
TACHYARRHYTHMIAS IN INFANTS AND CHILDREN

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Principles of Management

Rapid heart beat in children may be due to:

- Sinus tachycardia
- Supraventricular tachycardia (SVT)
- Ventricular tachycardia (VT)
- Post cardiac surgery, junctional ectopic tachycardia is common.

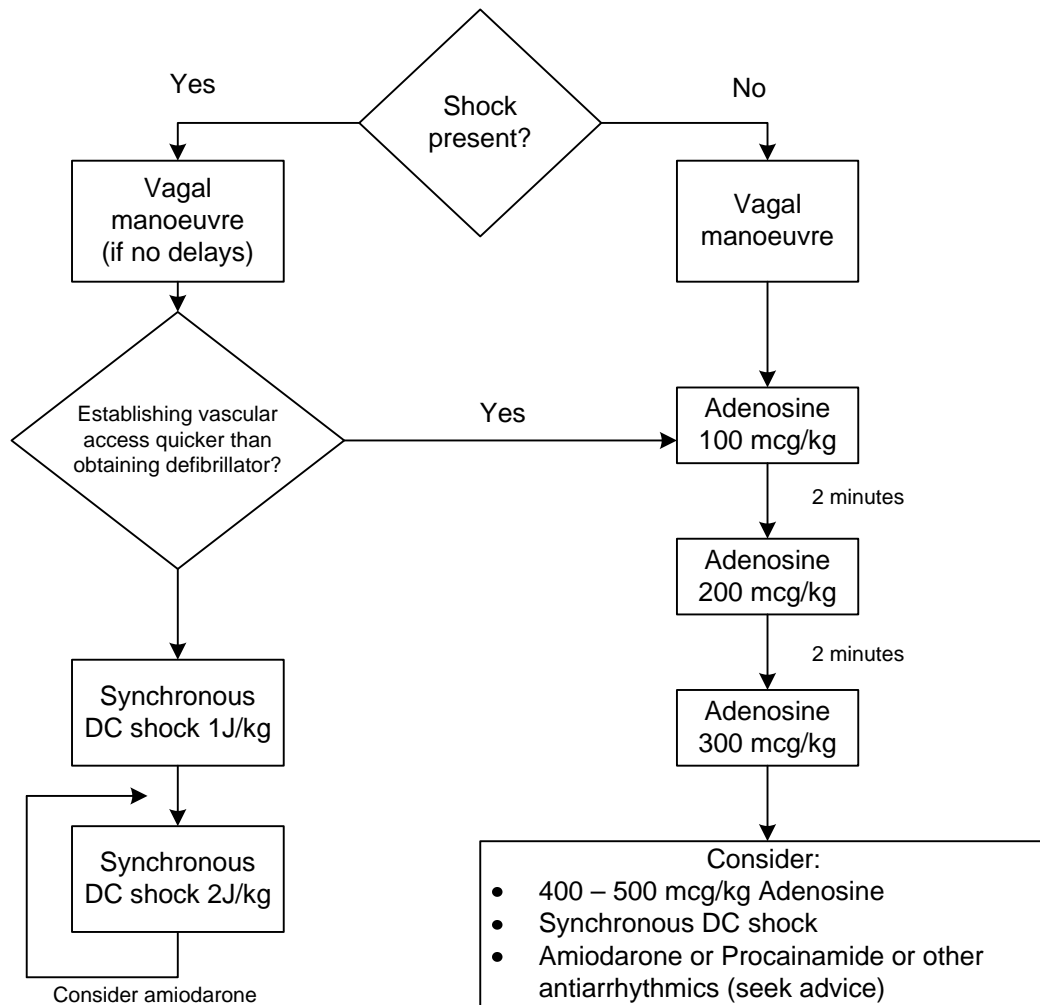
The following guidelines give practical suggestions for the diagnosis and management of these problems. Relevant history, physical examination and investigations are important however effective intervention must not be unduly delayed. Early consultation with paediatric cardiologist is desirable and is mandatory for patients with complex congenital heart disease.

Recommended approach:

1. A,B,C assessment. Is the child in shock?
2. 12 lead ECG. Is there a tachyarrhythmia? Broad or narrow complex? P-waves?
3. Institute appropriate management (see below).
4. Concurrently consider underlying causes / precipitating factors.
5. Review diagnosis if management unsuccessful.
6. Repeat 12 lead ECG.
7. Arrange appropriate ongoing care and follow-up.

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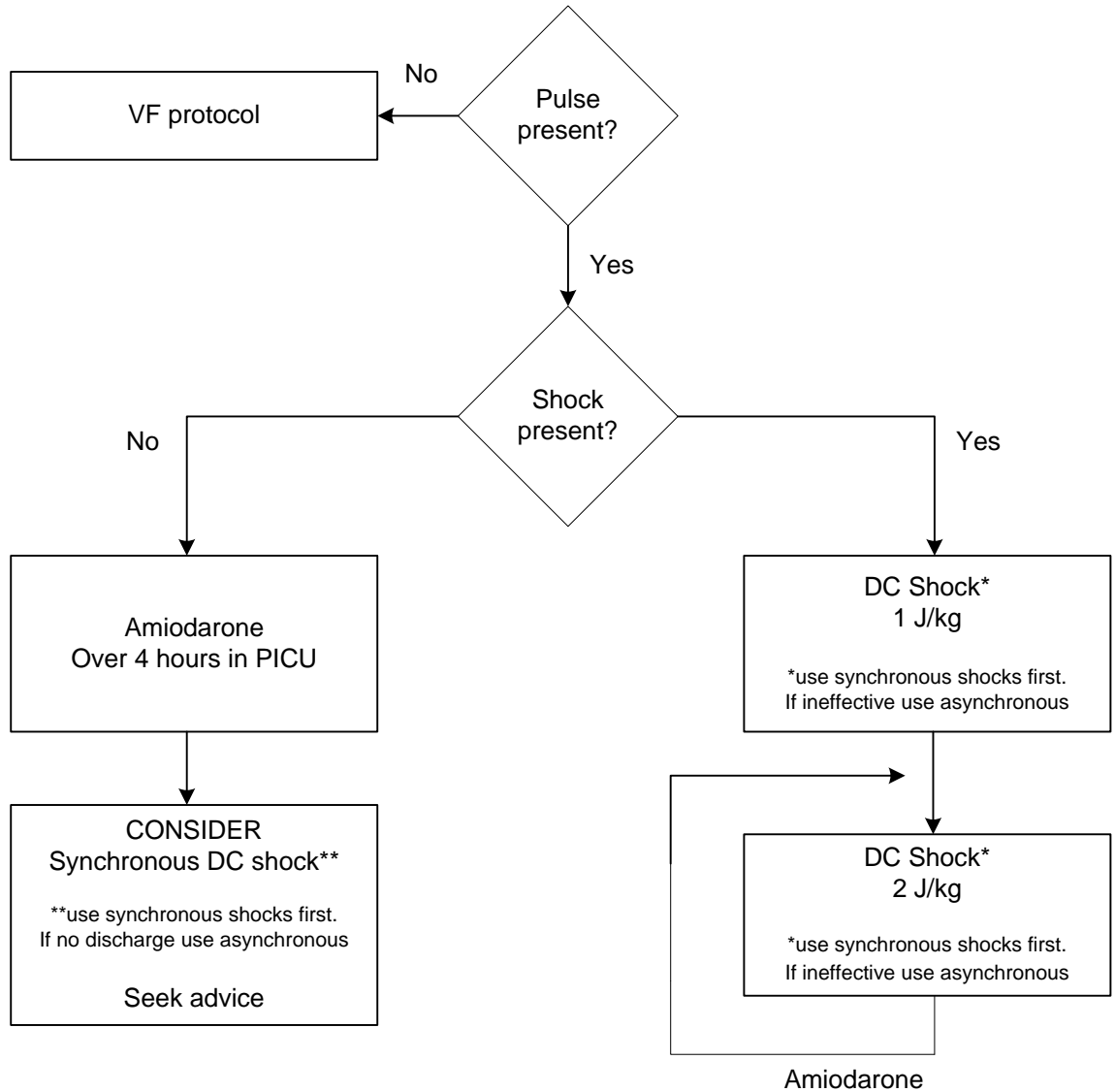
SVT Algorithm



SVT Algorithm, adapted from APLS Australia & NZ 2007.

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VT Algorithm



VT Algorithm, adapted from APLS, Australia & NZ 2007

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Interpretation of ECG

1. Determine heart rate. One useful method is to count the number of RR intervals in six large squares then multiply by 50 – see chart below for normal rates.
2. Is it the tachycardia wide or narrow complex? A QRS duration of >0.10 second at rates above 200 defines this – see chart below for normal durations.
3. Can you identify P waves and what is their relationship to the QRS complex? They may be absent, hidden or inverted. There may be AV dissociation.

It is best to assume a broad complex tachycardia is due to VT rather than SVT with aberration. The latter is much less common in children. Separating sinus tachycardia from SVT can be difficult. If the child looks very sick, has a variability in heart rate, has a rate <220 bpm and a normal P axis, sinus tachycardia is more likely. Conversely a 'fixed' heart rate >220 bpm in a relatively well looking child with a superior P axis is more likely to be due to SVT.

Normal heart rates:

Age (years)	Heart rate (bpm)
<1	110 – 160
1-2	100 – 150
2-5	95 – 140
5 – 12	80 – 120
>12	60 – 100

Tachyarrhythmia needs exclusion if a newborn or infant has a heart rate >200 beats/minute, a toddler >180 beats/minute or a school-aged child >160 beats/minute. Cardiac monitors are not very accurate for heart rates above 200.

Normal QRS Duration: Average (and upper limits) for age:

	0-1 mo	1-6 mo	6-12mo	1-3 yr	3-8 yr	8-12 yr	12-16yr	Adult
Seconds	0.05 (0.07)	0.05 (0.07)	0.05 (0.07)	0.06 (0.07)	0.07 (0.08)	0.07 (0.09)	0.07 (0.10)	0.08 (0.10)

Modified from Guntheroth WG Pediatric electrocardiography, Philadelphia 1965, Saunders

Supra-ventricular Tachycardia (SVT) Background

Supraventricular tachycardias (SVT) are common in infancy and childhood with an incidence between 1:250 to 1:1,000. In 90% of cases it is due to a re-entrant rhythm and usually occurs in otherwise normal children.

30-40% of children presenting with new onset SVT, do so in the first few weeks after birth. SVT can often be tolerated for many hours but because infants cannot verbally communicate their perceptions of tachycardia, early signs may be subtle until they develop haemodynamic compromise. They may have poor feeding, tachypnea, pallor, sweating, lethargy and irritability. Latter signs and symptoms reflect a measure of congestive heart failure. In rare instances SVT may have been present for days in a young infant.

Older children usually perceive tachycardia (palpitations) and may feel ill, breathless, sweaty, nauseated, dizzy or have orthostatic hypotension. Onset often occurs at rest, while they are sitting, reading, watching TV or in the 5-10 minutes *after* exercise. SVT rarely occurs in sleep or causes syncope. Sudden death from SVT has been reported but is rare.

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SVT Management

Vagal manoeuvres should be tried first but not cause undue delay. Technique is based on age:

- **Neonates and infants:** Facial immersion in ice water. **This technique must not be used for infants in circulatory shock.** The baby is attached to a cardiac monitor, arms are wrapped in a towel, the whole face is immersed in an ice water slurry for five seconds. It is unnecessary to occlude the nostrils. This technique is safe and 90% effective in terminating a tachycardia. Explain carefully to the parents what you are doing. The baby will not drown!
- **Toddlers:** Ice cold facecloth to the face. Older infants resist being dipped into the water as above but this technique is almost as effective. You should not use eyeball pressure as it can damage the retina. Unilateral carotid sinus massage can be used but is often difficult to perform.
- **School-aged children:** Valsalva technique; ask the child to blow on their thumb after full inspiration for 10-15 seconds. Demonstrate the technique and have the child copy you. There should be no air escape and the child should be seen to strain (playing the trumpet silently).

IV Adenosine: This is the drug of first choice for narrow complex tachyarrhythmias. This is both therapeutic and sometimes diagnostic. Technique is important due to a very short $\frac{1}{2}$ life.

- Give through a large vein (antecubital fossa) using a three way tap close to the cannula.
- Give adenosine on one port by rapid IV push.
- Follow immediately with rapid push of 5ml of normal saline through other port.
- First dose is 100 *micrograms*/kg followed by 200 mcg/kg then 300 mcg/kg (max 12mg).
- Record rhythm strip throughout (can use the defibrillator for this purpose), as may help later with diagnosis.

Older children complain of transient flushing, chest pain and nausea. Infants will frequently cry. The drug works by temporarily blocking the AV node and on ECG you frequently see a brief period of asystole before sinus rhythm returns.

If the technique is correct and the child does not revert to sinus rhythm after the maximum dosage, you should **REVIEW THE DIAGNOSIS**. It is likely that you are dealing with an atrial (non-junctional) tachyarrhythmia. eg atrial flutter.

IV Amiodarone. This is the safest antiarrhythmic in the post-operative situation, or where ventricular function is compromised, although some negative inotropic effect is present when given intravenously. Amiodarone is useful for atrial (non-junctional) tachycardias, particularly atrial flutter, which will not respond to Adenosine, and resistant WPW circuits as well as "stable" ventricular tachycardia.

There are few data available for the use of IV amiodarone in paediatrics but the following doses have been used:

IV: 25 microgram/kg/min for 4 hrs then 5-15 microgram/kg/min (max 1200 mg/24 hrs).

More rapid administration of the loading dose can be used but there is a significant risk of hypotension. In children who are cardiovascularly unstable, electrical cardioversion is usually a safer option than a more rapid infusion of amiodarone

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Verapamil is contraindicated in children under 1 year of age as it is associated with profound hypotension. Fatalities have been reported.

Electrical cardioversion: Can be used if there is no response to IV Adenosine and there is evidence of shock. In these circumstances a Paediatric Code Blue should have been called. If the patient is conscious they should have intravenous sedation/anaesthesia prior to DC cardioversion. Give synchronous DC shock at 1 J/kg. Further shocks at 2 J/kg may be necessary.

SVT Ongoing Care

A 12 lead ECG must be performed once sinus rhythm has been achieved. Ongoing care should be discussed with the senior clinician responsible for the child. Discuss with the on call paediatric cardiologist before starting prophylactic anti-arrhythmic medication.

Wolff-Parkinson-White syndrome - accounts for approximately 25% of SVT in children. They have a tendency to atrial fibrillation with rapid AV conduction. This predisposes them to ventricular tachycardia and sudden death, 1% risk per ten years. They should not be given Digoxin and require electrophysiological testing and probable radio-frequency ablation.

Infants - In long term follow up, infants with SVT had a 55% recurrence rate during infancy but 93% will have stop by the time they are 8-10 months of age (though may have recurrence in late childhood). Infants are more likely to be compromised by the rhythm and should be placed on prophylactic antiarrhythmic agent such as Atenolol (1mg/kg bd), Flecainide (2mg/kg bd) or Sotalol (1-2mg/kg tds) until they are over the age of one year. These latter two agents should be commenced in hospital as they are both pro-arrhythmic.

School Age Children - In this age group, this arrhythmia is generally a nuisance rather than life-threatening and prophylactic antiarrhythmic agents are not routinely indicated. Persistence is however more common and careful follow-up should be arranged. The incidence of underlying congenital heart disease is up to 20% (congenitally corrected transposition L-TGA and Ebstein's are the most common).

Admission: A study of ED presentations with new SVT found the majority of early recurrences and all adverse outcomes were identified if all patients under 3 months were admitted and the rest were monitored in ED for a minimum of 90 minutes. 24 hour review of those discharged was recommended. Infants being started on anti-arrhythmic medications require admission as above.

Follow up: All children with SVT should have Cardiology follow-up. A copy of the 12-lead ECG in SVT, the rhythm strip during reversion to sinus rhythm, and the 12-lead ECG in sinus rhythm should be sent with the referral letter.

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Ventricular Tachycardia (VT) Management

A broad complex tachycardia may be VT, SVT with aberrancy, WPW with antidromic tachycardia (down the accessory pathway and up the AV node), atrial tachycardia, or Mahaim fibre tachycardia (LBBB, left axis). The QRS may be broad at rest due to congenital or operated heart disease. **It is best to assume broad complex tachycardia is due to VT rather than SVT with aberration as the latter is much less common in children.** Initial management does not need a precise diagnosis and it is important not to delay a safe therapeutic intervention as the rhythm often deteriorates into pulseless VT or VF.

Consideration of underlying cause (congenital heart disease & surgery, electrolyte imbalance (K, Mg, Ca), medications and poisoning) and early consultation with a paediatric cardiologist is recommended.

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IV Lignocaine: This stabilises the irritable ventricle and reduces recurrence of VT after cardioversion. Give 0.5-1.0mg/kg initial bolus followed by infusion of 10-50mg/kg/min.

DC cardioversion: Generally given if haemodynamically unstable but may be treatment of choice in drug toxicity. Conscious patients should have intravenous sedation/anaesthesia prior to DC cardioversion. Give synchronous DC shock at 1 J/kg. For a second shock use 2J/kg. * Use non-synchronous shocks if the defibrillator cannot 'track' complexes.

Note: The only VT unlikely to respond to Amiodarone is fascicular ("verapamil sensitive") VT. This is has a characteristic pattern of RBBB with superior axis. Infusion of verapamil over 20 minutes is required after consultation with paediatric cardiology.

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