s | 0.6 – 1.0 m/s |
| Peak PG | 4 mmHg | < 4 mmHg |
| Mean PG | 2 mmHg | < 2 mmHg |
| PAT | 150 msec | > 120 msec |
| **Aortic Valve** | | |
| Peak Velocity | 1.3 m/s | 0.9 – 1.9 m/s |
| Peak PG | 7 mmHg | <16 mmHg |
| Mean PG | 3 mmHg | <10 mmHg |
| LVOT Max Vel | 1.0 m/s | 0.7 – 1.1 m/s |
| AoV VTI | 0.37 m | |

| Observations | |
|---|---|
| **Left Ventricle**: | Normal cavity size. Normal wall thickness. Normal global systolic function. Normal diastolic function.Normal left ventricular ejection fraction, calculated at 72% No resting wall motion abnormalities noted. |
| **Right Ventricle**: | Cavity size is normal. Global systolic function is normal. |
| **Left Atrium**: | Normal size. |
| **Right Atrium**: | Cavity size is normal. |
| **Mitral Valve**: | Mild prolapse of the anterior leaflet with no evidence of stenosis. Trace regurgitation seen. |
| **Aortic Valve**: | Structurally normal with no evidence of stenosis and no significant regurgitation visualized. |
| **Tricuspid Valve**: | Structurally normal with no evidence of stenosis.Trace regurgitation. |
| **Pulmonic Valve**: | Structurally normal with no evidence of stenosis and no significant insufficiency. |
| **Pericardium**: | Appears normal. No pericardial effusion visualized. |
| **Aorta**: | Normal aortic root size. |
| **Pressures**: | Pulmonary artery systolic pressure is normal. |
| **Venous**: | The inferior vena cava is not dilated and shows more than 50% respiratory variation. |
| **Other**: | No pleural effusion present. |

**Conclusions**

- Normal left ventricular ejection fraction, calculated at 72%
- Mild prolapse of the anterior mitral valve leaflet is present. Trace mitral regurgitation seen.
- Trace tricuspid regurgitation present.