Sheakley M, Baumberger J, Seidel C, Benjamin L, Rhodes C, A Case of Congenital Heart Defect for First Year Medical Students - team based learning format. MedEdPORTAL; Available from: http://services.aamc.org/mededportal ID=3174
I. **Title:** A Case of Congenital Heart Defect for First Year Medical Students – TBL format

II. **Purpose:** By the conclusion of this TBL module, students will be able to understand and appreciate the value of a systems-based approach to exploring and discussing a patient with a congenital heart defect. They will be able to describe the basic anatomy and physiology of the heart, with specific emphasis on pressures and blood flow through the heart. Students should also have an understanding of basic cardiovascular diagnostic tools such as an echocardiogram, electrocardiogram, wedge pressure and cardiac catheterization, and should recognize how to utilize these diagnostic tools to diagnose a basic cardiovascular pathology.

III. **The Learning Objectives:** Successful students will…
   a. Work effectively in small groups to solve a clinical problem.
   b. Describe basic cardiac anatomy and physiology, including the normal heart chamber pressures and the normal pathway of blood flow through the heart.
   c. Calculate cardiac output using oxygen saturation data and the Fick principle equation.
   d. Describe common cardiovascular diagnostic modalities, including non-invasive techniques (e.g. trans-thoracic echocardiogram, electrocardiogram, chest x-ray, cardiac auscultation, cardiac catheterization) and invasive cardiovascular techniques (e.g. trans-esophageal echocardiography, cardiac catheterization [wedge pressure measurement]).
   e. Discuss the effect of the congenital heart defect on this patient’s life.

IV. **Advanced Preparation Assignment:** This TBL module was designed to be used in the first year of medical school after cardiovascular anatomy, physiology, and some basic cardiac clinical techniques have been introduced. The materials for this module can be found in *Cardiovascular Physiology by Morhman & Heller, 6th edition, chapters 3, 4, and 5.* It is intended to assess an overall understanding of cardiovascular physiology.

V. **Readiness Assurance Questions:** IRAT and GRAT

1) Why does peripheral edema occur more often in the feet and lower legs than in other parts of the body?

*) Capillary hydrostatic pressure is higher in the feet  
B) Plasma oncotic pressure is lower in the feet  
C) Arterial blood pressure is higher in the feet  
D) Peripheral resistance is lower in the feet

- **Explanation of correct answer:** capillary hydrostatic pressure is a force which drives fluid from the blood vessels to the interstitial space. When standing, gravity pulls blood towards the feet and increases the capillary hydrostatic pressure in the lower extremities, thus increasing filtration of blood here. In pathological situations, this can lead to edema.
2) The increase in cardiac output from rest to severe exercise is chiefly due to an **INCREASE** in

A) blood viscosity.
B) ventilation/perfusion ratio.
C) peripheral resistance.
D) stroke volume.
*) heart rate.

*Explanation of correct answer: both heart rate and stroke volume contribute to the increase in cardiac output during exercise. Stroke volume is maxed out at about 15 L/min, which would be considered moderate exercise, but heart rate continues to increase as the severity of exercise increases. Thus, for the typical person, increases in cardiac output during exercise above about 15 L/min are primarily due to increasing heart rate.*

3) A four-year-old boy with chronic fatigue and exertional dyspnea (shortness of breath) is found to have mitral valve regurgitation. With a resting pulse rate of 100 bpm, the blood flow from the ventricle into the aorta with each beat is 40 ml. His arteriovenous \( O_2 \) difference is 50 ml/L of blood, and his rate of \( O_2 \) consumption is 150 ml \( O_2 / \) min. Approximately, what percent of his stroke volume is regurgitated into his left atrium?

A) 10%  
B) 15%  
*) 25%  
D) 35%  
E) 45%

*Explanation of correct answer: To determine the volume of blood shunted to his left atrium, you must calculate his cardiac output (CO) and his effective cardiac output (ECO), then subtract the ECO from the CO and determine the ratio.

First, determine his cardiac output (CO): CO = heart rate x stroke volume = 100 bpm x 40 ml = 4 L/min.

Next, determine his Effective Cardiac Output using the Fick Principle: Oxygen consumption = CO (arterial oxygen content – mixed venous oxygen content). 150 ml \( O_2 \) per minute = CO (50 mL/L). Solve for CO; CO = 150 ml \( O_2 \) per minute / 50 mL/L = 3 L/min effective cardiac output.

Subtract EFC from CO: 4 L/min – 3 L/min = 1 L/min (this is the volume that is shunted to the left atrium.

Finally, determine the ratio of blood that is shunted to the left atrium = ¼ or 25%.

Use the following data obtained from an individual to answer questions 4 & 5.

body temperature = 98^0 F
mean arterial blood pressure = 80 mm Hg
oxygen consumption = 400ml \( O_2 / \) min
pulmonary artery oxygen content = 15ml \( O_2 / 100ml \) blood
aortic oxygen content = 25ml \( O_2 / 100ml \) blood
vena cava oxygen content = 13ml \( O_2 / 100ml \) blood
end systolic volume = 40ml
end diastolic volume = 100ml
4) The cardiac output (L/min) of this person is:

A) 10  
B) 2  
*) 4  
D) 20  
E) 40

• Explanation of correct answer: The Fick principle is needed to solve this problem. Cardiac Output = Oxygen Consumption / (arterial oxygen content – mixed venous oxygen content). CO = 400 ml O₂ per min / (25ml O₂/ 100ml blood - 15ml O₂/ 100ml blood) = 4 L/min.

5) The ejection fraction of this person is approximately:

A) 45%  
B) 30%  
C) 10%  
D) 55%  
*) 60%

• Explanation of correct answer: Ejection fraction (EF) = (end diastolic volume – end systolic volume) / end diastolic volume. EF = (100 ml – 40 ml) / 100 ml = 0.6. Multiply by 100 to convert this to a percentage. 0.6 x 100 = 60%.

6) A 66-year-old woman sees her doctor for a routine physical, and a heart murmur is heard between S2 and S1. Further tests reveal a decreased left ventricular end diastolic volume and pressure. Which of the following valve disorders is most likely present in this patient?

A) Aortic valve stenosis  
B) Mitral valve regurgitation  
C) Tricuspid valve regurgitation  
D) Aortic valve regurgitation  
*) Mitral valve stenosis

• Explanation of correct answer: A murmur heard between S2 and S1 is diastolic murmur (thus A, B, and C are eliminated because they are systolic murmurs). Of the two remaining choices, only mitral stenosis would produce a reduced left ventricular end diastolic volume and pressure, so this is the correct answer. (aortic valve regurgitation would increase both of these end diastolic values because of increase backflow of blood through the aortic valve during diastole).
Use the ECG trace below to answer questions 7-10.

7) The Mean Electrical Axia (MEA) of this patient is between
A) +30° and +60°
B) 0° and +30°
C) +90° and +120°
D) +150° and +180°
E) -30° and -60°

*Explanation of correct answer: to solve for the MEA, students can use the quantitative or semi-quantitative method of determining the MEA, which involves plotting the net amplitude of the QRS complexes onto a radial axis and drawing the appropriate intersecting points to determine the MEA.*

8) Which of the following best describes the positioning of this patient's heart?
A) left axis deviation
B) normal
C) right axis deviation

*Explanation of correct answer: normal heart deviation is an MEA between 0° and +90° on the radial axis (some sources say -30° to +90°). The previous question determined that this person has an MEA between +30° to +60°, which is in the normal range.*

9) Which of the following is closest to this patient’s heart rate?
A) 60 bpm
B) 45 bpm
C) 100 bpm
D) 95 bpm
E) 85 bpm
- **Explanation of correct answer:** Heart rate can be determined on the ECG trace by counting the number of small boxes between any two “R” waves, and multiplying this by 0.04; 18 x 0.04 = 0.72, this is the length of time for one heart beat., then divide into 60 to find the beats per minute; 0.72 / 60 = 83bpm (estimated to 85 bpm in the answer choice above).

10) Based on the ECG above, a likely diagnosis for this patient would be

a) myocardial infarction.  
b) second degree heart block, type I.  
c) second degree heart block, type II.  
d) first degree heart block

- **Explanation of correct answer:** The ST segment elevation seen clearly in leads II and III on the ECG trace above is a good indicator of a myocardial infarction. Choice B and C can be eliminated because there is a sinus rhythm, and choice D can be eliminated because the PR interval in normal in the trace above.

**VI. Group Application Exercise:** A Case of Congenital Cardiac Defect for First Year Medical Students

Jane, a 30-year-old woman, became breathless, fatigued, dizzy and experienced heart palpitations while playing hide-and-seek with her 2 year-old daughter. She had never been very athletic as a child so tiring easily was not too much of a surprise. However, she was noticing that even simple activities like walking were making her feel breathless. These symptoms worried her so she visited her physician to see if anything could be wrong.

Her physician asked if this was the first time she had had heart palpitations. She said, “Sometimes my heart pounds when I lie down to go to sleep at night and even once when I tried to take a nap on a Sunday afternoon, but eventually it subsides”. Her past medical history indicated that during childhood she easily fatigued, often had respiratory illnesses and always was one of the shorter kids in her class. Her family history revealed that her sibling had died of a congenital heart defect at 3 months of age.

Physical exam indicated an apparently healthy 5-foot 5-inch tall women weighing 110 pounds. There were no signs of pallor or fever but there was some evidence of mild pedal (peripheral) edema. Her blood pressure was 115/70. Her chest was clear with no abnormal breath sounds. Cardiac auscultation indicated a split S2 that did not change through the respiratory cycle. A grade 3/6 systolic murmur was heard on the left side of the sternum in the second intercostal space as well as at the apex of the heart.

A complete blood count (CBC), echocardiogram, electrocardiogram (ECG), cardiac catheterization and X-ray were ordered.
Results:
A. CBC results: Normal
B. Echocardiogram:

Examination of image for facilitator: The echocardiogram image above shows four chambers of the heart in an apical view - left side of the heart to the right. Anatomically, the heart is in the correct position with the apex at bottom. It also shows an atrial septal defect (a hole in the septum between the right and left atria).

C. ECG Trace:

Examination of image for facilitator: The ECG trace is a typical 12 lead ECG trace. It shows an incomplete right bundle branch block, which is typical for an atrial septal defect, as well as a slight right axis deviation.
D. Chest X-ray:

![Chest X-ray Image]


- Explanation of image for facilitator: The chest X-ray shows a few typical signs of atrial septal defect; including Cardiomegaly, a prominent pulmonary artery segment (i.e. dilated pulmonary artery from increased flow due to the septal defect), and increased pulmonary vascular markings, which indicate increased blood flow through the pulmonary vasculature.

E. Cardiac catheterization results obtained with a Swan-Ganz catheter:

- Pulmonary wedge pressure: 11 mmHg (normal 2 - 10)
- Pulmonary artery pressure: 26 / 12 mmHg (normal systolic = 15 – 25; normal diastolic = 8 – 15)
- Right ventricular pressure: 32 / 7 mmHg (normal systolic = 15 – 25; normal diastolic = 3 – 12)
- Right atrial pressure: 10 mmHg (normal 2 - 8)
- Right atrial a- and v-waves elevated in magnitude
- Right ventricular oxygen saturation: 90% (normal 75%)
- Right atrial oxygen saturation: 90% (normal 75%)
- Femoral artery oxygen saturation: 97% (normal 97%)

1) Using the Echocardiogram image above, which chamber of Jane’s heart appears to be enlarged?

A) Right Atrium  
B) Left Atrium  
*) Right Ventricle  
D) Left Ventricle

Explanation of correct answer: With a left to right shunt as seen in atrial septal defect, the patient will usually present with right ventricular hypertrophy, which can be seen on the echocardiogram image above.
2) Using the ECG trace above, determine the orientation of Jane’s heart.

A) Normal orientation
B) Left axis deviation
*) Right axis deviation

Explanation of correct answer: Atrial septal defect patients often present with right axis deviation due to right ventricular hypertrophy. The students can draw the radial axis and plot leads I, II, III, aVR, aVL, and aVF on the axis to determine the orientation of Jane’s heart. Or, they can just plot Leads I and aVF (fast method) to determine the MEA is within the right axis deviation range.

3) Considering all the information you have about Jane, which of the following cardiovascular problems do you think she most likely has?

*) Atrial septal defect
B) Patent ductus arteriosis
C) Pulmonary valve stenosis
D) Ventricular septal defect
E) Tricuspid valve stenosis

Explanation of correct answer: Students should systematically use the data provided in the case to eliminate the answer choices one-by-one.
- Since a systolic murmur was detected, tricuspid valve stenosis (letter E) is eliminated because that would produce a diastolic murmur.
- Since the wedge pressure is at the high end of the normal range, this eliminates pulmonary valve stenosis (letter C) because this condition would produce a low wedge pressure due to reduced blood flow to the left heart.
- Since a higher than normal oxygen saturation was measured in the right atrium and ventricle, this eliminates patent ductus arteriosus (letter B) because a patent ductus arteriosus moves oxygenated blood from the Aorta to the pulmonary artery, but NOT to the right heart, thus the right heart should not have high oxygen saturation.
- Since both the right atrium and right ventricle have high oxygen saturation, ventricular septal defect (choice D) is eliminated because this shunt blood from the left ventricle to the right ventricle, increasing the oxygen saturation of the right ventricle only, but would not affect the oxygen saturation of the right atrium.
- Since both the right atrium and right ventricle have high oxygen saturation, the atrial septum must have a defect which allow newly oxygenated blood to flow from the left atrium to the right atrium, then the blood continues to the right ventricle. Further, this shunting of blood from the left to right heart explains the high right heart pressures and large a- and v-waves on the venous pressure graph. Also, the large volumes of blood in the heart may (over time) produce right heart failure, leading to peripheral edema and right axis deviation of the heart. Finally, the atrial septal defect can be seen on the echocardiogram. Thus, atrial septal defect (choice A) is the correct answer.
Note to facilitators: Due to time constraints in our curriculum, we do the group application exercise as a closed book exercise. If you have more time and want to use the traditional method of TBL, this group application section should be an open book exercise and the following questions could be added to the group application exercise:

5) Given the patient’s diagnosis, which procedure would most likely be performed on this patient?

A) Atrial septoplasty  
B) Coronary artery bypass  
C) Mitral valvulotomy  
*) Septal patching

• **Explanation of the correct answer:** In many cases (but not all), the ASD can be repaired without open heart surgery. The procedure involves placing a patch into the heart through a catheter, which is inserted into a vessel in the groin region and fed to the heart. The patch is placed across the ASD and the defect is closed.

6) What therapy does this patient need prior to any definitive surgical intervention?

A) Aspirin  
B) Clopidogrel  
C) Warfarin  
*) Antibiotics  
E) Diuretics  
F) Antiarrhythmics

• **Explanation of the correct answer:** ASD patients will need to take antibiotics before a visit to the dentist or if they need certain other kinds of surgery, such as tonsil removal. This is to prevent bacteria from getting into the bloodstream and causing bacterial endocarditis.

VII. **Context:** This case is one of three used for the Progressive Academic Education (PAcE) Program, an independent study program for first year medical students, at Ross University School of Medicine.

VIII. **Facilitation Schema:** (Explanation of the Team Based Learning (TBL) format)  
This case was written to be used in a Team-Based Learning (TBL) format. TBL cases utilize a specific written format and method of facilitating to produce very effective small group and class discussion. Michaelsen, Parmalee, McMahon and Levine describe in detail this theory and method in the book “Team-Based Learning for Health Professions Education”. You can also learn more about TBL at [http://www.ou.edu/pii/teamlarning/](http://www.ou.edu/pii/teamlarning/).  

In short, TBL cases should be written to utilize the “Four S’s” in order to foster team work and group discussion. These are: (1) the students should be working on a problem that is significant or relevant to them and/or their course of study (2) all students in the class
should be working on the same problem or assignment, (3) students should be required to make a specific choice, and (4) group should all simultaneously report their choices.

1. If the case/problem is not perceived as significant or relevant, students will think they are being asked to do “busywork” and will put forth just enough effort required to get a decent grade.

2. It is important that all groups are working on the same problem because this enables a discussion both within group and between groups. If each of the groups is working on a different problem, then there is no common ground for discussion between groups.

3. The assignment should be written so students have to make a specific choice (i.e. put a multiple choice question at the end of the assignment). If students are asked an open-ended question at the end of the assignment, they make come up with one or two answers then end their discussion. If faced with a choice between five to seven possibilities, they have to discuss each possibility fully in order to accept it or reject it. Thus, more discussion is elicited when students are asked to make a specific choice. The choices should be written rather vaguely to stimulate discussion, with one best choice but other possible correct choices

4. After group discussion, the group should be instructed to report their answer choice simultaneously. I do this by giving each group an envelope that contains 5 colored note cards lettered A, B, C, D, or E. The groups are asked to raise the note card which corresponds to their answer choice on the count of three. This allows the facilitator to immediately assess the overall performance of the class, and prevents groups from choosing their answer based on what other groups think. It also requires each group to commit to one answer choice and be ready to defend it.

Our groups are composed of 6 students per group, and a “sorting” process should be used to form the groups based on sorting criteria that you choose (i.e. students should not self-select their groups because they will sit with the people they know and a pre-established dynamic will exist, which we do not want). We form our TBL groups by asking all of the students to stand in the middle of the room. Then we ask all students who have a terminal degree of any sort (Ph.D., MD, Law, Chiropractor, etc.) to form a line around the perimeter of the room…this is our first sorting criteria. Next we ask all students who have a medical professional degree (i.e. EMT, PT, OT, Nurse, etc.) to get into the same line (this is our second sorting criteria). We continue through six sorting criteria that we have established until all of the students from the class are in the same line. Then, beginning with the first student in the line, we ask the students count off from 1-20, then begin counting at 1 again (we form 20 groups in our class, but this number will vary based on the number of groups you want to form). Then all students who counted a “1” are in the same group, and all students who counted a “2” are in the same group, and so forth.

This TBL session requires approximately two hours to complete in the TBL format. When students arrive to the class/session, they should sit in their assigned groups and the quizzes should be distributed. The students should be given approximately 15 minutes to complete the individual readiness assessment test (IRAT), where students should take the quiz by themselves. The next 15-20 minutes is used for the group readiness
assessment test (GRAT), where the same quiz is taken by the group, and the group should agree on one answer for each question. During the next 30 minutes, the facilitator should lead a whole class discussion, going through each question one by one and allowing students to discuss/debate the correct answers. The IRAT and GRAT are both closed book exercises. Answers for both exercises are recorded on Scantron sheets by each student and all IRAT and GRAT scores are graded and recorded.

Next, the group clinical application case should be distributed and the groups should discuss the case within their groups and answer the questions. Initially the groups should be allowed 15 minutes for this group discussion, then if more time is required, you can add an additional 5-10 minutes as needed. This discussion period should be closed-book, and no outside resources (internet, handouts, journals, etc.) should be used during the discussion or to answer the questions (traditionally, the group application sessions in TBL are open book and the use of extraneous resources is allowed, but due to time constraints in our program, we deviate from this general rule at our institution). After the discussion is finished, the students should simultaneously report their answer for the first question when you instruct them to do so. To facilitate simultaneous reporting, it is useful to hand out colored note cards that have the answer choices (A, B, C, D, E) written on them. Then you can ask the groups to raise the note card which corresponds to their answer choice on the count of three. This allows immediate assessment of the class responses, and makes it easy to facilitate whole class discussion based on which answers the students chose. After the first question is discussed, proceed to the remaining questions in the same format. Allow 20-30 minutes for whole class discussion of all of the questions. We also typically take a 10 minute break in between the RAT and group application sessions.

IX. Our experience with this module:
In our experience, the students found this case to be interesting and a positive learning experience, based on verbal feedback received at the end of the session. They liked interpreting the diagnostic tests (ECG, Echo and chest X-ray). The discussion was excellent, particularly for the second question of the clinical case, which was difficult enough to stimulate a lot of discussion as to why some of the answer choices were incorrect.

The students commented specifically on the excitement surrounding the interpretation of the ECG, X-ray and Echo, and the exposure to clinical material. Most of the groups did well on the RAT’s, but not so well on the group application exercise, but they relayed that the whole group discussion was facilitated well so that the student groups were debating the answers with each other, which they found rewarding. We did not correlate performance on the RAT’s or group exercise to exam performance.

X. References:
