REVIEW ARTICLE

Assessment of Tachyarrhythmias – ECG Basics and Common Pitfalls in Diagnoses

Adel Hamed Elbaih[1], Mustafa Muhammad Alkhalaf[2]

Authors Affiliation

Suez Canal University, Ismailia, Egypt[1,]
Sulaiman Al-Rajhi University, Clinical Medical Science, Saudi Arabia[2]

Correspondence to:

Dr. Adel Hamed Elbaih
Email:elbaihzico@yahoo.com

ABSTRACT

Background: - Tachyarrhythmia is a common presentation in the emergency department (ED). Some arrhythmias, if not treated properly or identified quickly, will lead to the development of multiple complications including syncopal attacks, strokes, heart failure, cardiac arrest and sudden death. Therefore, we aim to look into the teaching approach of tachyarrhythmias and common pitfalls that both medical students and new physicians face in the recognition, diagnosis, and management of these conditions.

METHODS

All possible available data about tachyarrythmias patients in the emergency department was retrieved using many research questions from Medline leterature search engine.

Keywords used included "ECG interpretations", "critical care", "emergency medicine", "principals of ACLS skills" and "ACLS and tachyarrythmias"

All studies included the initial theraphy and diagnosis of tachyarrythmias in patients Admitted in ED and critical care. Literature search also included recent therapeutic strategies

CONCLUSION

Knoledge of the steps involved to quickly assess, identify and treat tachyarrythmias is an essential skill for any emergency physician. Frequent techings and trainings are key to improve outcome of tachyarrythmias.

KEYWORDS

Tachyarrhythmias patients, Physicians, Skill Approach, ECG interpretations.

INTRODUCTION

Tachyarrhythmia is defined as an abnormality in heart rhythm with a pulse rate of ≥100 beats per minute.[2, 4] This condition is frequently symptomatic and often leads to seeking care in the emergency department. Signs and symptoms may include palpitation, shortness of breath, chest pain, decreased level of consciousness, syncope, acute myocardial infarction, and/or shock.[4] The goal of emergency department physician in all tachyarrhythmias is to determine whether the patient is presenting with a life threatening arrhythmia or an arrhythmia that requires immediate treatment and stabilization. Generally, the physician must determine the stability of the patient, the type of arrhythmia the patient is suffering from, and start the appropriate life-saving measures to restore effective circulation and to stabilize the patient.[1, 2, 4]

Tachyarrhythmia is a common presentation in the emergency department, as we will discuss later the incidence and prevalence of the most common types of arrhythmia.[4] It is extremely important that all emergency department physicians know the details of the presentation, approach to patients, and management algorithms including the common pitfall or mistakes that they may experience when they first see a case. This stems from the fact that some arrhythmias, if not treated properly or identified quickly, will lead to the development of multiple complications including syncopal attacks, strokes, heart failure, cardiac arrest and sudden death.[5-7] For this reason in this review we will look into the different types of tachyarrhythmias, along with the incidence, presentations, ED approach, and the steps of management for the common types of tachyarrhythmias. Also, we will look into the common pitfalls and mistakes that both medical students and new physicians face in the recognition, diagnosis, and management of this condition, we have also developed recommendations that may help those physicians and a checklist for skills examination for medical students to be tested with.

METHODOLOGY

In this review paper, we have looked through the recent literature that discusses approach, diagnosis, and step of management of tachharrythmias. We also used text books and articles that discussed the difficulties of this condition's approach in the ED. We collected of all possible available data about the 'ECG Interpretations' in the Emergency Department, by many research questions to achieve these aims. So a medline literature search was performed with the keywords "critical care", "emergency medicine", "principals of ACLS", "ACLS and ECG Interpretations", "ACLS skills", "ACLS and tachyarrhythmias". The literature search included an overview of the recent definition, causes, and recent therapeutic strategies.

Aim and outcome of the study: Initial assessment and evaluation of the suspected tachyarrhythmias in patients presenting to the emergency department to recognize potentially life-threatening arrhythmias and treat according to guidelines.

Discussion on tachyarrhythmias with ECG Interpretations of patients:

Tachyarrhythmia can be classified based on the location of the focus, supraventricular if it originated from within or above the AV node, ventricular if it originated below the AV node.[2-4] Also, it can be classified based on the width of the QRS complex on the ECG, narrow complex if the width is ≤120 milliseconds, wide complex if the width is ≥120 milliseconds.[2-4] So, a tachyarrhythmia that originated in atria and had a narrow QRS complex on the ECG is termed *narrow-complex supraventricular tachycardia*. The width of the QRS complex is of paramount importance since it determines the management approach, because causes of narrow-complex tachyarrhythmias differ from those causing wide-complex tachyarrhythmias.

The common types of narrow-complex tachyarrhythmia are: sinus tachycardia, atrioventricular nodal reentrant tachycardia (AVNRT), Atrioventricular reentrant tachycardia, atrial flutter, and atrial fibrillation.[3, 4] While the types of wide-complex tachyarrhythmia are: mono- and poly- morphic ventricular tachycardia, supraventricular tachycardia with aberrant conduction, and ventricular fibrillation.[2-4] We will review each of these arrhythmias on their own.

Sinus Tachycardia: The commonest cause of narrow-complex tachycardia. It occurs in even in patients with the normal structure of the heart. It could develop from a multitude of conditions, e.g. fever, volume depletion, anemia, hypoxia, pulmonary embolism, acute myocardial infarction, pain, and anxiety. Proper identification and management of the cause of tachycardia is all that is needed for this type of tachyarrhythmia.[2-4]

Atrioventricular nodal reentrant tachycardia (AVNRT): It is the most common form of regular, sustain, paroxysmal supraventricular tachycardia, (PSVT) with a heart rate of 120-220, affecting 2.29 per 1,000 persons.[8] Accounting for almost two-thirds of all PSVTs. Women are affected more than men, with a mean age at presentation of around 32 years of age.[9] This condition develops because of the presence of two conduction channels with different electrical properties within the AV node, termed the dual pathways. Since the electrical properties are different between the two, this creates fast and slow conduction pathways. The electrical impulse traveling down the fast pathway is transmitted to the bundle of his to complete the cardiac cycle and at the same time goes up the slow pathway, terminating the impulse traveling down the slow pathway. When a premature atrial beat reaches the AV node, it gets blocked by both slow and fast pathways because they are in the refractory period. However, the refractory period of the slow pathway is shorter than that of the fast pathway. So, if the premature atrial beat reaches the AV node when the slow pathway is not in the refractory period but the fast pathway is, a cycle develops in which the signal will travel from the slow pathway to the bundle of his and the fast pathway, then from the fast pathway to the atria and slow pathway.[3, 9] Patients usually present mostly with palpitation and dizziness. The onset and termination of the condition are usually sudden, hence the name paroxysmal. Patients presenting with shortness of breath and chest pain indicate the possibility of underlying heart disease.[6, 9]

Atrioventricular reentrant tachycardia (AVRT): This condition is very similar to atrioventricular nodal reentrant tachycardia in pathophysiology and presentation. While in AVNRT the cause was two separate pathways within the AV node. In this condition, there is an anatomically defined pathway that connects the atria and ventricles other than the AV node. For tachyarrhythmia to develop, the accessory pathway has to have different conduction speed and refractoriness from those of the AV node. Wolff-Parkinson-White (WPW) syndrome is an example of AVRT.[3, 10]

Atrial Flutter: This condition is characterized by a rapid, regular atrial depolarization at a rate of 300 BPM, with a regular ventricular response of around 150 BPM. It occurs if there is a reentrant circuit within the right atrium, very much similar to that of AVNRT. This circuit could develop after an acute MI, starting with antiarrhythmic drugs, thyrotoxicosis, pulmonary embolism, and obesity. The incidence of this problem is 88 per 100,000 person-years.[11] The usual presentation is that of palpitation, lightheadedness, and shortness of breath. Usually, the ventricular response is regular, i.e. after every 2 or 3 atrial beats the ventricles beat. However, in cases where there is scar tissue, the ventricular response might not be regular, resembling atrial fibrillation.[3, 12]

Atrial Fibrillation: The most common irregular cardiac arrhythmia. In this condition, multiple ectopic foci are firing at different timings, each depolarizing the cardiac tissue next to it. This in turn will lead to vibrating atria with no effective contraction. Usually, the atria depolarize at a rate greater than 300 BPM. Because of the multiplicity of the foci, it leads to an irregularly irregular rhythm and ventricular response.[3, 13] This condition affects 5.96 per 1,000 in men and 3.73 per 1,000 in women. Also, the lifetime prevalence for men and women is 23% and 22%, respectively. Causes are similar to those of atrial flutter.[14] The disease often has a paroxysmal inset, but it could still be persistent. While some cases are asymptomatic, the presentation of the disease is, like almost all SVTs, palpitations, lightheadedness, shortness of breath, and dizziness. [2, 4, 12]

Ventricular Tachycardia: The classical definition for ventricular tachycardia is "three or more consecutive premature ventricular complexes at a rate exceeding 100 BPM".[3] VT can arise from an ectopic ventricular focus or a reentrant circuit. To classify VT, we need to determine the duration; sustained or non-sustained, and the appearance; monomorphic or polymorphic. Non-sustained VT refers to an "attack" of VT lasting 30 seconds or less, while sustained VT refers to a VT that lasts more than 30 seconds or requiring DC shock to terminate. Monomorphic appearance means that all the QRS have the same morphology and axis, indicating that there is a single firing focus within the ventricles. However, polymorphic appearance refers to a VT with varying QRS morphologies and axes, indicating multiple firing foci within the ventricles. The most important type of polymorphic VT is torades de Pointes (TdP) since it can deteriorate into ventricular fibrillation if not managed immediately.[3, 4] The yearly incidence for this condition is 15.8 per 100,000 person-years.[15] However, it has a much higher frequency in critical case settings, rising to 2%-7%.[16] In a structurally normal heart, individuals can maintain left ventricular functions at a very fast rate, up to 200 BPM. However, if the patient already has a deficient left ventricular function, they will present with symptoms of palpitations, near-syncope, and syncope.[2-4, 16]

Ventricular Fibrillation: Similar to atrial fibrillation, multiple ectopic foci are firing in the ventricles. This leads to vibrating, functionless ventricles. Patients affected by VF will lose consciousness immediately and they will be in cardiac arrest. VF can be arbitrarily classified as fine or coarse based on the amplitude of the fibrillatory wave. The usual progression is from coarse, to fine, and ends with asystole.[2-4, 15, 16]

ECG FEATURES

Sinus Tachycardia: Normal P waves and PR interval, sinus rhythm, 1:1 atrioventricular conduction, the atrial rate between 100-160 BPM.[2, 3]

Atrioventricular nodal reentrant tachycardia (AVNRT): Absence of normal P waves, narrow QRS complex, the ventricular rate is usually 170-180 BPM.[2, 3]

Atrioventricular reentrant tachycardia (AVRT): similar to AVNRT, delta waves are present during non-attack periods in the case of WPW.[2, 3]

Atrial Flutter: Identifiable P waves (usually monomorphic), flutter waves in sawtooth appearance, narrow QRS complexes (unless there is a preexisting bundle branch block), regular rhythm (some irregularities might be present), the atrial rate is usually 300 BPM, the ventricular rate is usually 150 BPM.[2, 3]

Atrial Fibrillation: Absence of distinguishable P waves, flat or chaotic isoelectric baseline, narrow QRS complexes (unless there is a preexisting bundle branch block), irregularly irregular rhythm.[2, 3]

Ventricular Tachycardia: Complete AV dissociation, occasional dissociated P waves, the rate is usually 140-180 BPM, wide QRS complex, regular rhythm if monomorphic, irregular rhythm if polymorphic.[2, 3]

Ventricular Fibrillation: Disorganized rhythm, no discernable features can be noted.[2, 3]

DIAGNOSIS AND APPROACH

Fundamentally, once the patient presents to the ED, the physician must determine whether the patient is unstable or not. Markers for instability include hypotension (SBP <90 mmHg), altered mental status, ongoing ischemic chest pain, acute heart failure manifested as pulmonary edema, and signs of shock. In hemodynamically stable patients, however, a 12-lead ECG should be connected and close examination of the ECG should be carried out. The physician must answer three questions, is the rhythm sinus or not? Is the QRS complex narrow or wide? Is the rhythm regular or irregular? These questions, along with the systemic and careful reading of the ECG, will help the physician correctly identify 80% of the cases that present with tachyarrhythmias. Alas, due to the urgency that follows the application of the ACLS protocol, identification of specific rhythm may prove challenging.[1, 2, 4, 17]

Basics of Management in the Emergency Department

Once the patient reaches the emergency department, determine whether the patient has a pulse or not. If he or she does not have a pulse, you must start cardiopulmonary resuscitation according to the ACLS protocol.[1, 2]

If the patient has a pulse, however, our goal will be to identify and treat the underlying cause. First, we will maintain the patient's airway and assist breathing if necessary, maintaining an O_2 saturation of >94%. Blood

pressure must be monitored, and pulse oximetry should be placed. Also, the patient should be connected to a cardiac monitor to identify the rhythm and answer the three questions mentioned in the approach.

In all unstable patients, the focus should be on the restoration of hemodynamic stability.[2] Give synchronized cardioversion with a dose based on the rhythm and QRS complex duration Unless the cardiac monitor shows regular narrow complexes, then consider treatment with adenosine 6 mg IV push flushed with normal saline.[1, 2]

If the patient is stable, then intravenous access should be established, and a 12-lead ECG should be obtained. Read the ECG carefully to determine the arrhythmia responsible for the patient's condition. In the case of a regular rhythm with wide QRS complexes, consider amiodarone 150mg over 10 minutes, unless the ECG shows monomorphic QRS complexes.[1, 2] In the case that the ECG shows an irregular rhythm with wide QRS complexes, rule out the possibility of atrial fibrillation. If there is evidence of torsades de pointes, give magnesium sulfate 2 grams IV, prepare for synchronized cardioversion, and request expert consultation. In this case, the ECG shows a regular rhythm with narrow complexes, attempt vagal maneuvers in hope of restoration to the normal rate. Vagal maneuvers include carotid sinus massage, Valsalva maneuver, and diving reflex. If this fails then administer adenosine 6 mg IV push. If the rhythm is irregular, suspect atrial fibrillation or atypical atrial flutter, control the rate with

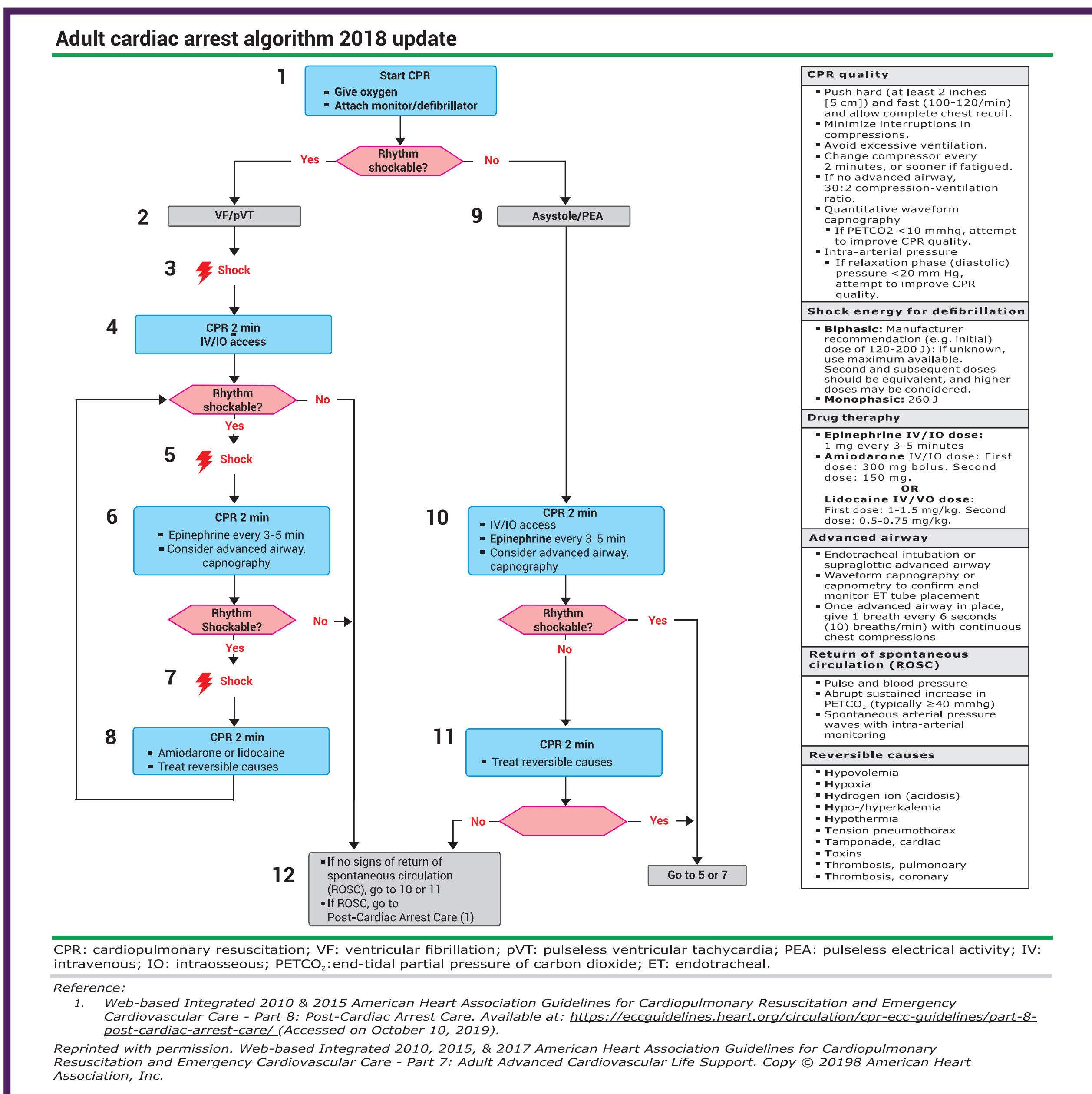

Figure 1. Cardiac arrest management algorithm.(1)

verapamil or metoprolol and request expert consultation.[1, 2, 4]

COMMON MISTAKES/PROBLEMS

From this review and others, we noted down a few issues that may arise starting from the presentation. These are: following the computer results of the ECG and treating the monitor, not the patient.

While the computer interpretation on the ECG paper can be of real value, especially for the heart rate, QRS complexes, axis, width, and the PR interval, however yet it still struggles for other values and requires an over reading by a doctor. Acute myocardial infarction, lead misplacement, and atrial fibrillation are examples of diagnoses that computers either cannot reach or diagnose incorrectly. A study has found that the false positive and false negatives rates for acute MI can reach up to 42%.[18] One value that some clinicians use the computer read is the QT and QT_C intervals. While the computer can provide an estimation, these values should always be calculated by a physician.[18] Another study found that the incorrect computer reads for atrial fibrillation and atrial flutter are 19.7% and 22.9%, respectively.[19]

All these points lead to the second point, which is to treat the patient not the monitor. This was demonstrated in a case study by *Mirijello et al.* A 70-year-old patient presented with dyspnea and had an ECG done, that showed torsades de pointes. However, the patient was clinically stable. She was treated with magnesium sulfate. She was noted to have high amplitude tremors. The limb

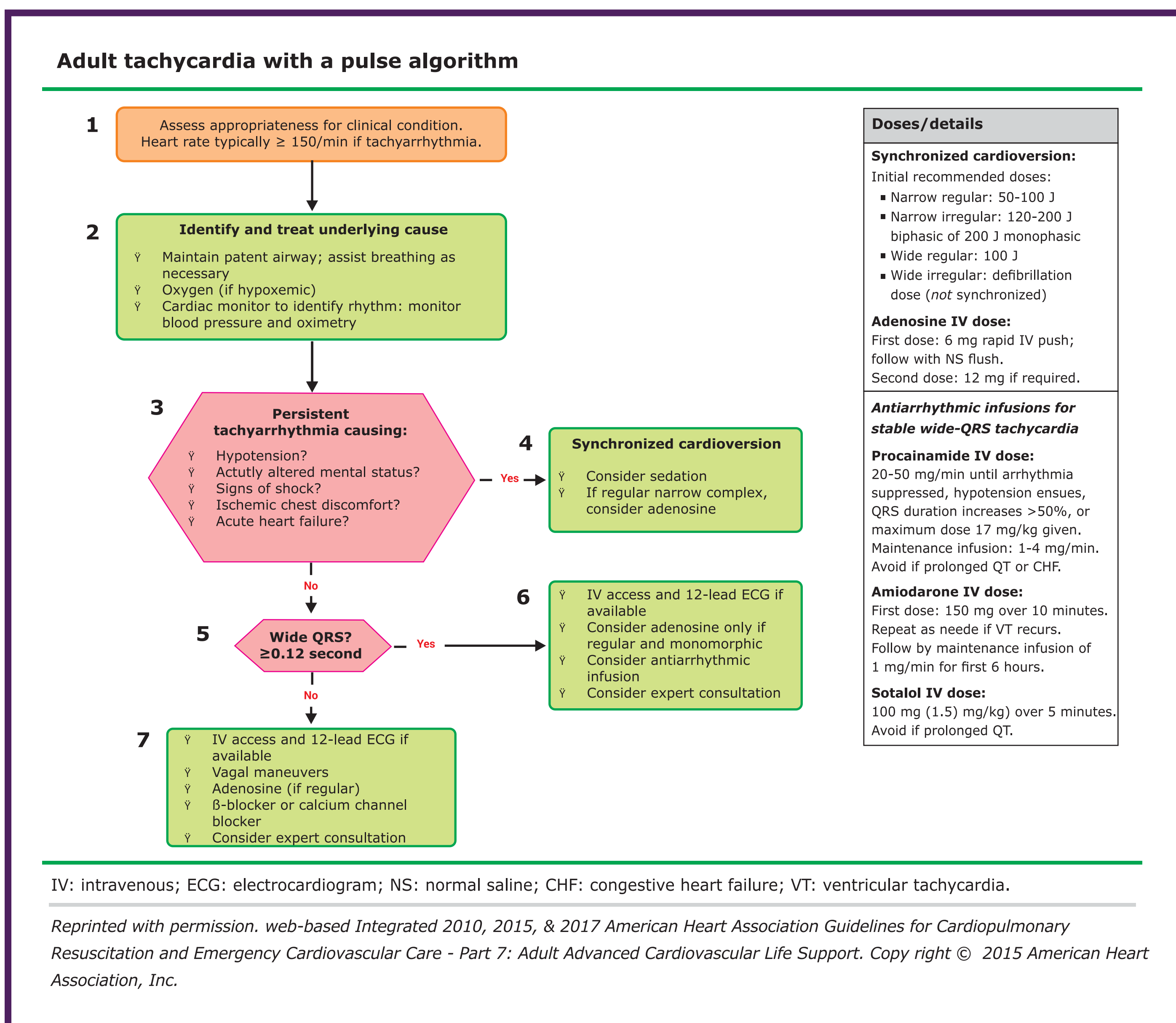

Figure 2. Tachycardia with a pulse management algorithm.(1)

leads were moved to the shoulder instead of the wrist and the arrhythmia was gone.[20]

The issue with these points is that the treating physician is either overtreating the patient, in case of false positive computer reads or does not treat the patient for a significant condition, in case of false negative computer reads. Also, many drugs can affect the QT interval. These include, but not limited to, antiarrhythmics, anticholinergics, antimalarials, antihistamines, anesthetics, and diuretics.[21] So, improper determination of the QT interval in patients who are on these drugs may predispose them to fatal arrhythmias and cardiac arrest.[2, 21]

This review has explained and presented the common tachyarrhythmias that present to the ED daily, along with the approach to diagnosis, and how to manage in the emergency setting. We also looked over some of the possible issues that may arise during the diagnosis and management of these cases. We hope that this review will help physicians review the common presenting tachyarrhythmias along with the management approach. For this sake, we will go over the steps to carefully assess and read an ECG, since the major problem delineated earlier occurs because of misreading.

HOW TO READ AN ECG

The electrocardiogram is a test that can visualize the rate, rhythm, and electrical activity of the heart. The reading is recorded on a paper that is divided into grid-like boxes, small and large. Every large box is composed of 25 small boxes arranged in a 5×5 configuration. Every small box is 1 millimeter in both width and height. The horizontal axis indicates time, while the vertical axis indicates voltage. Every 1 mm is 0.04 seconds horizontally and 0.1 milliVolts vertically. Normally, the ECG strip is calibrated to run at a rate of 25 mm/sec. A simple way to remember the different waves and intervals is the 5-4-3 rule for the ECG, 5 waveforms (P, QRS, ST, T, and U), 4 intervals (PR, QRS, QT, and RR/PP), and 3 segments (PR, ST, TP). For the sake of completion, we will follow the 14 steps to read the ECG.[3, 7]

1) *General Information:* note the patient's name, age, ECG date, paper speed, and calibration. The calibration is noted as "1 mV signal produces a 10 mm deflection". It is usually denoted as a 2 large square deflection at the start of the recording paper.[3, 7]

2) *Rate:* If the rhythm is regular, you can divide the number of large or small squares between 2 consecutive R waves by 300 or 1,500, respectively. If the rhythm is irregular, count the QRS in 6 seconds in the rhythm strip, and multiply by 10. This is one of the parameters that we can use the computer reading for with high accuracy.[3, 7, 18, 20]

3) *Rhythm:* Use the card method if the rhythm does not appear regular. Mark the position of 3 consecutive R waves in the ECG on a piece of paper, and change the position aligning it to the next group of R waves. Also, the regularity of the irregular rhythm is of importance. For instance, slight and regular changes in the rhythms that are associated with respiratory cycles are called sinus arrhythmia.[3, 7]

4) *QRS Complex Axis:* This denotes the overall direction of the cardiac depolarization cycle. The normal axis is between $<-30^{\circ}$ and $>+90^{\circ}$. The axis would be denoted as the left axis or right axis if it is $<-30^{\circ}$ or $>+90^{\circ}$, respectively. The easiest way to assess the axis is by using the QRS complexes in leads I and II. If they are both positive, it is the normal axis. If only lead I am negative then it is right axis deviation. If only lead II is negative then it is left axis deviation.[3, 7]

5) *P Wave:* This represents the atrial depolarization wave. Bell-shaped wave, with a duration of 0.06 to 0.10 second and an amplitude of 0.5 to 2.5 mm (0.05-0.25 mV). The morphology and duration are important in determining the abnormalities in the atria.[3, 7]

6) *PR Interval:* The measurement begins at the start of the P wave and ends at the beginning of the QRS complex. The normal duration is of 0.12-0.20 seconds. This is important in determining heart conduction blocks.[3, 7]

7) *QRS Complex Interval:* The normal duration is <0.12 seconds. If it is more then it could denote a conduction defect, metabolic disturbance, or ventricular rhythm. It is important to note the duration by eye, although computer reading is mostly accurate and sufficient.[3, 7, 18]

8) *QRS Complex Voltage:* This measurement is important for the diagnosis of right and left ventricular hypertrophy. Usually, the amplitude of the QRS complex is around 5-30 mm (0.5-3 mV). However, it depends on which lead is being read. This value should be determined by the treating physician, the computer's values are not accurate.[3, 7, 18]

9) *QT Interval:* Denoted the time needed for ventricles to depolarize and repolarize. This period varies with the rate. Measured starting from the beginning of the QRS complex to the end of the T wave. The more useful value is the corrected QT interval (QT_C). It is calculated by dividing the QT interval by the square root of the RR interval. . The normal QT_C is 0.38-0.42 seconds. This value is extremely important since prolongation of the 3could be indicative of myocardial infarction or metabolic disturbances, peaked in hyperkalemia, and flat in hypokalemia.[3, 7]

14) *U Waves:* These waves are not always present. They represent the repolarization of the ventricular

conduction system (His-Purkinje system). These waves are upright and are seen after the T waves. They are usually seen in cases of hypokalemia, hypercalcemia, digoxin toxicity, or patients taking sotalol. Its clinical relevance is questionable.[3, 7]

RECOMMENDATIONS

1. At the end of this review, we would like to propose a checklist that can be used to assess medical students' and physician's knowledge and skill in the settings of tachyarrhythmias [Table 1]. This checklist takes in mind the basic knowledge about the different presentation,

2. The step of management, and the common mistakes that were already discussed. Also, we propose that new, arising physicians adopt a more thorough and detailed system for reading an ECG. The system we have implemented is a safe one to reach the diagnoses most of the time.

3. They mustn't take computer values to a heart, rather, medicals students and new physicians should be encouraged to do a thorough read of the ECG paper themselves.

CONCLUSION

1. Tachyarrhythmias are common presenting diagnoses at the emergency department.

2. Physicians should know the different presentations of tachyarrhythmias in patients, the differences in clinical examination, and the main points for evaluations.

3. Students and senior physicians should also know how to read an ECG strip along with knowing when they can trust the computer values and when not.

4. The steps management of tachyarrhythmias patients should be known to all ED physicians. This review is hopefully enough to strengthen the knowledge of new physicians and, hopefully with the recommendations, reduce the rates of false diagnoses.

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Table 1. Skills Evaluated Checklist for Tachyarrhythmias Approach

Skills	Done Sufficiently (2)	Done Insufficiently (1)	Not Done (0)
Primary assessment			
Assess airway, breathing, circulation			
Implement appropriate initial intervention (Provide a rhythm strip at the last step)			
Maintain airway with O_2 Supply			
Connect a cardiac monitor			
Measure the blood pressure			
Place a pulse oximeter			
Correctly identify the cardiac rhythm on the provided rhythm strip			

List of Different presentations			
Present with a Pulse			
Determining the hemodynamic stability			
▪ Hypotension			
▪ Altered mental status			
▪ Signs of shock			
▪ Ischemic chest pain			
▪ Acute heart failure			
Unstable Patient			
Perform cardioversion, Identify the dose			
▪ Narrow regular: 50–100 J			
▪ Narrow irregular: 120–200 J biphasic or 200 J monophasic			
▪ Wide regular: 100 J			
▪ Wide irregular: Defibrillation			
Stable Patient (Provide a 12-lead ECG paper)			
Establish an IV access			
Connect a 12-lead ECG			
Correctly Identify the type of arrhythmia on the provided ECG			
Determine the QRS complex duration			
List initial management for the ECG provided			
Narrow QRS complex			
▪ Vagal maneuvers			
▪ Adenosine if vagal maneuver fails			
▪ Rate control for atrial fibrillation			
Wide QRS complex			
▪ Antiarrhythmic infusion			
▪ Adenosine if regular and monomorphic			
Pulseless			
Start CPR for 2 minutes			
Identify rhythm provided as shockable and deliver a shock			
Continue CPR after shock			
Identifies rhythm provided as unshockable			
Continue CPR			
Administer 1 mg epinephrine			
Identify ROSC			
▪ Breathing			
▪ Coughing			
▪ Spontaneous movement			
▪ Palpable pulse			
Post cardiac-arrest care			
Maintain O_2 saturation at >94%			
Monitor blood pressure (Systolic >90, Diastolic ≥60)			
Refer to ICU			

TYPES OF TACHYARRYTHMIAS

Tachycardia

Narrow or wide QRS complex

Narrow

Regular or irregular

Regular

Sinus tachycardia
Atrial tachycardia
AVRT
AVnRT
Junctional tachycardia
Atrial flutter

Irrigular

Atrial fibrillation
Multifocal atrial tachycardia (MAT)
Atrial flutter with variable block

Wide

Regular or irregular

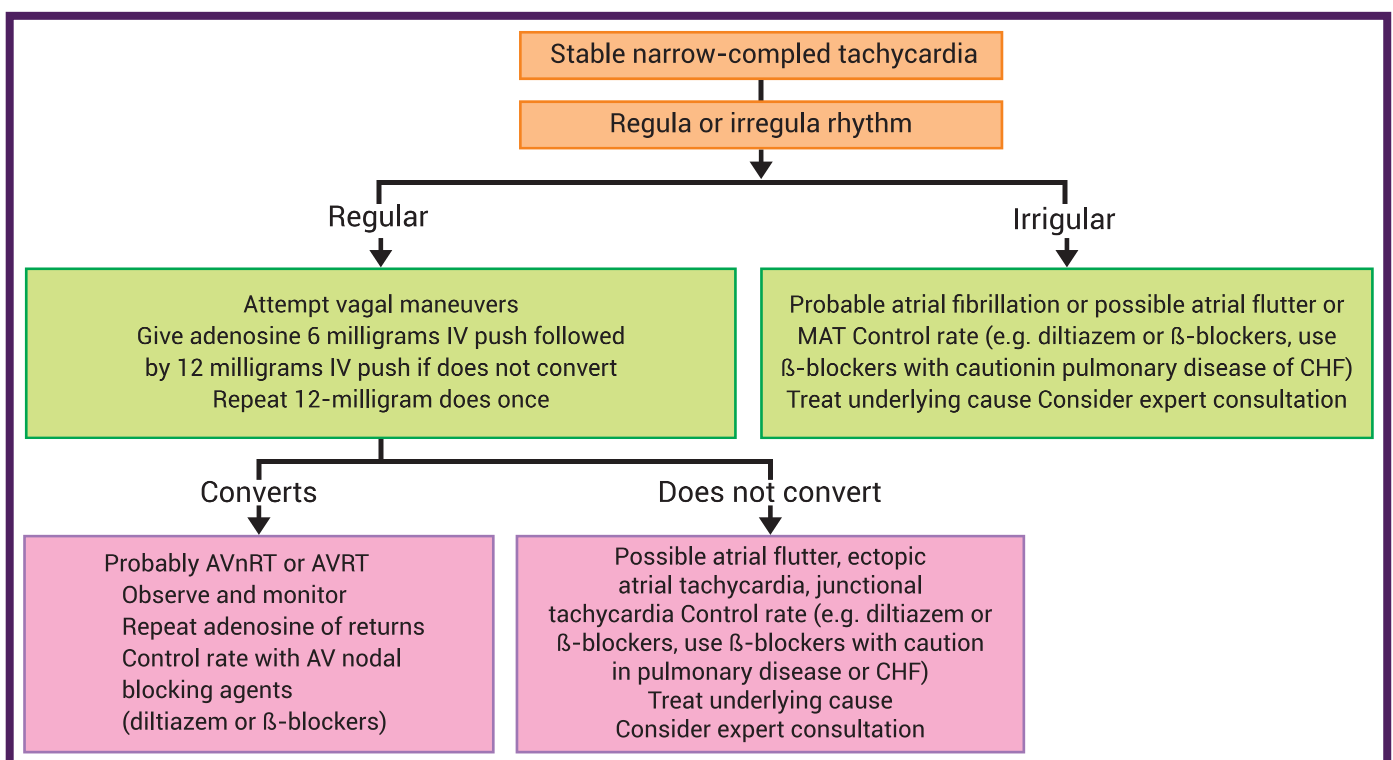
Regular

Ventricular tachycardia
Antidromic AVRT
Any supraventricular tachycardia with aberrancy

Irrigular

Polymorphic VT
Any supraventricular tachcardia with aberrancy

Figure 3. Approach to Tachyarrhythmia.(2)



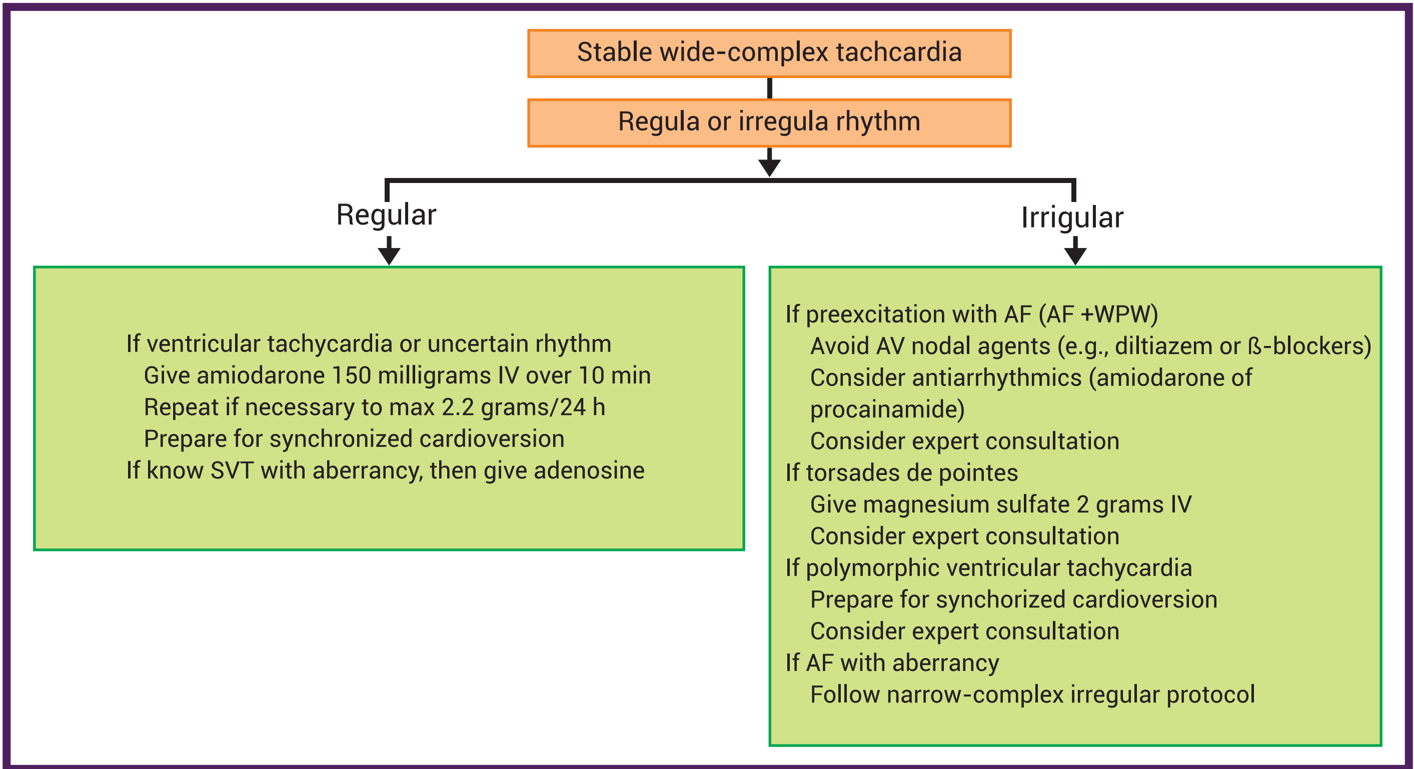


Figure 4. Management of Stable patients: a) Narrow complex tachyarrhythmia. b) Wide complex tachyarrhythmia.(2)

QRS
R
PR Segment
ST Segment
TP Segment
R
P
T
U
Q
S
PR Interval
QT Interval
RR Interval

Figure 5. Summary of ECG.(3)

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