# CHAPTER ELEVEN

# Arrhythmias and Cardiac Emergencies

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## LEARNING OUTCOMES

After completing this chapter you will be able to:

- Systematically interpret sinus, atrial, junctional, ventricular and heart block rhythms.
- Describe nursing implications and treatment for sinus, atrial, junctional, ventricular and heart block rhythms.
- Describe priority treatment for key cardiac emergencies such as cardiac arrest.
- Test your knowledge with practice questions and a case study at the conclusion of the chapter.

## INTRODUCTION

Arrhythmia interpretation and care of patients experiencing acute cardiac events is a foundational competency required of registered nurses working in critical care. The aim of this chapter is to provide a resource for critical care nurses internationally that will assist with recognition of key characteristics of sinus, atrial, junctional, ventricular arrhythmias and atrio-ventricular (AV) blocks. In addition, evidence-based care will be discussed in relation to symptomatic arrhythmias and cardiac emergencies such as myocardial infarction and cardiac arrest.

The chapter will conclude with practice questions and a case study. Helpful websites and further resources will also be provided. The intention of the chapter is to provide an overview of the key components of basic arrhythmias and a summary of treatment. The chapter is designed to accommodate learners that have a good understanding of cardiac anatomy and physiology in addition to an introductory level of understanding of cardiac arrhythmias.

### Arrhythmia interpretation: where to start

The first part of accurately interpreting arrhythmias is to use a systematic approach (see Table 1). However, before you begin to analyze the rhythm strip, ALWAYS check the patient first and ensure they are stable.

### Normal sinus rhythm

In order to analyze cardiac rhythms, it is essential to have an understanding of the 'benchmark' rhythm or hemodynamically perfect rhythm; which is referred to as normal sinus rhythm (see Figure 1) and sometimes abbreviated to NSR.

**Figure 1. Normal sinus rhythm**

In order to be considered normal sinus rhythm, the rhythm must have the following characteristics:

| Steps | Explanation |
|---|---|
| 1. Regularity | Assess whether the rhythm is regular or irregular |
| 2. Rate | Calculate ventricular and atrial rate |
| 3. Assess p waves | Are the p waves: rounded, symmetrical, one for every QRS, all look the same? |
| 4. Calculate pr interval | Normal =.12 to .20 seconds |
| 5. Calculate QRS interval | Normal = .06 to .10 seconds |
| 6. Assess ST segment | The ST segment should be on the baseline or 'isoelectric' line. If it is elevated or depressed it could mean cardiac injury or ischemia and requires urgent further assessment.<br>In addition, the physician should be notified immediately since this could indicate that the patient could be experiencing a myocardial infarction. |
| 7. Interpret the arrhythmia | Name the arrhythmia based on the characteristics above (i.e. atrial fibrillation) |
| 8. Nursing intervention/ treatment required | Determine what intervention is required.<br>Is the patient stable or unstable?<br>Should the physician be notified? |

**Table 1. Systematic approach to arrhythmia interpretation**

- Rhythm: regular
- Rate: 60 to 100/minute
- p waves: present, upright, symmetrical, one before every QRS
- pr interval: .12 to .20 seconds
- QRS length: .06 to .10 seconds

If the rhythm has all of the above characteristics but the ST segment is elevated, it would be referred to as sinus rhythm with an elevated ST segment versus 'normal' sinus rhythm.

### Sinus rhythms

In the next section, arrhythmias originating in the sino-atrial (SA)node will be explored. The characteristics, causes, nursing implications and treatment required for sinus bradycardia, sinus tachycardia, sinus arrhythmia and wandering atrial pacemaker will be presented.

### Slow rhythms: sinus bradycardia

A patient is considered to be bradycardic when their heart rate drops below 60 beats per minute. Generally, a person often becomes symptomatic when their heart rate drops below 50 beats/minute, (see Figure 2) however slower heart rates can be observed in fit and athletic individuals, who will often remain asymptomatic. As a

general rule, when a patient's heart rate is less than 60/minute critical care nurses should be prepared to immediately assess for signs of decreased cardiac output (i.e. decreased level of consciousness, hypotension, chest pain).

The characteristics of sinus bradycardia are:

- Rhythm: regular
- Rate: < 60/minute
- p waves: present, upright, symmetrical, one before every QRS
- pr interval: .12 to .20 seconds
- QRS length: .06 to .10 seconds
- Cause: parasympathetic stimulation (i.e. medications, vomiting, suctioning, bearing down); hypoxemia
- Treatment: only treated if patient is symptomatic. If symptomatic, Atropine administered IV bolus is the treatment of choice. If the patient becomes unstable (i.e. exhibits symptoms of chest pain, heart failure, syncope or a reduced level of consciousness) an intravenous chronotrope infusion (such as epinephrine or dopamine) or external transcutaneous pacing should be considered.

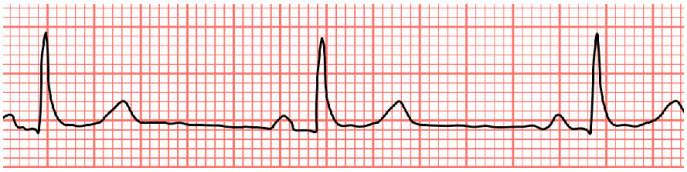


**Figure 2. Sinus bradycardia**

### Fast rhythms: sinus tachycardia

A patient is considered tachycardic when their heart rate rises above 100/minute, although typically individuals do not experience symptoms until the heart rate climbs above 150/minute (see Figure 3). It is best practice for a critical care nurse to assess for signs and symptoms of decreased cardiac output (i.e. hypotension, decreased level of consciousness) when the heart rate is greater than 100/minute since this could result in patients developing cardiac ischemia, angina or even a myocardial infarction.

Characteristics of sinus tachycardia are:

- Rhythm: regular
- Rate: >100/minute
- p waves: present, upright, symmetrical, one before every QRS
- pr interval: .12 to .20 seconds
- QRS length: .06 to .10 seconds
- Cause: sympathetic stimulation (i.e. medications, pain, fever, anxiety, shock); hypoxemia. Typically gradual in onset versus paroxysmal
- Treatment: aimed at treating the underlying cause (i.e. intravenous fluids for hypovolaemia or analgesics for acute pain).

**Figure 3. Sinus tachycardia**

### Irregular rhythms: sinus arrhythmia and wandering atrial pacemaker

The next two arrhythmias, sinus arrhythmia (see Figure 4) and wandering atrial pacemaker (see Figure 5) are typically benign and do not require treatment.

The characteristics of sinus arrhythmia are:

- Rhythm: irregular
- Rate: 60-100/minute
- p waves: present, upright, symmetrical, one before every QRS
- pr interval: .12 to .20 seconds
- QRS length: .06 to .10 seconds
- Cause: can be a normal aberration; seen in children and also in mechanically ventilated patients
- Treatment: no treatment required; observe for further arrhythmia development.

The characteristics of wandering atrial pacemaker are:

- Rhythm: regular or slightly irregular
- Rate: 60-100/minute
- p waves: vary in shape and size
- pr interval: .12 to .20 seconds
- QRS length: .06 to .10 seconds
- Cause: can be a normal aberration; ischemia
- Treatment: no treatment required.

**Figure 4. Sinus arrhythmia**

**Figure 5. Wandering atrial pacemaker**

### Atrial rhythms

In the next section, rhythms originating in the atria will be explored. These arrhythmias include: premature atrial contractions (PAC: see Figure 6), atrial flutter (see Figure 7), atrial fibrillation (see Figure 8) and supraventricular tachycardia (see Figure 9). Key characteristics of these rhythms will be identified along with nursing implications and helpful tips to assist critical care nurses in accurately interpreting atrial arrhythmias.

Thecharacteristics of premature atrial contractions are:

- Rhythm: early beat (PAC) causes rhythm to be irregular
- Rate: underlying rhythm usually 60-100/minute
- p waves: have different configuration than underlying rhythm
- pr interval: .12 to .20 seconds in underlying rhythm
- QRS length: .06 to .10 seconds in underlying rhythm
- Cause: can be a normal aberration; ischemia; or a signal of atrial irritability - can lead to more serious atrial rhythms
- Treatment: no treatment required for isolated PACs. Assess for increasing PACs since this indicates increasing atrial irritability and underlying cause (i.e. hypovolemia, hypervolemia or electrolyte imbalance) needs to be treated.

The characteristics of atrial flutter are:

- Rhythm: regular or irregular
- Rate: 60-100/minute (ventricular rate) 250-400 (atrial rate)
- p waves: none present; flutter waves (F waves) or 'sawtooth' waves
- pr interval: no pr interval since no p wave
- QRS length: .06 to .10 seconds
- Cause: electrolyte imbalance; hypertension; ischaemic heart disease; congenital heart disease; rheumatic valve disease; following cardiac surgery
- Treatment: anticoagulation should be considered due to the risk of atrial thrombus formation. Medications for rhythm and rate are recommended. Cardioversion or ablation may also be considered.

The characteristics of atrial fibrillation are:

- Rhythm: irregular
- Rate: 60 to 100/minute (ventricular rate) > 400/minute (atrial rate)
- p waves: none; fibrillatory waves (f waves)
- pr interval: no pr interval since no p waves
- QRS length: .06 to .10 seconds
- Cause: electrolyte imbalance; hypertension; ischaemic heart disease; congenital heart disease; rheumatic valve disease; following cardiac surgery
- Treatment: anticoagulation should be considered due to the risk of atrial thrombus formation. Medications for rhythm and rate are recommended. Cardioversion or ablation may also be considered.

The characteristics of supraventricular tachycardia (SVT) are:

- Rhythm: regular
- Rate: 150 to 250/minute
- p waves: may not be seen at higher rates
- pr interval: .12 to .20 seconds (if seen)
- QRS length: .06 to .10 seconds
- Cause: congenital heart disease; emotional stress; physical stress or exertion; illegal drugs (e.g. cocaine or ecstasy); alcohol; caffeine
- Treatment: urgent expert referral; oxygen administration if required; intravenous access; vagal maneuvers (i.e. carotid sinus massage or Valsalva maneuver); intravenous adenosine; other rate controlling agents may be considered if the patient is not haemodynamically compromised.

**Figure 6. Premature atrial contractions**

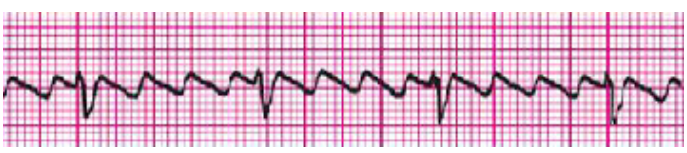


**Figure 7. Atrial flutter**

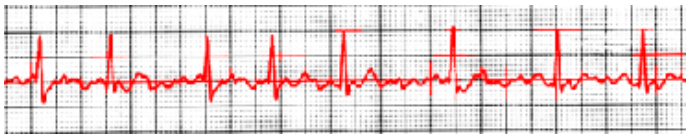


**Figure 8. Atrial fibrillation**

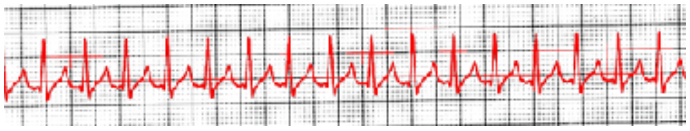


**Figure 9. Supraventricular tachycardia**

### Junctional rhythms

Junctional rhythms originate in the AV node or junctional area and are typically transient and non-lethal. The rhythms that will be presented in this section include: premature junctional contractions (see Figure 10), junctional rhythm (see Figure 11), accelerated junctional rhythm (see Figure 12) and paroxysmal junctional tachycardia (see Figure 13). All junctional rhythms have the common feature of inverted p waves although in some cases the p waves are not seen since the depolarization of the atria is occurring close to the time that the ventricles are being depolarized. Junctional rhythms are simply differentiated by rate since they possess the same characteristics.

The characteristics of premature junctional contraction (PJC) are:

- Rhythm: early beat (PJC) causes the rhythm to be irregular
- Rate: 60 to 100/minute (underlying rhythm)
- p waves: inverted or not seen in PJC
- pr interval: not applicable
- QRS lenght: .06 to .10 seconds (in underlying rhythm)
- Cause: medication toxicity (e.g. digoxin); ischemia
- Treatment: no treatment required; continue to observe for increasing number of PJCs since this indicates increasing AV node irritability.

The characteristics of junctional rhythm are:

- Rhythm: regular
- Rate: < 60/minute
- p waves: inverted or absent
- pr interval: .12 to .20 seconds
- QRS length: .06 to .10 seconds
- Cause: medication toxicity (e.g. digoxin); ischemia
- Treatment: treat cause.

The characteristics of accelerated junctional rhythm are:

- Rhythm: regular
- Rate: 60 to 100/minute
- p waves: inverted or absent
- pr interval: not applicable
- QRS length: .06 to .10 seconds
- Cause: medication toxicity (e.g. digoxin); ischemia
- Treatment: treat cause.

The characteristics of paroxysmal junctional tachycardia (PJT) are:

- Rhythm: regular
- Rate: 150 to 250/minute
- p waves: inverted or absent (if seen)
- pr interval: not applicable
- QRS length: .06 to .10 seconds
- Cause: ischemia
- Treatment: see SVT

**Figure 10. Premature junctional contractions**

**Figure 11. Junctional rhythm**

**Figure 12. Accelerated junctional rhythm**

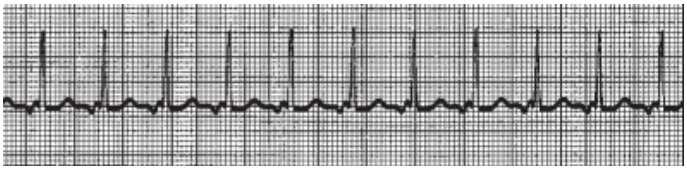


**Figure 13. Paroxysmal junctional tachycardia**

### Ventricular rhythms

Ventricular rhythms are characterized by wide and bizarre QRS complexes. The rhythms that will be explored in this section include those caused by irritability which include: premature ventricular contractions (PVCs: see Figure 14), ventricular tachycardia (see Figure 15) and ventricular fibrillation (see Figure 16). In addition, ventricular rhythms that arise due to failure of higher level pacemakers (i.e. idioventricular, accelerated ventricular and aganol rhythms). It is important to distinguish between these two types of ventricular rhythms since the treatment and implications are very different (see Figures 17, 18 and 19).

The characteristics of premature ventricular contractions (PVCs) are:

- Rhythm: early beat (PVC) causes the rhythm to be irregular
- Rate: 60 to 100/minute (underlying rhythm)
- p waves: none (in PVC)
- pr interval: none (in PVC)
- QRS length: > .12 seconds (wide and bizzare)
- Cause: ventricular irritability (e.g. hypoxemia, acid-base imbalance, medications, electrolyte imbalance)
- Treatment: no treatment required for isolated PVCs; watch for an increase in PVCs (> 10/minute) since this indicates an increase in ventricular irritability. Note morphology and incidence of PVCs and escalate if required (PVCs could be multifocal, unifocal, couplets, bigeminal or trigeminal).

The characteristics of ventricular tachycardia (VT) are:

- Rhythm: regular
- Rate: 150 to 250/min
- p waves: none
- pr interval: none
- QRS length: > .12 seconds (wide and bizzare)
- Cause: ventricular irritability (e.g. hypoxemia, acid-base imbalance, medications, electrolyte imbalance)
- Treatment: confirm signs of life (i.e. presence of pulse and normal respiratory effort); obtain emergency assistance (i.e. cardiac arrest or rapid response team if available);

  if no signs of life (pulseless VT):
  - commence basic life support in accordance to national resuscitation guidelines (chest compressions and ventilation breaths)
  - defibrillate as per national resuscitation guidelines
  - secure intravenous access & administer Epinephrine & Amiodarone as per guidelines;

  if signs of life are noted (VT with a pulse):
  - administer oxygen as required
  - obtain intravenous access
  - administer intravenous Amiodarone
  - correct abnormal electrolytes.

The characteristics of ventricular fibrillation (VF) are:

- Rhythm: irregular and chaotic
- Rate: cannot calculate
- p waves: none
- pr interval: none
- QRS: none
- Cause: ventricular irritability (e.g. hypoxemia, acid-base imbalance, medications, electrolyte imbalance)
- Treatment: confirm signs of life (i.e. presence of pulse and normal respiratory effort); obtain emergency assistance (i.e. cardiac arrest or rapid response team if available); commence basic life support in accordance to national resuscitation guidelines (chest compressions and ventilation breaths); defibrillate as per national resuscitation guidelines; secure intravenous access and administer epinephrine and amiodarone as per guidelines.

The characteristics of idioventricular rhythm are:

- Rhythm: regular
- Rate: < 40/minute
- p waves: none
- pr interval: none
- QRS length: > .12 seconds (wide and bizarre)
- Cause: ischemia, reperfusion post thrombolytics
- Treatment: typically benign, transient; however if the patient exhibits signs of haemodynamic compromise, treat with interventions listed for bradycardia: atropine, chronotropic agents (intravenous infusion of Epinephrine), transcutaneous pacing.

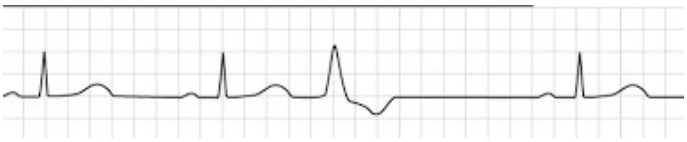


Figure 14. Premature ventricular contractions

Figure 15. Ventricular tachycardia

Figure 16. Ventricular fibrillation

Figure 17. Idioventricular rhythm

Figure 18. Accelerated idioventricular rhythm

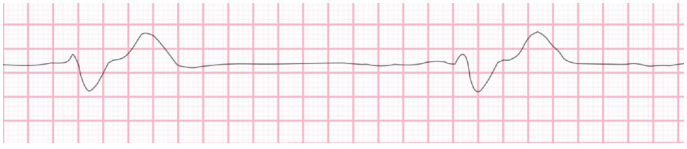


Figure 19. Agonal rhythm

The characteristics of accelerated idioventricular rhythm (AIVR) are:

- Rhythm: regular
- Rate: 40 to 100/minute
- p waves: none
- pr interval: none
- QRS length: > .12 seconds (wide and bizarre)
- Cause: drug toxicity, especially digoxin, cocaine and volatile anaesthetics such as desflurane; electrolyte abnormalities; cardiomyopathy; congenital heart disease; myocarditis; return of spontaneous circulation following cardiac arrest
- Treatment: typically transient, no treatment required.

The characteristics of aganol rhythm are:

- Rhythm: very irregular
- Rate: < 40/minute
- p waves: none
- pr interval: none
- QRS length: > .12 seconds seconds
- Cause: end stage cardiac disease
- Treatment: this rhythm technically indicates a refractory end of life situation.

### AV Blocks

Atrioventricular (AV) blocks are characterized by electrical conduction dysfunction through the myocardium. This is manifested as obstructed, delayed or variable electrical conduction through the AV node. Types of AV block include: 1st degree heart block (see Figure 20), 2nd degree heart block (Mobitz type 1 or Wenkebach: see Figure 21), 2nd degree heart block (Mobitz type 2: see Figure 22) and 3rd degree heart block (complete heart block: see Figure 23). AV blocks can be associated with significant risk deterioration or haemodynamic compromise, so prompt identification and treatment is vital for the critical care nurse. Characteristics of each AV block will be explored, including nursing considerations and treatment options.

The characteristics of first degree AV Block are:

- Rhythm: regular
- Rate: 60 to 100/minute
- p waves: normal
- pr interval: >.20 seconds
- QRS length: .06 to .10 seconds
- Cause: AV nodal disease; enhanced vagal tone (e.g. athletes); myocarditis; following myocardial infarction; electrolyte disturbances; medications (e.g. calcium channel blockers, beta blockers)
- Treatment: no treatment required; observe for further block.

The characteristics of second degree block Type I are:

- Rhythm: regular or slightly irregular
- Rate: 60 to 100/minute
- p waves: normal
- pr interval: progressively gets longer until a beat is dropped
- QRS length: .06 to .10 seconds
- Cause: ischemia
- Treatment: usually benign, with no treatment required; if patient becomes haemodynamically compromised consider interventions for bradycardia; observe for worsening AV block.

The characteristics of second degree AV block Type II are:

- Rhythm: regular or irregular
- Rate: varies
- p waves: more p waves than QRS complexes
- pr interval: constant
- QRS length: .06 to .10 seconds or may be widened
- Cause: ischemia; myocardial infarction
- Treatment: if patient becomes haemodynamically compromised consider interventions for bradycardia; observe for worsening AV block; may require temporary or permanent pacing.

The characteristics third degree heart block are:

- Rhythm: ventricular rhythm regular (R-R) and atrial rhythm regular (p-p)
- Rate: ventricular rate typically < 40/min and atrial rate 60 to 100/minute
- p waves: no relationship between p waves and QRS complex
- pr interval: not applicable
- QRS length: usually >.12 seconds but may be normal
- Cause: ischaemic heart disease; following myocardial infarction; Lyme disease; congenital
- Treatment: if patient becomes haemodynamically compromised consider interventions for bradycardia; may require temporary or permanent pacing.

**Figure 20. First degree heart block**

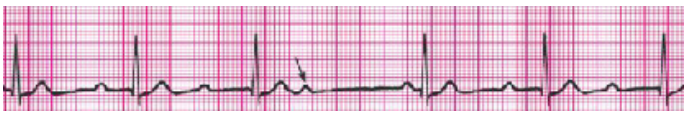


**Figure 21. 2nd degree heart block (Mobitz type 1 or Wenkebach)**

**Figure 22. 2nd degree heart block (Mobitz type 2)**

Figure 23. 3rd degree heart block

## SUMMARY

In this chapter, a systematic approach was presented for interpreting arrhythmias. This approach should be routinely used to ensure accurate interpretation of arrhythmias when caring for your critically ill patient.

In the event that the patient is hemodynamically unstable or unresponsive, the first priority would be to assess the patient first and provide emergency treatment.

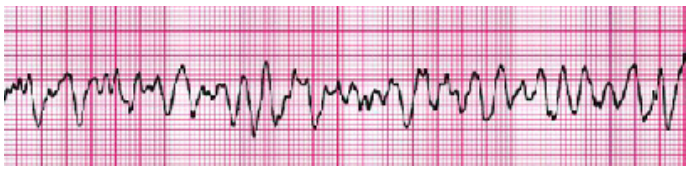
For further development in your skill in interpreting basic arrhythmias, we recommend continued development by further rhythm practice and attendance at arrhythmia refresher courses when possible. In addition, we have provided resources at the end of this chapter that we hope you find helpful as you develop further competency in this subject area.

### Practice questions - test yourself

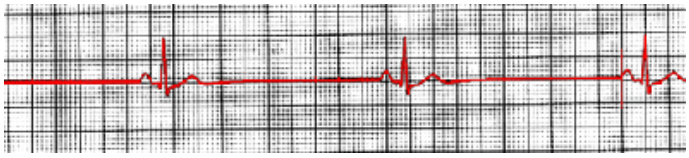
Below you will find a case study and several practice questions to test your knowledge after reviewing this chapter.

***Case Study***

Mr Mohammed Ahmed is a 59 year male, who has presented to his local hospital with severe central, crushing chest pain. He has a past medical history of diabetes, hypertension and a high body mass index. On admission to hospital, Mr Ahmed's ECG, clinical presentation & blood results confirm a diagnosis of an inferior ST elevation myocardial infarction (STEMI), then then proceeds to the cardiac catheterization lab for primary percutaneous coronary intervention (PPCI). During the procedure, the cardiac catheterization lab team notes a cardiac rhythm change:



This rhythm change is treated immediately and the patient returns to normal sinus rhythm (NSR) at a rate of 90 beats per minute. Following the procedure, Mr Ahmed is transferred to the cardiac care unit. He recovers well following his STEMI & PPCI, however the following day a further rhythm change is noted by the nursing team:



Mr Ahmed becomes symptomatic with this new cardiac rhythm, with profound hypotension (BP of 68/45 mmHg) and a reduced level of consciousness. The physician attends and requests emergency interventions.

***Multiple choice questions***

**1. Concerning the first rhythm (Ventricular Fibrillation). What key treatment interventions are required immediately?**

a. Epinephrine and cardiopulmonary resuscitation (CPR)
b. Cardiopulmonary resuscitation (CPR), defibrillation
c. Confirmation of cardiac arrest, cardiopulmonary resuscitation (CPR) and defibrillation
d. Transcutaneous pacing.

**2. Ventricular fibrillation (VF) should be described by which statement?**

a. A regular, fast rhythm, which is characterized by a wide QRS and no clear P wave activity
b. An irregular, chaotic fast rhythm, which features no clear P wave or QRS complexes
c. An irregular, fast rhythm, which has fibrillatory P waves and normal QRS complexes
d. A regular, normal speed rhythm, which is characterized by clear P wave activity and normal QRS complexes.

**3. Concerning management of the 2nd cardiac rhythm & Mr Ahmeds deterioration, what interventions are required?**

a. Commence cardiopulmonary resuscitation (CPR) and defibrillate
b. Administer an intravenous fluid bolus
c. Administer intravenous atropine. If no improvement, consider transcutaneous pacing via a pacing enabled defibrillator
d. Commence an intravenous infusion of epinephrine.

### Answers

1. c. Confirmation of cardiac arrest, cardiopulmonary resuscitation (CPR) and defibrillation. Artifact or patient movement can mimic ventricular fibrillation (VF), so it is vital that the healthcare professional confirms cardiac arrest prior to calling for assistance, commencing CPR or initiation of defibrillation. CPR should be initiated immediately to ensure that key organs remain perfused. Once a defibrillator is available, the patient should receive a shock, followed by further CPR.

2. b. Ventricular fibrillation (VF) can be described as a complex, irregular and chaotic rhythm, which features no clear P waves and QRS complexes that have a random width and amplitude. VF is a cardiac arrest rhythm and warrants immediate CPR and defibrillation.

3. c. Mr Ahmed's rhythm deteriorated into sinus bradycardia. Treatment for symptomatic bradycardia includes administration of intravenous atropine. If atropine fails to achieve a satisfactory result, transcutaneous pacing can be implemented via a pacing enabled defibrillator.

## FURTHER READING

Aehlert B (2018). ECGs Made Easy, 6th ed. Mosby: St. Louis, Missouri.

Link M, Berkow L, Kudenchuk P et al. (2015). Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, Part 7: Adult Advanced Cardiac Life Support. Circulation 132(18 Suppl 2): S444-64.

Goldsworthy S (2012). Coronary Care 1 and 2 Manual. Durham College Continuing Education: Oshawa, Canada.

Walraven G (2011). Basic Arrhythmias 7th ed. Pearson Publishers: Toronto, Ontario.

### Other helpful resources

ECGlibrary.com. [for practice]. Available at: https://ecglibrary.com/ecghome.php.