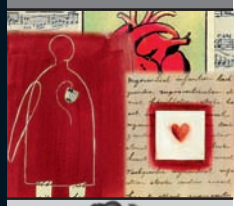

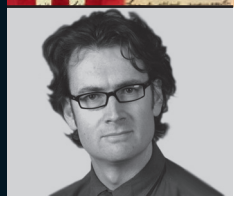

Pharmacologic management of tachycardia

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BACKGROUND
Cardiac arrhythmias may present with palpitations, chest pain, shortness of breath, dizziness and syncope. Diagnosis may be complicated by an inability to document the arrhythmia particularly when symptoms are infrequent and short lived.

OBJECTIVE
This article aims to provide an overview of the pharmacological management of supraventricular tachycardia including atrial flutter and haemodynamically stable ventricular tachycardia. Management of atrial fibrillation is discussed in a companion article in this issue.

DISCUSSION
Antiarrhythmic medications are effective in reducing symptoms, however, side effects are frequent. Fortunately nonpharmacological strategies such as catheter ablation have evolved which offer long term cure in the majority of patients. However, despite technological advances, pharmacotherapy retains an important place in the therapeutic approach to cardiac arrhythmias in many patients. It is important to remember that pharmacological management should also address any underlying cardiac disease process.

Arrhythmias may be responsible for worsening heart failure, stroke, myocardial infarction or sudden death. They may be primary or occur secondary to underlying cardiac, pulmonary or endocrine disease. It is important to remember that pharmacological management is not confined to modulation of the cardiac ion channel but should also address any underlying cardiac disease process.

An understanding of the underlying mechanism and categorisation according to cardiac chamber assists the therapeutic approach to cardiac arrhythmias. Atrial arrhythmias include:

- ectopy
- supraventricular tachycardia (SVT) due to
  – atrioventricular (AV) nodal re-entry tachycardia (AVNRT)
  – AV re-entrant tachycardia (AVRT), or
  – atrial tachycardia (AT) (*Figure 1a–d*).

Atrial tachycardia is further divided according to electrophysiological mechanism into focal (previously paroxysmal AT) and macro re-entrant (atrial flutter). The most common sustained arrhythmia: atrial fibrillation (AF) is the subject of a separate review.

Ventricular arrhythmias also include ectopic beats and tachycardia. Further management of ventricular tachycardia (VT) requires assessment of underlying cardiac function. This is important in determining the risk of sudden cardiac death and the need for an implantable cardioverter defibrillator (ICD).

Supraventricular tachycardia

Acute management

Management depends on the accurate diagnosis of a narrow complex tachycardia (QRS width <120 ms) typically without discernible P waves. Broad complex tachycardia (QRS width >120 ms) should be managed as VT unless there is strong evidence to support alternate diagnoses. If the patient is hemodynamically compromised, electrical cardioversion should be considered.

If the patient is stable, carotid sinus massage or Valsalva manoeuvre may be useful in producing transient AV block and terminating tachycardia. However this manoeuvre will be ineffective for arrhythmia circuits that do not include the AV node.

The most effective approach in terminating SVT is the administration of adenosine (*Figure 2a*). Adenosine has a half life of 10 seconds and requires cardiac monitoring during intravenous (IV) administration. Monitoring is not only important in terminating arrhythmias safely, but provides diagnostic information regarding arrhythmia mechanism (*Table 1, Figure 2b*). Patients should be warned of the sense of impending doom before the administration of adenosine. Approximately 90% of tachycardia due to AVNRT and AVRT are terminated by a 12 mg dose of adenosine.[1] A rebound sinus tachycardia is commonly seen following termination of SVT by adenosine. If adenosine is contraindicated or ineffective, IV verapamil or a beta blocker is also effective and helps prevent early recurrence.

Atrioventricular nodal blocking agents should not be used in patients with:

- broad complex tachycardia, or
- evidence of pre-excitation on baseline electrocardiogram (ECG) (Wolff-Parkinson-White [WPW] syndrome, ie. antegrade conduction via an accessory pathway) as blocking the AV node leads to unopposed conduction down the accessory pathway which can result in ventricular fibrillation (VF).[2] The treatment of choice is IV procainamide. Flecainide is also effective but should only be used if coronary artery disease and structural heart disease have been excluded. Intravenous sotalol and amiodarone are also effective agents.

DC cardioversion is an alternative at any stage in the management algorithm for SVT and is indicated if all prior means have failed or hemodynamic compromise develops (*Figure 3*).

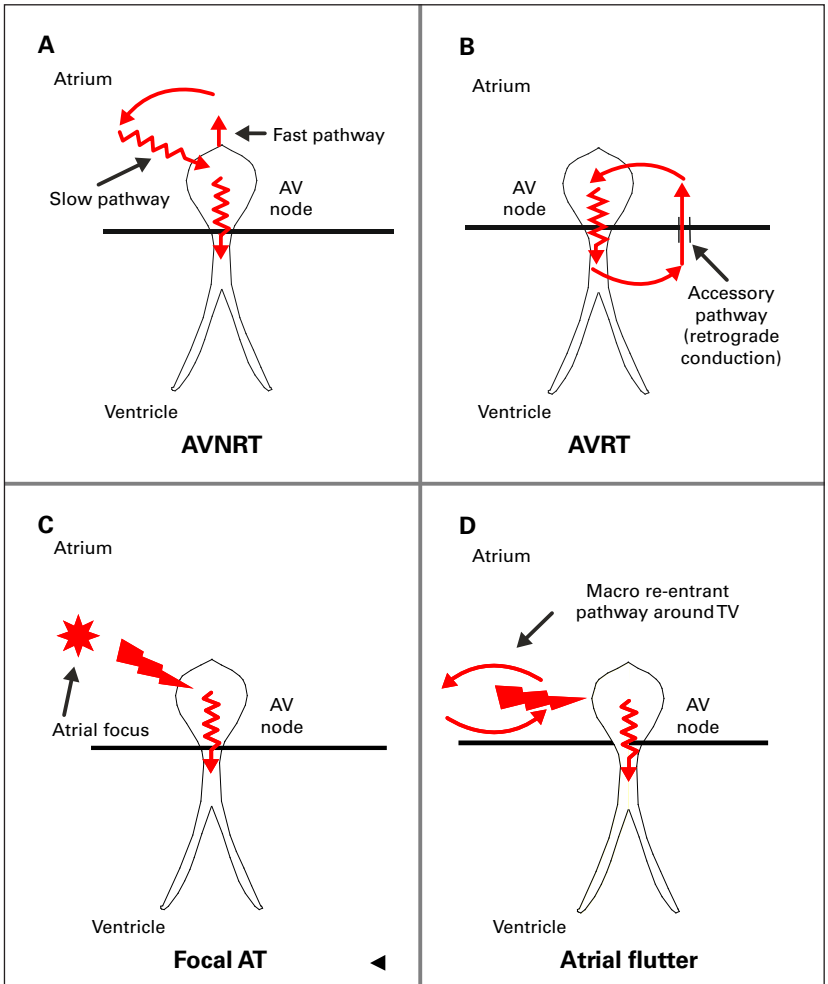

Figure 1. Mechanisms of SVT

A. Common AVNRT conduction occurs via the slow pathway and retrograde conduction via the fast pathway. Atria and ventricles are activated synchronously (retrograde P wave rarely seen). In uncommon AVNRT the antegrade conduction occurs via the fast pathway and retrograde via the slow pathway (retrograde P wave)

B. Orthodromic AVRT occurs when the AV node conducts antegradely to the ventricle and the accessory pathway conducts retrogradely (retrograde P wave). Antidromic AVRT occurs when the accessory pathway conducts antegradely to the ventricle (resulting in pre-excitation, WPW pattern with delta wave on ECG) and the AV node conducts retrogradely (retrograde P wave)

C. Focal AT results when impulse arises from a nonsinus node atrial origin

D. Typical atrial flutter is due to a large re-entrant circuit circumnavigating the tricuspid valve

Atrial flutter

A narrow complex tachycardia at a ventricular rate of 150 bpm is likely to represent atrial flutter with 2:1 AV block. Assessment of the patient's risk of thromboembolic complication is of utmost importance before deciding on a strategy of restoring sinus rhythm ('rhythm control') versus control of ventricular rate ('rate control'). At initial assessment low molecular weight or unfractionated heparin should be administered. If the duration of atrial flutter can be established as less than 48 hours, cardioversion may be considered. Atrial flutter is relatively insensitive to pharmacologic cardioversion but sensitive to low energy electrical reversion or atrial overdrive pace termination. It is the atrial mechanical 'stunning' as a result of the termination of atrial flutter that determines stroke risk rather than the means in which sinus rhythm is restored. Under deep sedation, direct current reversion (DCR), typically with 50 J, is the most effective means of restoring sinus rhythm. If there is uncertainty regarding arrhythmia duration then rate control and anticoagulation should be pursued. If cardioversion is required in a patient with uncertain duration of atrial flutter then transoesophageal echo should be performed to exclude the presence of left atrial thrombus.

The ventricular response to atrial flutter or 'rate

control' is an effective alternative strategy to acute cardioversion. Drugs acting at the AV node (beta blockers, verapamil, diltiazem or digoxin) will reduce the ventricular response but not terminate the arrhythmia (*Figure 2b*).

Focal atrial tachycardia

Focal AT is due to a rapidly firing non-sinoatrial (SA) nodal atrial focus that is typically remote to the AV node. Therefore most forms of AT do not respond to IV adenosine and may be recognised by a continuation of the tachycardic P waves during a period of adenosine induced AV block. Pharmacologic treatment can be difficult and requires the use of antiarrhythmic drugs that act on the atrial myocardium. These include class IA (eg. procainamide), class IC (eg. flecainide) or class III agents (amiodarone, sotalol).[3] DC cardioversion is effective in termination, however early recurrence is common.

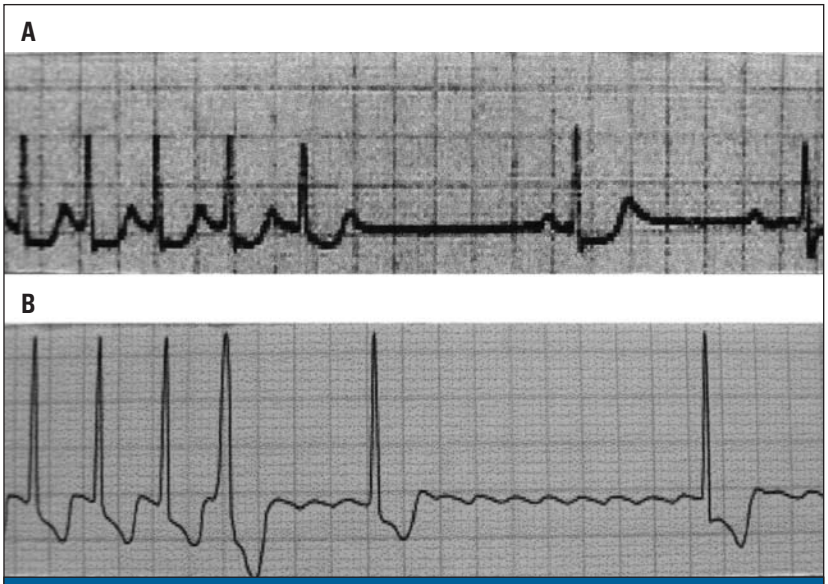

Figure 2. AV nodal block with adenosine terminating AVNRT (A) and revealing underlying atrial flutter (B)

Table 1. Response of narrow complex tachycardia to vagal manoeuvres or adenosine

No change	Consider inadequate dose/poor technique
Sudden reversion to SR*	Atrioventricular re-entry tachycardia
	Atrioventricular nodal re-entry tachycardia
	Atrial tachycardia (rarely reverts)
Atrioventricular block	Atrial flutter
	Atrial tachycardia
Gradual slowing and acceleration	Atrial tachycardia
	Sinus tachycardia

* Tachycardia which terminates with a nonconducted P wave is most likely due to AVNRT or AVRT

Long term management

Investigations in patients with SVT are usually limited to a 12 lead ECG in sinus rhythm. Echocardiography may be indicated in patients with right sided accessory pathways to exclude Ebstein anomaly. In patients with palpitations, efforts should be directed at documenting tachycardia before embarking on specific therapy. Not all patients with a single episode or recurrent SVT require long term treatment. The most effective form of therapy is catheter ablation, however this may not be available or warranted in all patients. In patients with infrequent episodes a 'pill in the pocket' approach may be useful.[4] This involves confining the administration of antiarrhythmic medication to the period of the arrhythmia. Therefore the strategy does not prevent episodes but aims to reduce symptoms. Patients with SVT should be instructed on Valsalva techniques and the avoidance of precipitants. Referral is warranted in the following circumstances (*Table 2*).

Atrial ectopy

Reassurance and lifestyle modification (eg. coffee and alcohol intake, smoking) are usually all that are required for symptomatic patients. If symptoms remain distressing despite these measures, beta blockers or verapamil are effective.

Atrial flutter

If prevention of atrial flutter is required following reversion then antiarrhythmics or electrophysiological study and ablation can be undertaken. Flecainide may have a long term efficacy of 50% in maintaining SR.[5] Because flecainide can slow the flutter rate, AV nodal blocking agents need to be used with flecainide to prevent 1:1 conduction. For maintenance of SR, sotalol or amiodarone can also be used.

AV node blocking agents alone in the long term can be used to affectively rate control patients with atrial flutter. Although the risk of thromboembolism is less compared to AF, long term anticoagulation (INR 2–3) recommendations are the same for atrial flutter and are presented in the 'Management of atrial fibrillation' article in this issue.

AVNRT/AVRT

In patients with burdensome symptoms who do not wish to undergo catheter ablation, first line treatment is AV nodal blocking agents (except in patients with pre-excitation). Atrioventricular nodal blocking agents in combination can also be used. A randomised trial comparing verapamil, digoxin and propanolol failed to reveal a superior agent over another.[6]

Class I or class III antiarrhythmic drugs should not

be administered without documentation of tachycardia due to the potential for proarrhythmic effects. In patients with structurally normal hearts and no evidence of coronary ischaemia, flecainide can be used. Flecainide is combined with an AV nodal blocking agent to reduce 1:1 conduction if atrial flutter ensues. Flecainide appears to be superior to verapamil in reducing the frequency of tachycardia. In one study, flecainide completely suppressed episodes in 65% of patients.[5] The addition of a beta blocker to flecainide results in greater than 90% efficacy of reducing tachycardia.[5] Amiodarone[7] and Sotalol[8] have also been used, although their use is limited. Serum potassium and renal function require monitoring to avoid QT prolongation.

Long term treatment in patients with pre-excitation should involve an arrhythmia specialist. If catheter ablation is not possible, class I drugs (flecainide) alone or in combination with an AV nodal blocking agent are effective.

Patients with WPW syndrome may also become tachycardic secondary to AF, atrial flutter, AT, or AVNRT, necessitating treatment targeting these disturbances. Atrial fibrillation is potentially life threatening in patients with WPW syndrome and is prevalent in up to a third of these patients.[9] In such situations rapid conduction down the accessory pathway can cause hemodynamic compromise.

For patients with occasional haemodynamically stable symptoms that are burdensome, pill-in-the-pocket therapy may be attempted. This refers to use of an agent/s only during an episode. A one off dose of diltiazem (120 mg) and propanolol (80 mg) has been shown to reduce emergency department visits in suitable patients.[10] This combination has been shown to be more efficacious than flecainide for pill-in-the-pocket therapy.[10] Hypotension and bradycardia are occasional complications. Pill-in-the pocket therapy with flecainide or sotalol can be used for suitable patients with pre-excitation.

Focal atrial tachycardia

Focal AT responds poorly to pharmacotherapy. Flecainide combined with an AV blocking agent, sotalol or amiodarone may be used. Fortunately with the advent of radio frequency ablation this form of tachycardia, which often is unresponsive to drug therapy, can be treated with high long term success.[11]

Multifocal atrial tachycardia is commonly due to pulmonary disease, less commonly due to metabolic and electrolyte disturbances and seldom due to digoxin. Treatment should be directed at treating the underlying causative disorder and if required calcium channel blockers may be used long term.

Table 2. When to refer to an arrhythmia specialist*

- Tachycardia with wide QRS
- Pre-excitation syndrome (WPW)
- Arrhythmia with burdensome symptoms
- Patient preference to be free of medications
- Patients intolerant to medications
- Arrhythmia refractory to medications
- Need to start/alter antiarrhythmic drug
- Hemodynamic instability
- High risk occupation (eg. pilot)
- High risk recreational pursuits (eg. diving)
- Uncertainty regarding further investigation/management

* An arrhythmia specialist refers to a electrophysiologist, cardiologist or a physician with an interest in arrhythmia management

Ventricular tachycardia

Acute management

Patients presenting with wide complex tachycardia have VT unless there is strong evidence to the contrary. Alternate diagnoses include SVT with aberration or antidromic (conduction anterograde via the accessory pathway and retrograde via the AV node) tachycardia.

In the presence of hemodynamic compromise DC cardioversion should be performed. In the hemodynamically stable patient antiarrhythmic medication may be used. Limitations include delay in onset of action and the risk of proarrhythmia or hemodynamic compromise. Intravenous amiodarone or procainamide are both effective in terminating VT. Lignocaine is particularly effective in the setting of acute cardiac ischaemia.[12] Sotalol can be used in stable patients with no left ventricular dysfunction.

Polymorphic VT when associated with prolonged corrected QT intervals is termed 'torsades de pointes'. This typically occurs in the context of a QT prolonging drug or electrolyte disturbance (potassium, magnesium, calcium). Treatment involves cessation of the offending drug and correction of the electrolyte disturbance. When associated with bradycardia, options include: isoprenaline, atropine, transvenous pacing and intravenous magnesium. If associated with hemodynamic compromise, cardioversion should be performed.

Long term management

Patients with ventricular arrhythmias require referral to an arrhythmia specialist (*Table 2*). The cornerstone of risk stratification in patients with ventricular arrhythmias is assessment of left ventricular function. This can be

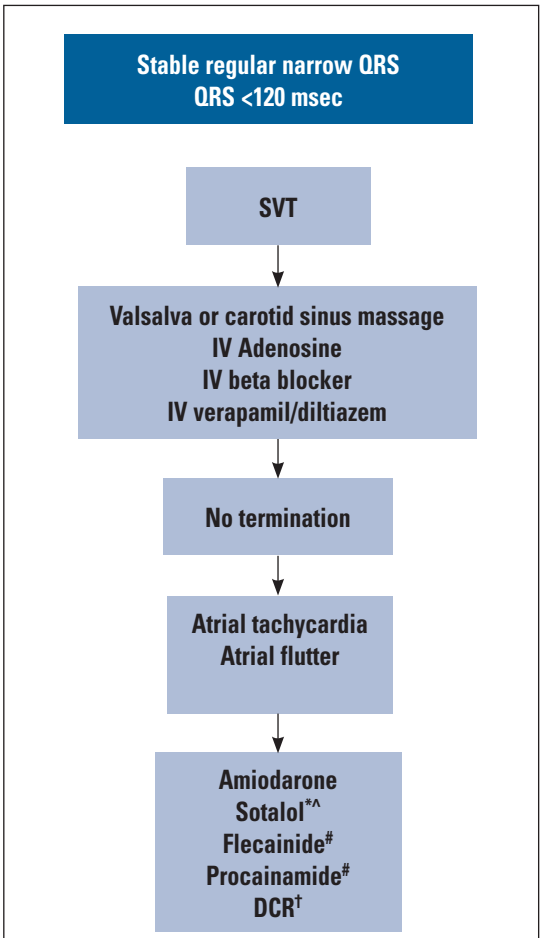

Figure 3. Acutely managing SVT
† DC cardioversion remains an alternative at any point in the treatment regimen, as a last resort, or if hemodynamiclly compromised
# Not to be used in patients with LV dysfunction
* Reduce dose in renal impairment
^ Caution should be used in patients with LV dysfunction

achieved by echo, nuclear gated blood pool scan or left ventriculography. If LV function is compromised then further assessment of underlying aetiologies (eg. ischaemic heart disease, cardiomyopathy, valvular disease) should be investigated. Ventricular tachycardia may also occur in the structurally normal heart and be associated with a good prognosis.

In patients with ventricular arrhythmias and a left ventricular ejection fraction <40%, an ICD is associated with improved survival and should be considered. The device offers antitachycardia pacing in addition to electrical cardioversion to revert arrhythmias.

Beta blockers have been shown to prolong survival and prevent ventricular arrhythmias in patients with and without heart failure and should be used as first line agents.[13] Amiodarone may be added if arrhythmias break through on beta blockers. Amiodarone is associated with a reduction in arrhythmic death[13] but most studies have shown no clear overall survival benefit of amiodarone in heart failure.[14] Similarly, sotalol, despite being effective in suppressing VT, has not been shown to prolong survival.[15]

Beta blockers, sotalol, amiodarone and combinations have been shown to reduce appropriate and inappropriate ICD firing in patients with heart failure.[16] This may become an increasingly common patient population as ICD increases in response to increase of heart failure prevalence.

Ventricular ectopy

Frequent ventricular ectopy are often benign but may represent underlying cardiac disease. Investigations include echocardiography and provocative testing to determine the presence of coronary ischaemia. Therapies may be targeted at the underlying cardiac condition (eg. beta blockers in acute myocardial infarct [AMI] patients and antihypertensive drugs in LVH). In patients with structurally normal hearts, beta blockers are usually effective in alleviating symptoms.

Conclusion

Antiarrhythmic drugs play an important role in the acute management of arrhythmias. Patients with recurrent symptoms or single episodes associated with haemodynamic compromise should be referred to an arrhythmia specialist for consideration of long term therapy. This may include catheter ablation, pharmacological management or device based therapy.

Conflict of interest: none declared.

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