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EDUCATIONAL TECHNIQUE

Drawing for Retention: Using Visual Arts to Teach Cardiovascular Pathophysiology in Athletic Training

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Context: Sudden cardiac arrest is the leading cause of sport-related deaths in young athletes. Athletic training students must understand cardiovascular anatomy and physiology in addition to pathophysiology to appropriately care for patients with cardiovascular conditions.

Objective: Describe a teaching technique to actively engage students in lecture about cardiovascular anatomy, physiology, pathophysiology, and electrocardiograms.

Background: Drawing for retention is an educational technique used in medical education to help students recognize patterns, reinforce knowledge, and retain information. Using drawing for abstract concepts that cannot always be visualized or applied enhances comprehension.

Description: An educational technique using drawing for retention to teach cardiovascular concepts, conditions, and basic electrocardiogram interpretation was implemented in an emergency care in athletic training course. The instructor drew and lectured on concepts of anatomy, physiology, pathophysiology, electrocardiograms, and interventions while the students drew and took notes on the concepts.

Educational Advantage(s): Students describe this activity as a beneficial way to learn and apply cardiovascular anatomy and physiology to cardiovascular conditions and treatment.

Conclusions: Faculty may consider implementing drawing for retention as an active learning technique to engage students with complex or abstract topics.

Key Words: Heart anatomy, educational technique, student-generated drawing

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Drawing for Retention: Using Visual Arts to Teach Cardiovascular Pathophysiology in Athletic Training

Ashley B. Thrasher, EdD, LAT, ATC, CSCS; Susan S. Braithwaite, EdD

KEY POINTS

- Athletic trainers should have a strong foundation of cardiovascular anatomy and physiology to treat cardiovascular conditions.
- Drawing actively engages students during lecture, which enhances retention.
- Using drawing to teach cardiovascular anatomy, physiology, and electrocardiograms is a simple, yet impactful, way to teach these concepts.

INTRODUCTION

Sudden cardiac arrest is gaining a tremendous amount of publicity in athletics and is the leading cause of sport-related deaths in young athletes, with between 100 and 150 sudden cardiac deaths occurring annually during athletic participation.[1] However, athletic trainers (ATs) and athletic training students need to be able to recognize and manage all cardiac pathologies, emergent or not. An understanding of cardiac physiology, function, and pathologies is vital to recognizing and managing cardiac conditions. With the 2020 Commission on Accreditation of Athletic Training Education (CAATE) standards,[2] additional topics related to evaluating and managing cardiac conditions were included, such as the delivery of nitroglycerin as part of the treatment plan and obtaining or performing diagnostic testing, including electrocardiogram (ECG), to facilitate a treatment and referral plan.[2] A thorough understanding of cardiac anatomy, physiology, and function assists ATs and athletic training students in evaluating and managing cardiac pathologies. For example, ATs must be able to recognize when providing nitroglycerin is appropriate and when it is contraindicated. To fully understand the delivery of nitroglycerin, students must understand the concept of cardiac load, including stroke volume, preload, and afterload.[3] To understand and use ECGs, students must understand cardiac physiology, which can be a complex and challenging topic.[4]

One educational method that can be used to assist students in learning these topics is drawing for retention. Heavily used for anatomy, histology, and medical education, drawing for retention is using visual arts to engage students in the content.[5–8] Initially drawn by the instructor, concepts are presented and redrawn by students. Through repetition, students are able to redraw the images while explaining the concepts from memory. Using drawing as an educational technique can actively engage students in the learning process and has positive benefits on patient care through promoting observational skills.[5,6] Previous researchers exploring the use of art in a histology class found that students who drew during the course felt it was a valuable way to learn the concepts.[5]

Simply adding visual aids and pictures enhances retention.[7] A seminal research article exploring cardiovascular function found that students who learned through drawing a simple heart while listening as compared to verbal instruction alone scored significantly higher on assessments, both immediately and 2 weeks later.[8] Rooted in experiential learning theory, drawing while listening and taking notes simultaneously engages multiple cognitive levels[8] and helps learners develop a mental model,[9] which enhances information retrieval. Multiple studies have demonstrated that drawing is more effective in retaining information than simply viewing illustrations.[7] Previous research also suggests that drawing may lead to more efficient learning.[5,6] Preclinical medical students who used body paint to learn hand anatomy reported painting helped them easily identify structures of the hand and facilitated their learning.[6] Additionally, compared to their control group classmates, students who were in the drawing group spent less time studying and scored significantly higher on questions related to hand anatomy both immediately (ie, on the exam) and 1 month after the learning activity, which demonstrated positive effects on retention. Through passive learning, students tend to retain less than 50% of what they learn.[10] As students actively engage in the content through drawing, doing a dramatic presentation, simulation, or performing the technique, students can retain up to 90% of the content.[10] However, abstract concepts cannot always be performed or simulated, such as cardiac physiology. Therefore, drawing for retention is a technique instructors can use to turn abstract concepts into active learning. The purpose of this educational technique is to demonstrate how instructors can use drawing for retention to teach cardiovascular physiology and pathophysiology, cardiovascular conditions and treatments, and basic ECG interpretation. In accordance with the Common Rule and federal definition of research, the university institutional review board did not require review of this educational strategy because it was an educational technique that was completed as a part of educational practice and was not considered research.

TEACHING TECHNIQUE DESCRIPTION AND PURPOSE

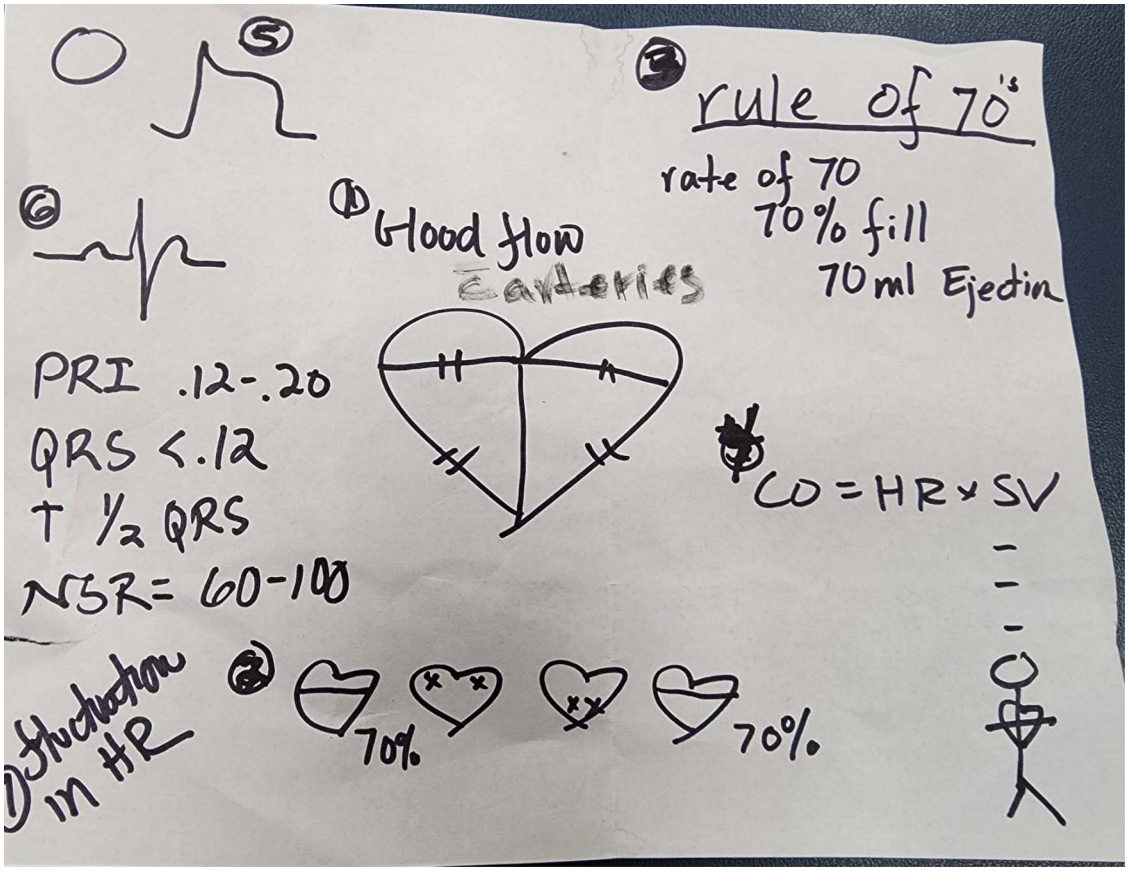
This class activity was integrated into an Emergency Care for the Athletic Trainer course as a part of a larger section dedicated to cardiovascular emergencies. Objectives for this section of the course aligned with CAATE standards 70 (cardiac compromise), 71 (cardiovascular system), 72 (ECG), and 79 (cardiovascular disease).[2]

STRATEGIES FOR IMPLEMENTATION

Materials Needed

Noted advantages of the drawing-for-retention method are its reduced reliance on materials and that it does not require any technology. The drawing method is best delivered in a classroom equipped with a whiteboard and an array of colored dry erase markers. Students received paper and colored pencils, markers, or crayons. A variety of colors is best to improve visual stimulation, which aids retention. Students also received ECG paper.

Figure 1. Lesson plan.



Lesson Planning

Arguably the greatest challenge for an instructor wishing to teach using the drawing-for-retention method is lesson planning. Planning for the lesson begins exactly as with any topic, by outlining the most important concepts that must be delivered. The goal of the lesson becomes a series of learning objectives. As the instructor develops the points within each objective, simple images are planned with notations for each to explain content (Figure 1). Similarly to having a PowerPoint presentation with notes outlined, the instructor has an outline of the concepts and images to draw. For instructors who are new to the technique, we recommend having notes outlined along with the pictures to ensure all the relevant information is included. Additionally, predrawn images are helpful for instructors who might not feel as comfortable performing the initial drawings in front of the class. At times, there is not an obvious image related to a concept. An image can be chosen, or a search engine can be used to generate ideas. As an example, the concept of *good* suggests images such as a thumbs-up or smiley face, whereas the concept of *evil* reveals a frowning face with horns. Relationships between concepts can be represented with simple arrows or colors. Images can be anything; the key is to select images that will become the prompts, which tell the story. Students will then connect the images with the concepts. For cardiovascular concepts, we used a simple valentine heart with various colors and arrows drawn. Effectiveness of delivery is not dictated by the quality of the image drawn. The Table outlines concepts that were taught with drawing for retention in this course.

Implementation

At the beginning of the class, the course instructor distributed crayons, markers, colored pens or pencils, regular paper, and ECG paper and explained how the students would take notes for the day. Students were not able to use technology (eg, laptop, iPad) to take notes. Students were instructed to draw along as the instructor drew on the board. They also could take notes based on what the instructor was saying. Students were informed that success of drawing for retention is not related to drawing skill, but rather to simple concepts that can be repeated. While teaching the concept, it is important to provide time for students to draw along with the instructor.

The lesson began with a review of the chambers of the heart and blood flow through the heart. A simple valentine heart was drawn with lines denoting the 4 chambers, arrows demonstrating the path of blood flow, and labeled lines for arteries and veins (Figure 2). Arteries were drawn in red, and veins were drawn in blue. The instructor drew images and provided descriptions throughout the lesson, starting with cardiovascular anatomy and physiology (Figures 2 and 3). Continuing with the drawing, the instructor discussed cardiac output and how that is impacted by various cardiovascular conditions (Figure 4). For example, myocardial infarction was drawn using the concept of cardiac output and how the changes in blood flow to the heart muscle impact cardiac output. Concepts were then connected to treatment, in which the instructor differentiated between a right ventricular and left ventricular myocardial infarction, which impacts the use of nitroglycerin

Table. Concepts Taught

Concept	Objective	Connection to Standard
Foundation		
Cardiovascular anatomy	Chambers, blood flow	Standard 55: human anatomy, pathophysiology
Cardiac cycle	Diastole, systole, ventricular fill, ejection	Standard 71: cardiovascular system
Conduction system	Anatomy	
Depolarization of the heart	Phases of depolarization	
The ECG		
Waveforms	Electrode placement, positive/negative/isoelectric, waves and segments	Standard 72: ECG
Normal sinus rhythm	Waves and segments, rate	
Dysrhythmia; ventricular, supraventricular tachycardia	Automaticity, ectopic focus	Standard 79: cardiovascular disease
Pathophysiology of dysrhythmia	Hypoxia, hypoperfusion, coronary artery disease	
Cardiac output		
Formula	Cardiac output is equal to stroke volume × heart rate	Standard 55: human anatomy, pathophysiology
Stroke volume factors	Preload, afterload, contractility	
Impact of rate; tachycardia, bradycardia	Loss of ventricular fill, Starling's law	
Applying concepts		
Case: runner with exercise-induced tachycardia and increased QRS amplitude	Normal variations in the athlete's ECG, presentation, assessment	Standard 72: ECG
Pathophysiology and ECG output: hypertrophic cardiomyopathy, commotio cordis, sudden cardiac arrest, myocardial infarction, long QT syndrome	Abnormal presentations, pathophysiology	Standard 55: human anatomy, pathophysiology Standard 71: cardiovascular system Standard 79: cardiovascular disease
Impact of treatment	Nitroglycerin Low-dose aspirin IV fluid Science of CPR	Standard 70: cardiovascular compromise including emergency cardiac care, nitroglycerin, low-dose aspirin, supplemental oxygen

Abbreviations: CPR, cardiopulmonary resuscitation; ECG, electrocardiogram; IV, intravenous.

Figure 2. Heart anatomy.

(Figures 5 and 6). The instructor and students then drew up how nitroglycerin, low-dose aspirin, and oxygen impact cardiac compromise. Student examples of notes are provided in Figures 7 through 10. Similar to students taking notes in class, the drawings were different based on student style. All students provided their permission to have their images used in this article.

The instructor then connected the foundational concepts of anatomy and physiology to the ECG (Figure 11). Using ECG paper, students drew and labeled normal sinus rhythm. Then, the instructor modeled and students drew abnormal rhythms seen in athletic training practice (eg, tachycardia, bradycardia, dysrhythmia, myocardial infarction, long QT syndrome, hypertrophic cardiomyopathy,

Figure 3. Circulation and conduction.

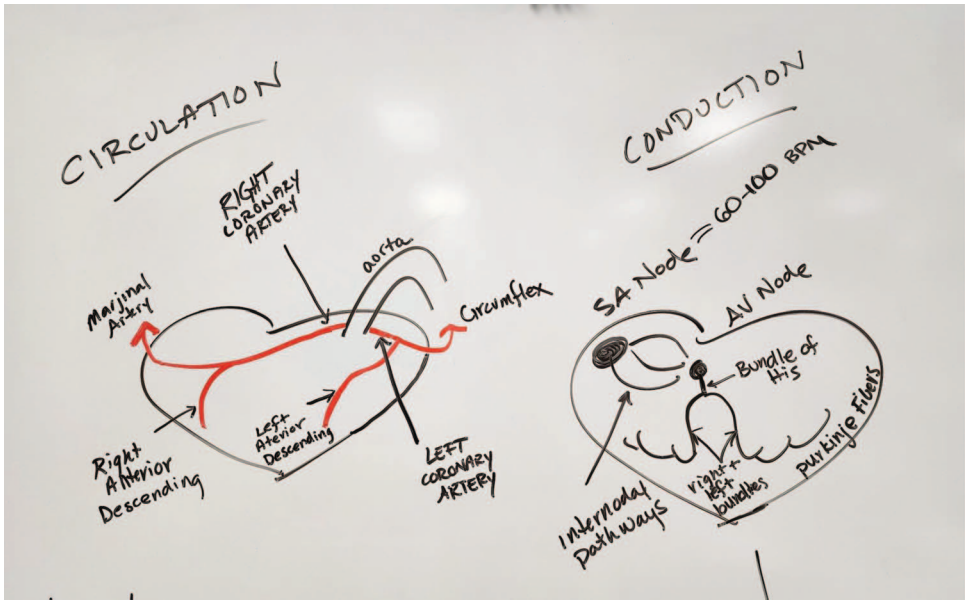
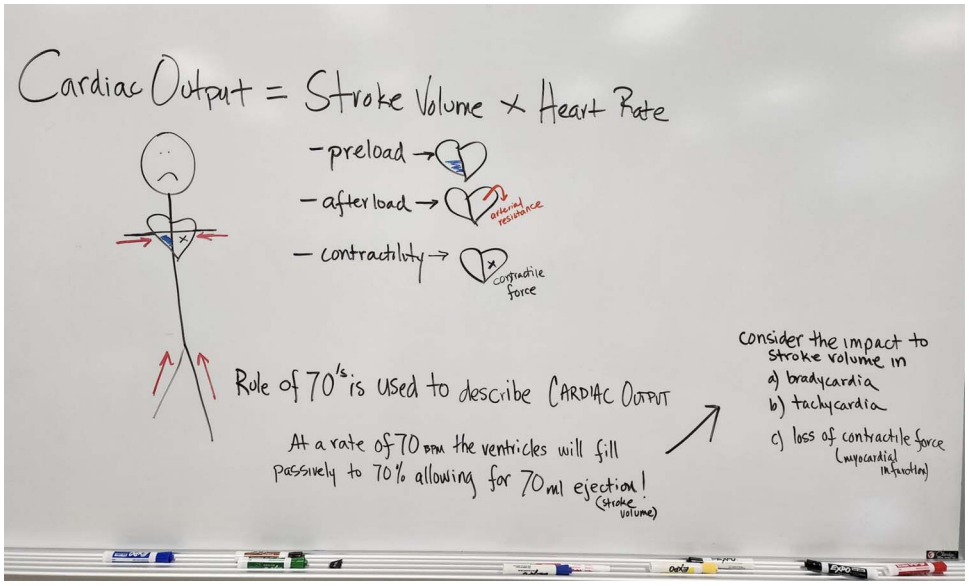


Figure 4. Cardiac output.



commotio cordis) (Figures 12 and 13). Student examples of ECGs are provided in Figures 14 and 15. By the end of the class session, students had drawings and notes of the cardiovascular anatomy and physiology, cardiac output concepts, ECG waveforms, and impact of various cardiovascular treatments (eg, nitroglycerin, aspirin).

OUTCOMES AND LESSONS LEARNED

Students responded very well to learning through drawing the cardiovascular system. This course activity did not include any formal assessments; however, students stated that they better understood the components of the ECG, what to look for when reading the ECG, and when to administer nitroglycerin. After the course session, students were asked to provide informal feedback. Students also provided formal feedback on their course evaluations. For direct quotes, students provided their consent to have their comments included in this article. Students commented on many benefits of this activity, such as helping them draw out the heart and see how different conditions present on the ECG. One student stated, "I am a visual learner and being able to draw and use an ECG sheet made it so much easier, also I can recreate these drawings

Figure 5. Myocardial infarction.

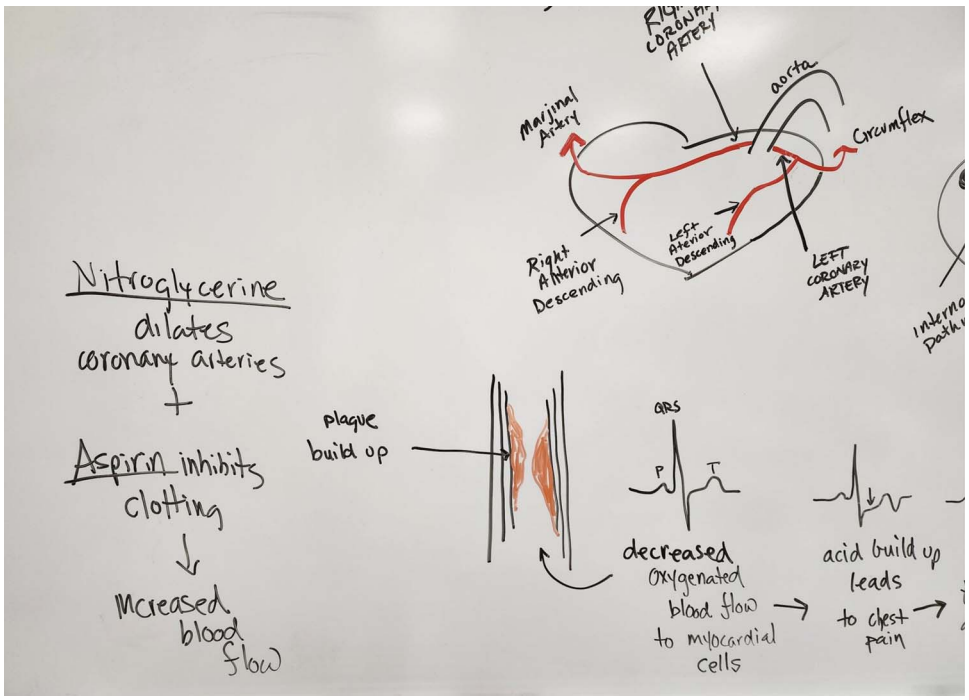
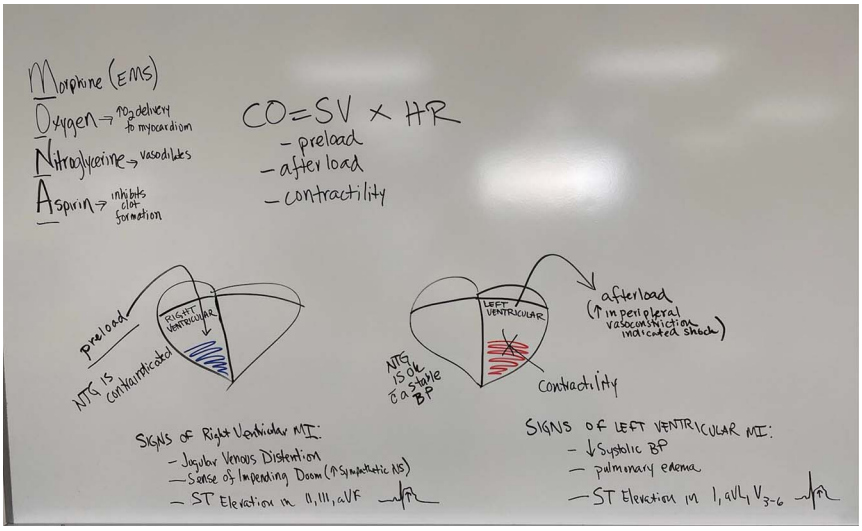


Figure 6. Myocardial infarction treatment.



during an exam to help with recall." Another commented, "The teaching method used was very helpful. I am a kinesthetic learner so getting to draw it helped me put things together." Even students who did not draw often still benefited from drawing the cardiovascular system and ECGs. One commented, "Typically, I am not a drawing person. However, being able to visualize and draw these concepts really helped." Another student stated,

Figure 7. Example of student notes.

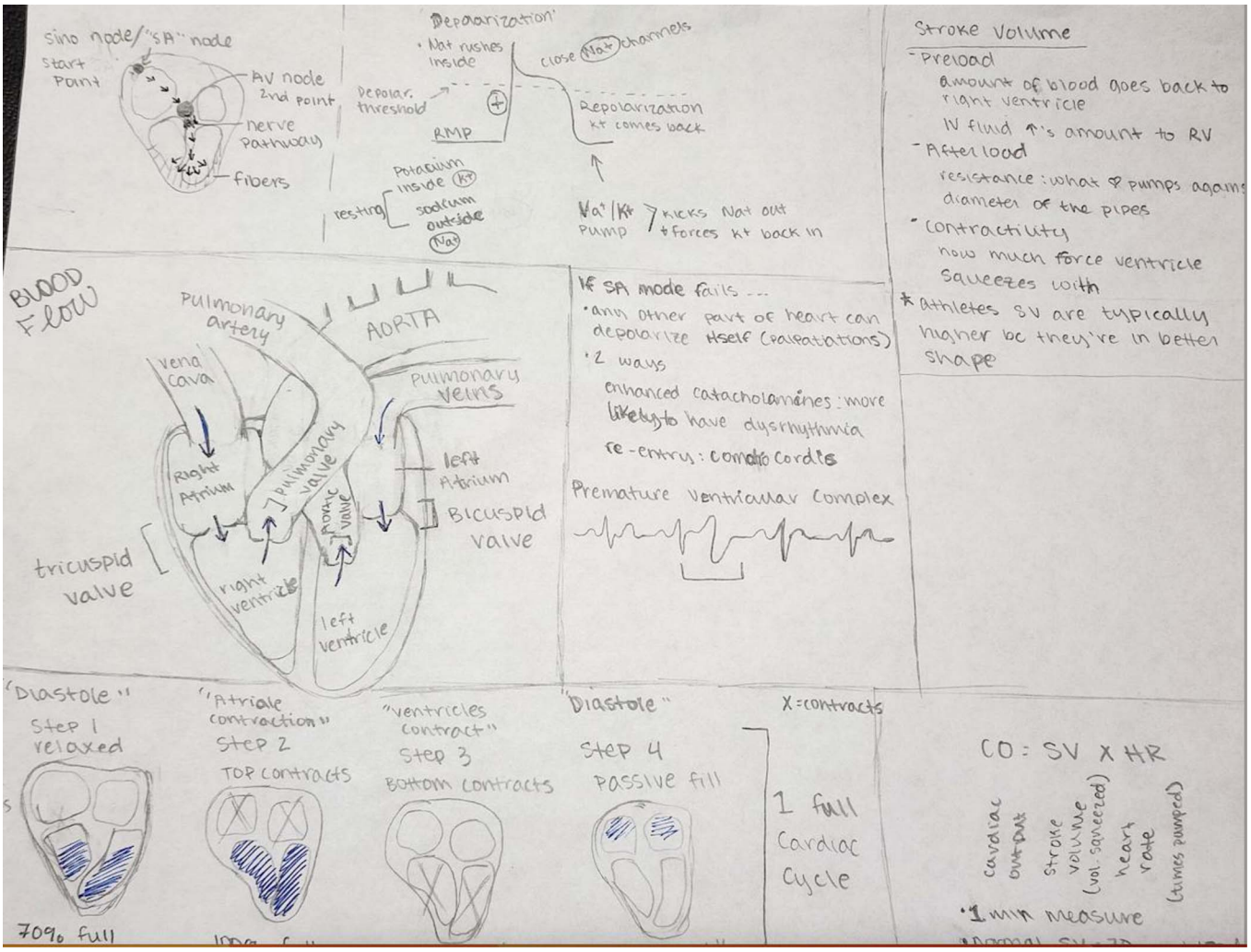
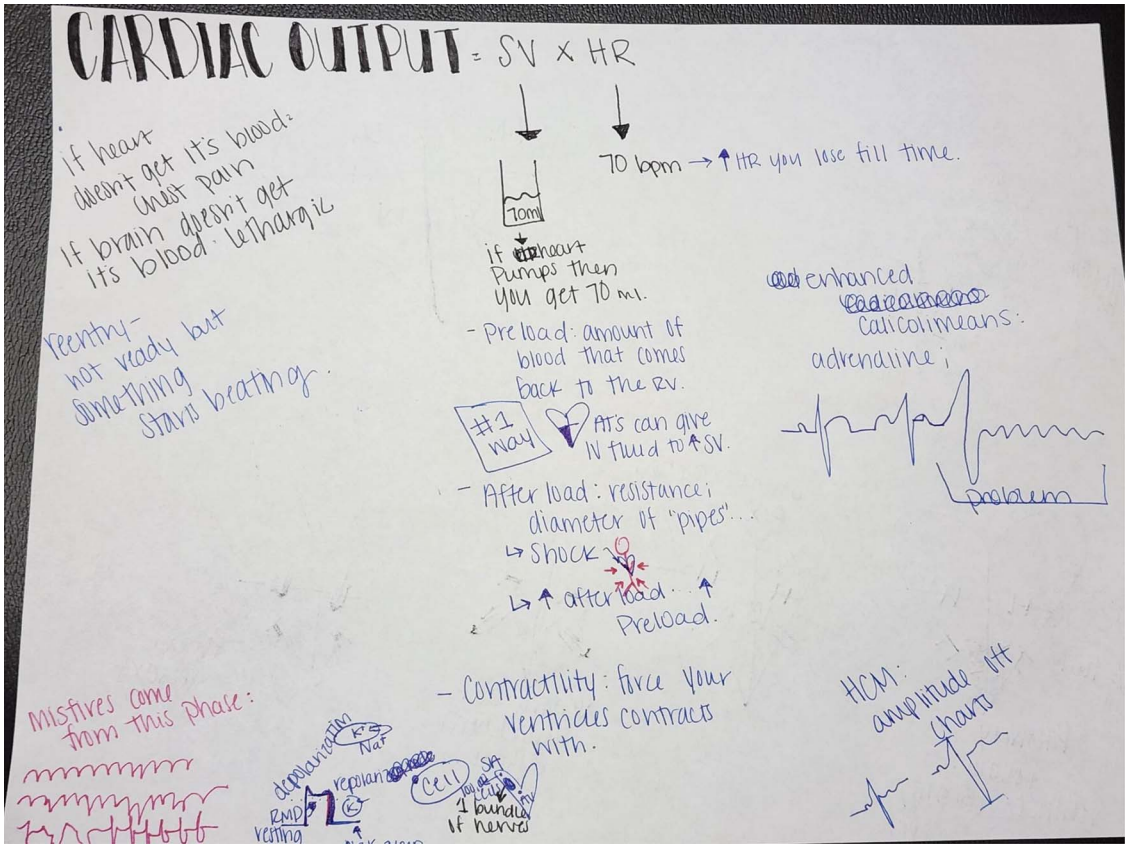


Figure 8. Example of student notes.



I truly enjoyed today's class! I enjoyed learning the statistics behind the different learning technique, and then having the instructor using the technique to teach the class. I think that it was very beneficial in learning the material. I have always loved learning about the heart and being able to draw the heart and the different stages helped further my knowledge on the heart. Each symbol in my notes, I can recall the information and the pathway of the blood. I did find it beneficial.

Another student commented:

This was very helpful. If I can write or draw it out, I understand better. The use of the simplified explanations helped with the additional drawings that any person could do. The educational words were not so intimidating as they were before.

Recently, a student wrote a discussion board for a different class,

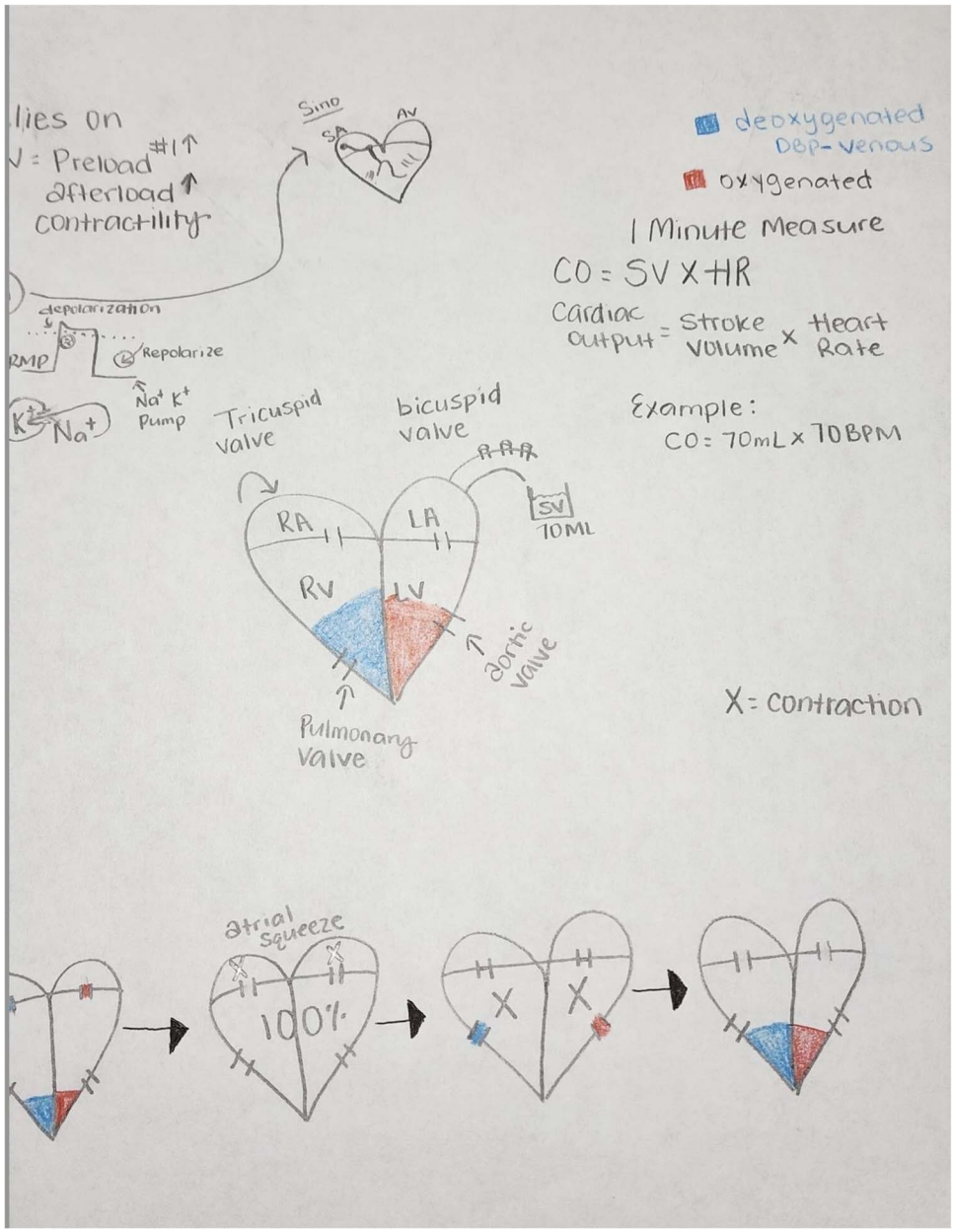
We did ECGs during PPEs [preparticipation physical examinations]. I did get to complete them on a good amount of athletes and I can actually remember what we learned from emergency care over the summer with the waves and what they stand for when reading them.

This student demonstrated retention over a year later when applying these concepts during their clinical education experience. Although these are anecdotal outcomes, future research should further explore confidence levels, retention, and perceptions of using drawing for retention.

During this course, the instructor used drawing for retention only for teaching information, not for formative or summative assessment. This technique can be expanded to reinforce or assess knowledge. For example, at the beginning of the next class session, the instructor can give the students about 3 to 5 minutes to draw and label the concept from memory. Then, the student can pair up with another student and see how much they can brainstorm of the concept together. Depending on the complexity of the concept and size of the course, the students can join another pair and compare drawings and understanding of the topic. According to the Dale cone of learning, students retain approximately 90% of the content if they can draw and describe the concept.[10] This can also be used for assessment. For example, students can be asked to draw and label concepts on examinations. As an extra credit question on their final exam for the course described in this article, students were instructed to draw and label how blood travels through the heart and the phases of the ECG cycle. Anecdotally, students retained information from this course activity for the final examination.

This activity was only used as a portion of the course for emergency procedures in athletic training; however, this technique has been used by an instructor of the emergency medical care program to teach the entire courses of cardiology and ECG techniques and interpretation, and some concepts in

Figure 9. Example of student notes.

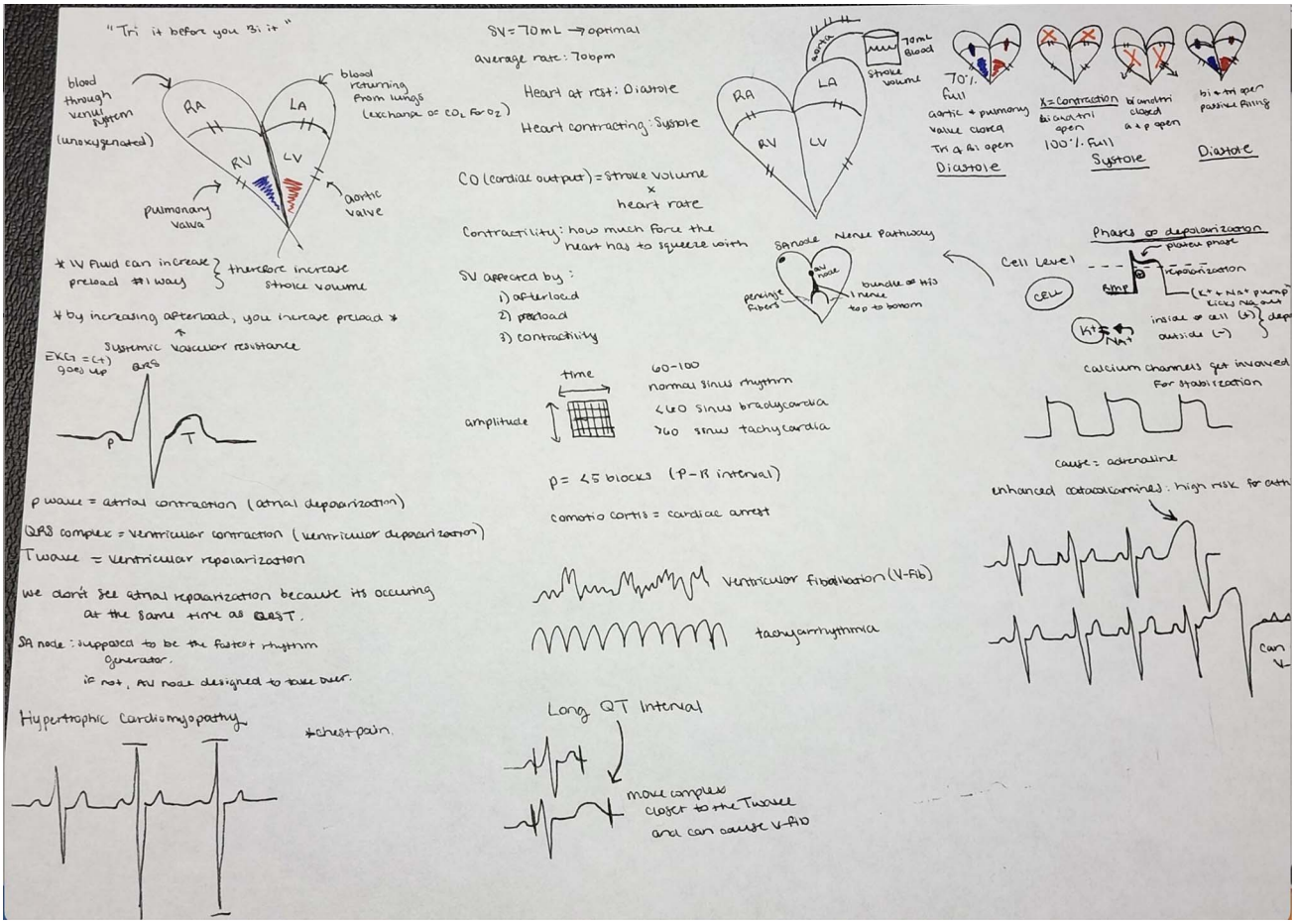


medical trauma. Drawing for retention has been successfully implemented for these courses, and lessons have been learned along the way. This activity can be time-consuming if all the course content is to be drawn. The instructor should select the most pertinent information for students to draw and supplement the information with lectures, online lectures, and readings. Additionally, the instructor should keep the images simple so they can describe and explain the concepts while drawing. Complicated images may intimidate students, and they might not be as engaged with learning the material if they are attempting a complicated drawing. As the instructor is drawing, they should draw small amounts at a time and then stop to explain the concepts and check for understanding. We recommend drawing a small amount, checking in with students, and seeing if they can repeat the drawing, label the image, or explain the concept in their own words to ensure they understand the concepts. If students can understand and explain their drawings from memory, they are more likely to retain the material. Finally, instructors should encourage students to use colors in their drawings, as matching colors aids retention. For example, when drawing arterial blood, use bright red for the drawing and labeling, which helps students make the connection.

EDUCATIONAL ADVANTAGE

There are many foundational concepts or conditions in athletic training education that present a challenge to using active learning techniques. Yet these are important concepts and provide the foundation for how ATs determine treatments. For example, students learn that nitroglycerin is contraindicated in a right ventricular myocardial infarction. With a traditional lecture, they might understand the

Figure 10. Example of student notes.



concept of right versus left myocardial infarction and learn how to recognize the signs and symptoms; however, by drawing out what is happening at the ventricular level and seeing how it presents on the ECG, students can better understand *why* nitroglycerin is contraindicated and better recognize appropriate treatments. Once students understand the foundation, these concepts can be applied in patient cases.

Figure 11. Electrocardiogram.

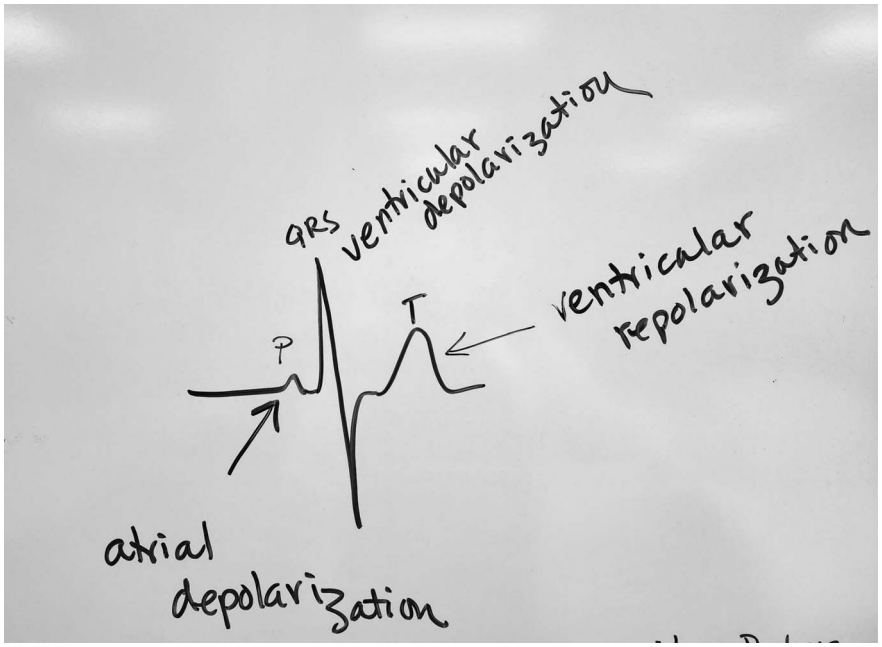
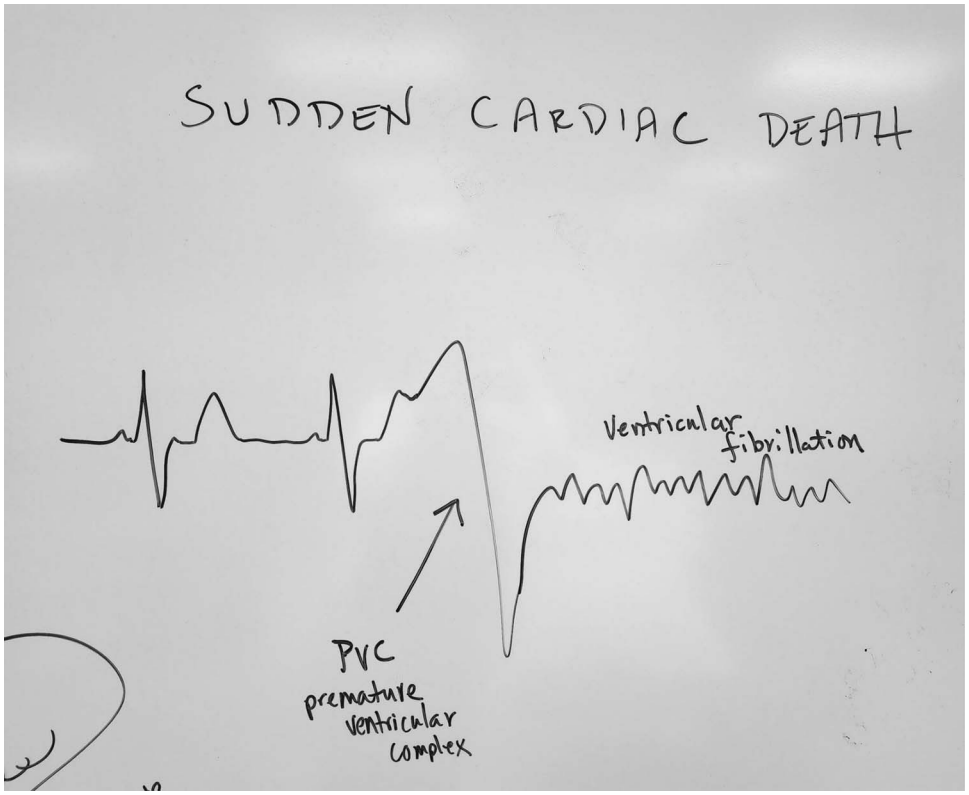


Figure 12. Sudden death on electrocardiogram.



Although this teaching technique was used in an athletic training lecture setting, there are ways to expand this content and topic through collaborations with emergency medical care or nursing students. Through this class, the students encountered a case of a cross-country runner with exercise-induced tachycardia. The athletic training students performed an initial evaluation and determined they needed to refer the patient for diagnostic testing (ECG).

Figure 13. Commotio cordis on electrocardiogram.

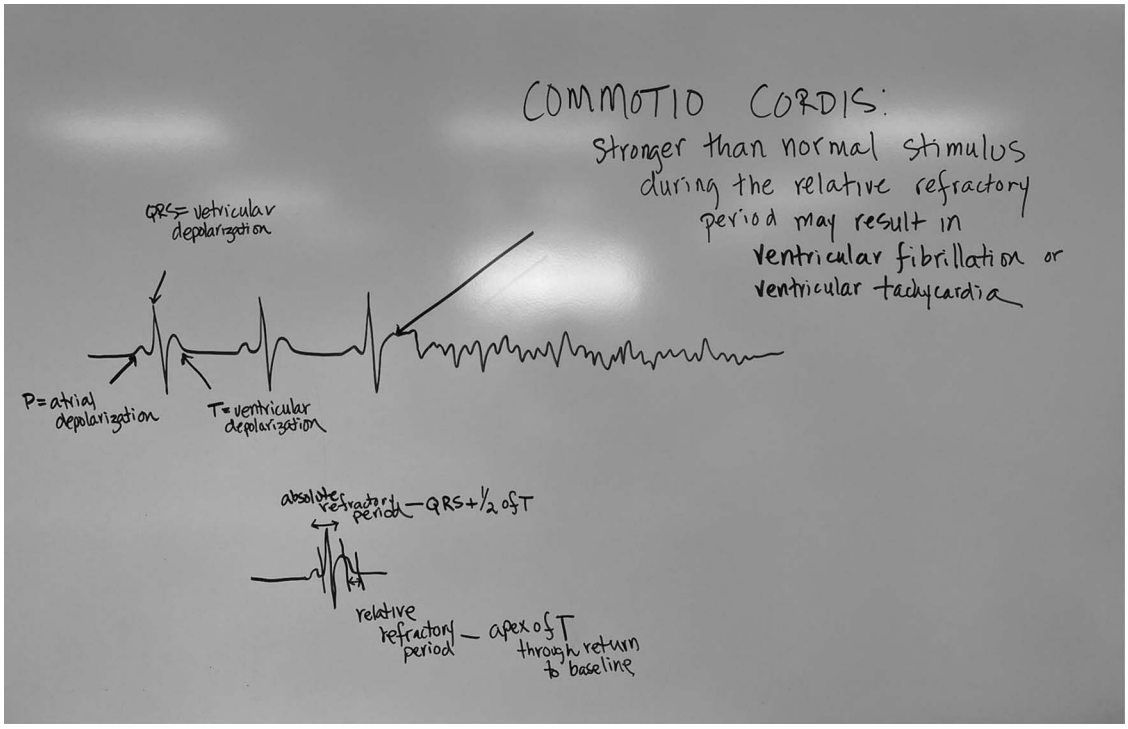
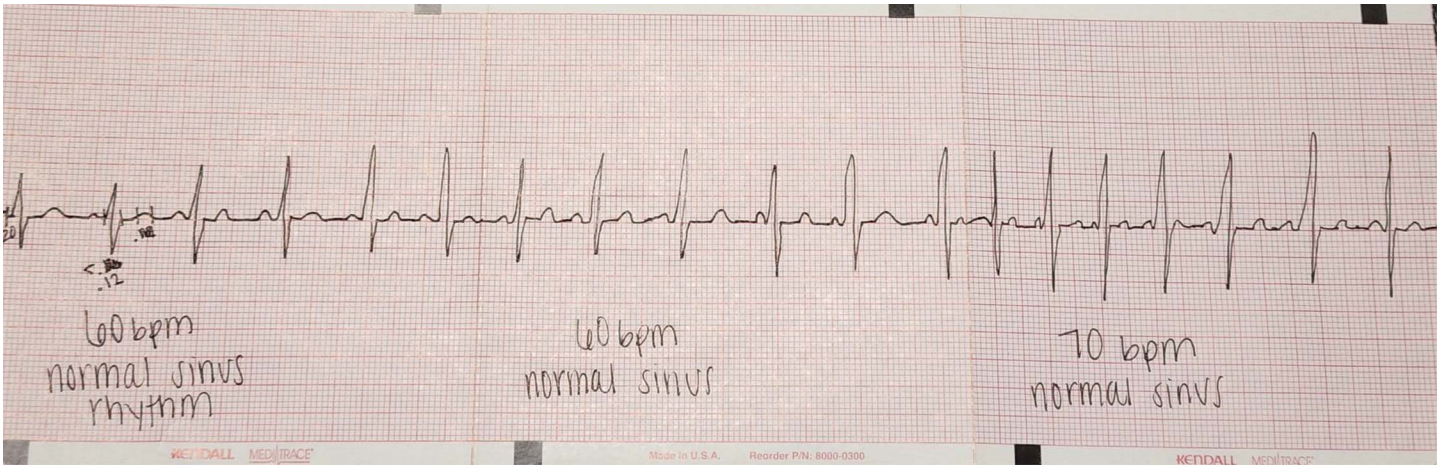


Figure 14. Example of student electrocardiogram notes.



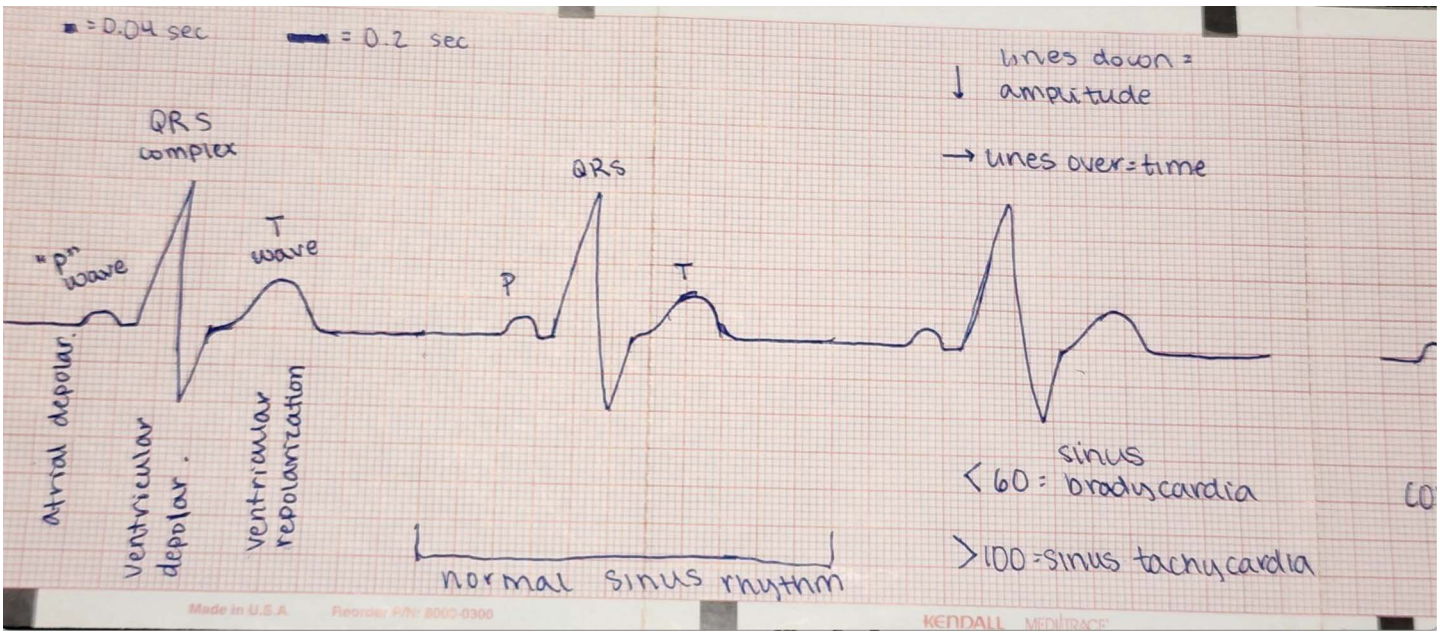
This runner was then referred to the emergency medical care course, in which the emergency medical care students performed a 12-lead ECG on the cross-country runner. They found the runner had increased QRS amplitude. The 2 groups of students then collaborated and discussed potential causes and treatment options. By having the foundation of drawing the ECGs, athletic training students were able to better understand the results of the 12-lead ECG.

Drawing for retention is an active learning technique that can supplement other active learning techniques in an emergency care course. Although we only used this technique for cardiovascular topics, this technique could be used with other topics, such as anatomy and physiology, the inflammatory response and healing, pathophysiology, or other emergent conditions. Previous research supports the use of drawing for retention in medical and health care education[5,6] and can easily be expanded to athletic training education.

CONCLUSIONS

Athletic training programs must prepare students to recognize, evaluate, and form a plan of care for cardiovascular conditions; however, foundational concepts such as anatomy and physiology may be learned through passive techniques.[2,4] Drawing for retention is an active learning technique that can be easily and inexpensively integrated into athletic training courses. Athletic training students perceived this was a valuable activity and they learned and retained information learned through drawing. This is a simple yet impactful way to enhance knowledge and retention of foundational topics.

Figure 15. Example of student electrocardiogram notes.



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