Drugs for the paediatric heart

A scenario-based guide to practice.

John Lawrenson, MB BCh, MMed, FCP (SA)
Head, Paediatric Cardiology Service of the Western Cape, Department of Paediatrics and Child Health, Stellenbosch University
John Lawrenson is a reformed adult cardiologist who spends his days looking after children with heart disease in the Western Cape at Tygerberg and Red Cross Children's hospitals. His interests include echocardiography and the life-time management of patients with complex heart disease.

Harold Pribut, MB ChB, DA, FCPPaeds (SA)
Paediatric cardiologist, Private practice, Christian Barnard Hospital, Cape Town
Harold Pribut is a paediatric cardiologist in private practice who taught the first author most of what he knows. His interests also include the care of complex patients and echocardiography. He also wants to become the world's first 60-year-old professional cyclist.

Liesl Zühlke, MB ChB, DCH, FCPPaeds (SA), Cert Cardiology (Paeds), MPH(Clinical Research)
Paediatric cardiologist, Red Cross War Memorial Children's Hospital, University of Cape Town
Liesl Zühlke is a paediatric cardiologist and researcher who is well on the way to becoming a world expert on rheumatic heart disease. The first two authors claim to have been her teachers but they are wrong as their influence on her career has been minimal.

Correspondence to: John Lawrenson (jlawrens@pgwc.gov.za)

Prescribing cardiac drugs in children differs in a number of ways from adult practice. In general terms cardiac drugs used in children are used by extension from adult practice without most of the drugs being tested in children ('off label'). In addition, the aetiology of heart disease in children differs from adults. For example, heart failure in children is due to idiopathic muscle disease but heart failure in adults is more often secondary to hypertension or due to ischaemic heart disease. Moreover, the prescription of cardiac drugs for a child will often be initiated by a specialist cardiologist rather than a generalist.

In neonates, thiazide drugs are used because of concern over excessive calcium loss and the potential to create calcium stones in the kidney.

The following scenarios are intended to illustrate some of the uses for cardiac medication in children as well as practical issues involved in that use.

Scenario A

A 4-year-old child has been diagnosed as having a cardiomyopathy following an earlier episode of viral myocarditis. You are working as a community service medical officer in a regional hospital and are asked to repeat a prescription for the patient's medication after the mother loses the medication when her shack is flooded. On the prescription chart you note that the patient is receiving spironolactone, furosemide and captopril. The following questions occur to you:

- Are diuretics used in the child in the same way as in adults?
- Why is this patient not receiving digoxin?
- Your adult patients with 'stable' cardiac failure are taking a beta blocker – are these drugs used in children?
- The pharmacy only has enalapril available – can you substitute this drug for the captopril?

Let's consider the diuretics first: loop diuretics are effective preload reducers and relieve the symptoms such as upper abdominal pain due to liver congestion. In neonates, thiazide drugs are used instead because of concern over excessive calcium loss and the potential to create calcium stones in the kidney. The spironolactone is used for two reasons – firstly, the supplementation of potassium in children is tricky because potassium chloride in unpalatable and not available in commercial pharmacies and, secondly, as an extrapolation of the data in adults showing that spironolactone is able to cause limitation of fibrosis at a tissue level in patients with heart failure. In adults, this resulted in a survival benefit for patients.

The treatment of cardiac failure in children is largely based on adoption of adult practice. This is probably appropriate in patients with 'heart muscle failure'. It is unclear whether heart failure due to other causes such as a large left-to-right shunt present before surgery will respond to standard antifailure drugs.

Digoxin is a medicine with a great potential for toxicity but a surprisingly persistent reputation for efficacy that has not been borne out by randomised controlled trials in adults or children.

Despite the need to give the medication three times a day, captopril is probably the easiest angiotensin-converting enzyme inhibitor to use because of the ability to easily break standard tablets into smaller doses (without the benefit of a calculator). Without a dispensing pharmacist it is relatively difficult to create smaller doses of drugs such as lisinopril or enalapril for use in smaller children.

Although drug trials are rare in children with many types of cardiac disease, the only placebo-controlled randomised trial of beta blockers in children with heart failure failed to show any advantage to those in heart failure receiving active drug. There are limited data available on other drugs such as angiotensin receptor blockers or natriuretic peptides and these drugs are generally not used in children.

The treatment of cardiac failure in children is largely based on adoption of adult practice; this is probably appropriate in patients with 'heart muscle failure'.

Captopril: start with 1 mg/kg/day in three divided doses 8-hourly and increase to 3 mg/kg/day in 3 divided doses (1 mg/kg/dose 8-hourly) over 2 - 3 days. Captopril should not be used in neonates or infants unless its use is initiated by a cardiologist in a hospital setting.

Enalapril: initiation of therapy can be tricky – the initial dose is 0.08 mg/kg daily, maximum dose 0.5 mg/kg/day.

Furosemide: 1 mg/kg per dose usually given twice daily.

Spironolactone: 0.5 - 1.5 mg/kg/day given twice daily.

Scenario B

A 6-year-old child with previous rheumatic fever who subsequently developed mild mitral regurgitation consults a GP complaining of pain in the jaw. The GP refers him to a local dentist for a dental extraction of a carious molar. The GP prescribes clindamycin for the patient to take with her to the dentist, with the instruction to take the capsules all together 30 minutes before she expects to see the dentist. The mother asks the GP the following questions:

- Is the dental prophylaxis really necessary?
- Does the patient need to return for her monthly prophylactic pencillin injection that month seeing as she will be taking such a large dose of antibiotic all at once?

The prescription of prophylactic antibiotics in patients with cardiac lesions has become a vexed and vexing issue in recent years. Two separate policies emanating from different sides of the Atlantic offer contrasting advice. The authors of the British guidelines state that antibiotic prophylaxis is no longer necessary at all and that good dental hygiene and regular dental visits are all that can be justified scientifically in patients with heart lesions. The American guidelines have drastically pruned the indications for prophylaxis – antibiotics are no longer suggested in patients undergoing urogenital surgery, for example. Dental work is still an indication. In South Africa, because of a high prevalence of poor dental hygiene and a large load of patients with valvular heart disease, practitioners are advised to follow the American guidelines.

The best form of prophylaxis against rheumatic fever is monthly intramuscular benzathine penicillin – the length of prophylaxis is debated but is related to the extent of valvular disease. This patient should be receiving intramuscular injection monthly until 10 years after her last episode of acute rheumatic fever or until 21 years of age – whichever period is longer. Clindamycin is prescribed in this patient for her dental work as she is already receiving penicillin. Patients with other forms of cardiac disease will usually receive amoxicillin prior to dental work.

Amoxycillin: 50 mg/kg as a single dose up to a maximum of 2 g taken half an hour before dental work.

Clindamycin: 15 mg/kg up to a maximum of 600 mg.

Benzathine penicillin G: 1.2 million units IM monthly if the patient weighs more than 20 kg; if less than 20 kg use 600 000 units.

Scenario C

A 2-year-old critically ill child is admitted to the emergency unit of a hospital with a diagnosis of probable meningococcal septicaemia. Aggressive treatment including the administration of intravenous fluids and intravenous antibiotics is initiated. Despite this the patient is still hypotensive and it is felt that an inotropic agent is necessary. The medical officer in charge has to consider the following issues:

- What dose of adrenaline would I use if the patient needed cardiopulmonary resuscitation?
- Which agent is the most appropriate to use in the emergency unit in a secondary level hospital?

The prescription of prophylactic antibiotics in patients with cardiac lesions has become a vexed and vexing issue in recent years.

Adrenaline (epinephrine) is the standard inotropic agent used during cardiopulmonary resuscitation. The drug is best given intravenously as a bolus injection. If venous access is not obtainable, the drug can be administered via an intraosseous line. In anaphylactic shock, adrenaline can be administered intramuscularly.

In profound shock, the patient should receive an infusion of adrenaline. Adrenaline is a powerful agent with different effects depending on dosage. At higher doses it is both a powerful inotrope and vasoconstrictor. A better alternative in patients who are not in extremis is dobutamine. This inotropic agent which has strong inotropic effects but causes little vasoconstriction can be given via a peripheral line. Its cheaper relative, dopamine, can also be used. This agent should preferably not be given via a peripheral line as it can cause tissue necrosis if extravasation occurs. Continued use of inotropic agents must preferably occur in the setting of an intensive care unit.

Adrenaline during cardiac arrest: Dilute an ampoule 1 mg (1ml) in 9 ml of saline (1:10 000), giving you a 1 ml=100 µg solution. Administer 0.1 mg/kg (10 µg/kg) of the resultant solution as an intravenous bolus.

Adrenaline during anaphylaxis: Dilute an ampoule 1mg (1 ml) in 9 ml of saline (1:10 000), giving you a 1 ml=100 µg solution. Administer 0.1 mg/kg (10 µg/kg) of the resultant solution by intramuscular injection. If the patient appears to be in danger of imminent arrest, this dose can be repeated at 5-minute intervals.

Adrenaline as an inotropic agent: Adrenaline 0.15 mg/kg in 50 ml 5% dextrose gives a solution of 1 ml/h equivalent to 0.05 µg/kg/min. All syringes must be labelled clearly. Dose in children is 0.05 - 0.5 µg/kg/min.

Dobutamine: 6 mg /kg in 50 ml 5% dextrose gives a solution of 1 ml/h equivalent to 2 µg/kg/min. All syringes must be labelled clearly. Dose in children is 5 - 8 µg/kg/min.

Dopamine: 6 mg /kg in 50 ml 5% dextrose gives a solution of 1 ml/h equivalent to 2 µg/kg/min. All syringes must be labelled clearly. Dose in children is 5 - 10 µg/kg/min.

Prescription of drugs for children is always risky and frequent errors may occur, particularly during resuscitation. Dosages of resuscitation drugs are best displayed on clear simple notices in the resuscitation areas. Inotrope infusions should be calculated using easily available, simple instructions. Such standardised instructions should be easily accessible in a resuscitation area or ICU. It is good practice to label every syringe with the name of the drug and the dosage, clearly showing the flow rate in mg/ml.

Scenario D

A paediatrician working in a small town is called to the nursery to see a 2-day-old neonate who has become cyanosed. After excluding respiratory distress, the paediatrician is concerned that the patient may have congenital heart disease and decides to refer the patient to a larger centre. She is particularly concerned that the patient has a duct-dependent cardiac lesion.

- What drug will she use to keep the duct patent?
- What other non-pharmacological measures must she undertake to ensure that the patient arrives at the referral centre in a stable condition?

Prescription of drugs for children is always risky and frequent errors may occur, particularly during resuscitation.

Transporting an ill newborn patient should occur as rapidly as possible. The patient must be placed into a warmed incubator, intravenous access should be established and an infusion of glucose-containing fluids started. A medically qualified person should accompany the patient if possible.

All cyanosed children must be suspected of having a duct-dependent lesion and prostaglandin therapy must be commenced. In South Africa in regional and secondary level hospitals only oral prostaglandins (Prostin[R]) are available. These agents are registered for cervical ripening and are used off-label. Despite little published evidence, paediatric cardiologists have amassed a large collective experience of using these drugs. In other parts of the world intravenous prostaglandin is used. The major side-effect of the intravenous prostaglandin is apnoea and infants require prophylactic endotracheal intubation. If the child does not have a duct-dependent lesion, the other pharmacological effects of the drug such as pulmonary vasodilation are not likely to influence the clinical course of the patient prior to a definitive cardiac diagnosis being established.

Oral prostaglandin E2 (Dinoprostone): 25 µg/kg orally half-hourly (for the average newborn child this is a quarter tablet half-hourly).

Alprostadil: IV prostaglandin – used as an intravenous infusion: 60 µg/kg in 50 ml 5% dextrose at 0.5 – 3 ml/h equivalent to 10 - 60 ng/kg/min.

Scenario E

A 10-year-old boy arrives at a referral hospital complaining that his heart is beating so fast it feels as if it wants to jump out of his chest. He has a history of occasional palpitations and this episode occurred after his uncle gave him caffeine-containing 'energy drink'. His heart rate is 200 per minute; he is sweating but not shocked. An ECG is recorded showing a narrow complex tachycardia. Vagal manoeuvres (carotid massage and immersion of the face in cold water) are not effective. The nursing sister hands the doctor a box containing intravenous verapamil ampoules – he politely takes the box but breaks the ampoules and throws them away.

- What has caused this medical professional's apparently irrational behaviour?
- Which drug therapy should he use?

Verapamil has been used for years as an emergency drug for the treatment of tachyarrhythmias in adults. Calcium channel blockers are hardly ever used in children; verapamil in particular is considered to be extremely dangerous in children and fatalities have been reported because of profound hypotension. (It is also known as 'verapakill'.)

Adenosine is a far more effective drug for the treatment of narrow complex tachyarrhythmias in both children and adults. The drug works by causing brief atrioventricular nodal block and interrupting the re-entry pathway. Its duration of action is seconds and the drug can be used in all children, although neonates may require higher doses than older children. The drug must be used in an area where resuscitation equipment is available – rare side-effects include apnoea and the rapid conduction of atrial fibrillation to the ventricle. In addition, the transient atrioventricular node block induced by the drug will help the expert diagnose the mechanism of the arrhythmia even if cardioversion does not occur. (It is always appropriate to record a rhythm strip on an ECG machine or monitor when administering adenosine. If no hard copy is available, freeze the tracing on the monitor, and take a picture of it with your cell phone!).

Adenosine is a far more effective drug for the treatment of narrow complex tachyarrhythmias in both children and adults.

Other antiarrhythmic drugs such as amiodarone should seldom be used in children outside of a tertiary care setting as there is limited literature available to guide their use.

Recurrent episodes of supraventricular tachycardia can be prevented with the use of beta blockers.

Radiofrequency ablation of accessory pathways is the curative therapy in cases of recurrence.

Adenosine: 0.1 mg/kg by rapid IV bolus followed in rapid succession by a 2 - 5 ml normal saline flush (preferably administered through a 3-way tap). This can be increased incrementally by 0.1 mg/kg every 2 minutes to a maximum of 0.5 mg/kg. The cannula should be inserted in as proximal a vein as possible.

Scenario F

A 17-month-old child is seen by a GP on a number of occasions during a week-long illness characterised by a high swinging fever, chelitis, irritability, a fleeting skin rash and cervical adenopathy. She is concerned and refers the patient to a regional hospital where there is a specialist paediatrician. A month later she sees the patient in follow-up and notes from the hospital discharge summary that the patient has been diagnosed as having Kawasaki disease and has been prescribed daily aspirin. The doctor is puzzled:

- When working as a locum senior house officer in an English hospital she was admonished by a registrar for prescribing aspirin in an older child and told never to give aspirin to children; why is this child receiving aspirin?
- Why has the child's mother been told not to go for the 18-month immunisation at the local clinic?

Kawasaki disease (mucocutaneous lymph node syndrome) is a febrile illness which is associated with a systemic vasculitis involving medium-sized vessels. Coronary vasculitis can occur. Kawasaki disease occurs in patients from all communities in South Africa and the diagnosis is easy to miss. Aspirin is no longer used for relief of fever in general in children since its use is associated with rare cares of fulminant hepatic failure in children with varicella or influenza infections (Reye syndrome). In children with coronary involvement (aneurysms and stenoses) after Kawasaki disease, however, aspirin is prescribed for its antiplatelet effect to prevent coronary thrombosis. Subsequent immunisation of children with Kawasaki disease against influenza, varicella and measles may be tricky since high-dose immunoglobulin is administered during the acute phase of the illness to prevent the development of coronary aneurysms. Antibodies present in the immunoglobulin preparation may neutralise an immune response to immunisations for periods in excess of 6 months.

Aspirin: 3 - 5 mg/kg per day as a single daily dose.

General comments

The above situations have been cited to remind the generalist about the essential aspects of prescribing cardiac medication in children. Simple extrapolation of adult practice to children is unfortunately not possible and the practitioner is advised to exercise caution and never treat cardiac disease in children in haste.

Further reading available at www.cmej.org.za

In a nutshell

- Clinical situations such as cardiac failure are not necessarily equivalent in adult and paediatric practice.
- A good practitioner will always try to follow evidence-based guidelines when prescribing medications. Where this evidence is missing or incomplete, the practitioner must be cautious.
- Drug dosages must always be checked when prescribing medication in children. This is even true when the doctor prescribes the drug regularly. When minute doses of drugs are being used (applicable to adrenaline in particular), the syringe should be labelled with both the name of the drug and the concentration of drug per millilitre.
- Cardiac disease in children is a significantly less frequent occurrence than in adults. The generalist should not hesitate to seek expert advice when managing these conditions. In this situation, it should be noted that a paediatric cardiologist and paediatrician represent better resources than an 'adult' cardiologist.

Single suture

Mind control key to improving Parkinson's symptoms

How well can you control your thoughts? Mind-control training could improve symptoms of Parkinson's disease.

Deep brain stimulation, which involves implanting electrodes in the brain, helps to alleviate problems with movement experienced by people with Parkinson's disease.

'If putting in an electrode works, we thought training brains to self-regulate might work as well,' says David Linden at Cardiff University, UK.

To find out, Linden's team asked 10 people with Parkinson's to think about moving while having their brains scanned by fMRI for 45 minutes. Five were given real-time neurofeedback showing how well they activated a brain region that controls movement. Each participant was then told to practise such thoughts at home.

Two months later, movement problems including rigidity and tremor had improved by 37% in the group that received feedback compared with no change in the rest. 'Sending signals to brain areas normally deprived of input could be reshaping neural networks,' says Linden.

Roger Barker, a neuroscientist at the University of Cambridge, points out that the treatment would not work for everyone with Parkinson's disease. 'If the person has a bad tremor then it would be difficult to get an image, while others don't like being inside the scanners,' he says.

But he agrees that the technique could be a useful option for some, especially young people with the condition. 'Young people don't like taking medications [for Parkinson's] because they can have side-effects in the long term' such as uncontrolled movements and behaviour changes, he says. 'It's great to focus on non-pharmacological approaches.'

New Scientist, 8 November 2011.