and Z Bozoky, personal communication, 1999). The task now is to establish the cost-benefit of vaccine introduction for the UK to convince the health care professionals and the vaccine policy makers.

MARY RAMSAY

Consultant Epidemiologist,
PHLS Communicable Disease Surveillance Centre,
61 Colindale Avenue, London NW9 5EQ, UK

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Catheter ablation in paediatric arrhythmias

The introduction of catheter ablation in the early 1990s was a major step forward in the management of arrhythmias. Before that most children were controlled with long term drug treatment, while a few underwent open heart surgery. Radiofrequency ablation now offers a non-surgical cure and has rapidly been adopted for the treatment of a wide variety of tachycardias. It has also redefined theories about the substrates and mechanisms of several tachycardias (so called “learning while burning”).

What is radiofrequency ablation?

Catheter ablation is usually performed in conjunction with an invasive diagnostic electrophysiology study, which will identify the critical site in the tachycardia circuit or the origin of abnormal impulse formation. Radiofrequency ablation involves delivery of a high frequency (500 kHz), low energy electric current to the critical area via an intracardiac catheter. The current induces a rise in tissue temperature at the point of contact with the heart and is similar, in a way, to low energy diathermy although the energy, frequency, and waveform are different. If the burn is precisely targeted it will produce a localised lesion to destroy the arrhythmia substrate. Energy delivery can be precisely controlled with catheter tip temperature feedback.

Diagnosis and natural history of tachycardia

The key to management of all tachycardias is a precise diagnosis. “Supraventricular tachycardia” is an inadequate term for a group of up to 12 different tachycardia mechanisms. Knowledge of the age of onset and analysis of 12 lead electrocardiograms recorded in tachycardia and in sinus rhythm will lead to a precise diagnosis in most cases. Knowing the diagnosis, one can define the natural history and plan treatment.

Most tachycardias in infancy are due to atrioventricular re-entry via an accessory pathway. In some the pathway functions anterogradely in sinus rhythm producing ventricular pre-excitation (Wolff-Parkinson-White syndrome) whereas in most the pathway conducts in a retrograde direction only and is known as “concealed”. Most infants with atrioventricular re-entry tachycardia will have no further problems beyond the age of 6 or 12 months but in some the problem will persist or recur. Antiarrhythmic drug treatment is usually given for several months and then withdrawn. Those with persistent or recurrent tachycardia are managed as discussed below. Other tachycardias encountered in infancy include atrial ectopic tachycardia and atrial flutter, both of which will usually resolve, and permanent junctional reciprocating tachycardia and His bundle tachycardia, both of which are persistent.¹

In school aged children the most common cause of “supraventricular tachycardia” is also atrioventricular re-entry via an accessory pathway. However, in this age group the problem will usually persist, so a long treatment strategy is required. In later childhood, atrioventricular nodal re-entry tachycardia is also seen relatively commonly and becomes the main differential diagnosis.² Other arrhythmias such as atrial ectopic tachycardia, permanent junctional reciprocating tachycardia, and atrial flutter may also be encountered during school age.¹ They are less common but require precise diagnosis from the ECG. All of these are likely to persist.

Ventricular tachycardias are less common in paediatric practice but may be encountered in infancy or childhood. Accurate diagnosis is required to define the natural history. Some types of ventricular tachycardia in infancy may resolve after drug treatment and a few of those encountered in childhood may be suitable for radiofrequency ablation.^{3,4}

Choice of treatment

Most tachycardias in childhood are not life threatening, and decisions about treatment are therefore based on symptoms, taking into account the frequency, duration, and severity of attacks. One should also take account of the anxiety induced in children and their families, and the disruption caused by children being sent home from school or not being allowed to take part in school activities. The main treatment options are long term drug control and radiofrequency ablation. The choice is made by balancing the risks, inconvenience, cost, and benefit of each option. Although the introduction of each antiarrhythmic drug into paediatric practice has been accompanied by enthusiastic reports of efficacy, experience highlights the limitations including failure to control tachycardia, side effects, inconvenience, and potential for production of new arrhythmias. The most common indication for radiofrequency catheter ablation is patient choice, although failure of medical treatment is also a frequent factor.⁵⁻⁷

Garson and Kanter recently provided a cost effectiveness model for management of tachycardia.⁸ They compared the cost, morbidity, mortality, and efficacy of drug treatment, surgery, and radiofrequency ablation for a 5 year old child with symptomatic tachycardia associated with Wolff-Parkinson-White syndrome. They concluded that catheter ablation has a lower cost, mortality, and morbidity than either medical management or surgery and is the treatment of choice. They also concluded that several years of drug treatment before later radiofrequency ablation was a less desirable treatment plan. Their analysis and conclusions can be extrapolated to other forms of persistent tachycardia in childhood.

Technique of catheter ablation

The aim of catheter ablation of tachycardia in a patient with an accessory pathway is to destroy the accessory connection, thereby removing the arrhythmia substrate.⁹ Right sided and "septal" pathways are approached transvenously. Access to left sided pathways is usually gained transeptally (via a foramen ovale or transeptal puncture) but may also be retrograde via the femoral artery. In children with atrioventricular nodal reentry tachycardia (perhaps better regarded as atrio-nodal reentry) the arrhythmia circuit involves both the atrioventricular node and the adjacent atrium; anterior ("fast") fibres and posterior ("slow") fibres. The aim is to modify the tachycardia circuit by destroying part of the circuit yet leaving normal antero-grade function of the node.² The radiofrequency lesion is usually placed in the posterior atrio-nodal fibres with careful monitoring of atrioventricular conduction and of the response to the burn.² Most other arrhythmias involve reentry circuits and catheter ablation targets the critical point in the circuit.¹ A few originate from ectopic or automatic foci and the aim of ablation is to destroy the point source of such tachycardias.¹

Results of catheter ablation of common tachycardias

As is the case with most newly introduced techniques, there was a learning curve in the early days of radiofrequency ablation, as shown by reports from single institutions or multicentre registries.¹⁰⁻¹¹ The Pediatric Electrophysiology Society maintains the largest register and reports the greatest experience.⁵ Contributors include large centres with great experience and smaller centres with less experience. The immediate success rates for accessory pathway ablation are around 85-90% and for atrioventricular nodal re-entry tachycardia 96%. Catheter ablation may appear successful at the time when the accessory pathway has been "stunned" rather than destroyed so tachycardia may recur

later. The registry reports about 75% freedom from recurrence at three years. Other large series report similar results.⁹⁻¹²⁻¹⁴ Experience in the United Kingdom is probably similar although there is considerable variation in institutional experience and no national registry or centralised data collection.

Catheter ablation of other arrhythmias

Most experience so far has been with catheter ablation of common arrhythmias, particularly accessory pathway tachycardias and atrioventricular nodal re-entry tachycardia. Some less common arrhythmias such as permanent junctional reciprocating tachycardia and atrial ectopic tachycardia are also particularly amenable to ablation with high success rates and rare complications.¹³ Some rare types of ventricular tachycardia are also effectively treated by catheter ablation.³⁻⁴⁻¹⁵⁻¹⁶ The remaining challenge is in the management of atrial and ventricular arrhythmias late after repair of structural heart disease.¹⁷ Those most commonly encountered are various types of atrial tachycardia or atrial flutter after atrial repair of transposition of the great arteries (Senning or Mustard operations) and atrio-pulmonary bypass for complex malformations with functionally one ventricle (Fontan operation and variants). Atrial tachycardias in such patients are particularly difficult to control with drugs and are probably associated with an increased risk of sudden death. Experience with catheter ablation of typical atrial flutter in structurally normal hearts led to enthusiasm that the procedure would also be effective in repaired congenital heart disease. The complexity of mapping has been greater than anticipated and results overall so far have been disappointing. This is partly due to the physical difficulty of mapping in such patients and partly due to the presence of more than one tachycardia circuit. It is to be hoped that the use of newly introduced computerised mapping techniques may lead to an advance in catheter ablation of such arrhythmias.

Complications of radiofrequency ablation

Significant complications of catheter ablation are rare. The main concern is overproduction of atrioventricular block by ablation of septal pathways close to the atrioventricular node or by radiofrequency modification of atrioventricular nodal re-entry tachycardia. The overall risk of atrioventricular block is quite low and is reported as around 1-5% in modification of AV nodal tachycardia.⁵⁻¹²⁻¹⁸ Damage to the mitral or aortic valves is rare.⁵⁻¹² The risk is probably higher with a retrograde (transarterial) approach to left sided pathways than with an antero-grade (transeptal) approach. Patients are usually anticoagulated during the procedure so embolic problems are rare. Death from catheter ablation is rare. Four deaths were reported in over 4000 children by the Pediatric Electrophysiology Society.⁵ Two deaths occurred after catheter ablation in infancy and two in children, one related to late ventricular perforation and one to early thrombotic occlusion of the origin of the left main coronary artery.

Long term implications

Most catheter ablation procedures are performed at the atrioventricular junction, which also contains the major epicardial coronary arteries. Early coronary artery damage is rare but long term follow up will be required before we can be confident that late coronary artery lesions are not produced, bringing their own problems.⁹⁻¹³⁻¹⁹ Other concerns include the long term effects of multiple applications of radiofrequency energy on myocardium or on atrioventricular valve function.⁹⁻¹⁵

Recommendations

There are few if any indications for catheter ablation in infancy because most tachycardias can be controlled and many will resolve spontaneously.⁶

Taking into account the risks, disadvantages, and benefits of treatments on offer, catheter ablation is probably the treatment of choice for symptomatic tachycardias associated with accessory pathways and for atrioventricular nodal re-entry tachycardia in school age. Less common arrhythmias such as permanent junctional reciprocating tachycardia and atrial ectopic tachycardia need precise identification because they are also very suitable for catheter ablation. Catheter ablation is an option for some children with ventricular tachycardia after expert evaluation, and it is to be hoped that it will eventually have a significant role in the management of late postoperative atrial and ventricular arrhythmias.

CHRISTOPHER WREN

Consultant Paediatric Cardiologist,
Freeman Hospital, Newcastle upon Tyne NE7 7DN, UK

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Role of clinical ethics committees

Most clinicians encounter ethical dilemmas, the resolution of which produces tensions within the multidisciplinary teams that deliver much contemporary health care.¹ Despite the growth of medical ethics and publication of professional codes of practice^{2,3} there is no clear consensus on how individuals, teams, and hospitals might obtain specific guidance in resolving the dilemmas they face. Indeed, current methods of resolving dilemmas may be ad hoc, unstructured, and subject to time constraints.⁴

In North America health care ethics committees (HEC) have been established whose remit includes ethical debate and analysis of individual cases and topics, policy development, and education.⁵ Although 60% of US paediatric units have HECs, their role has been criticised and up to 33% may be inactive.⁶ UK experience with HECs is limited but interest is growing⁷ and a specific need has been identified in teaching and district general hospitals.^{4,7,8} In 1996 a clinical ethics forum (CEF) was established at Great Ormond Street Hospital NHS Trust in London in response to staff requests for a group having the following functions:

- Confidential, multidisciplinary analysis and discussion of cases and topics away from the acute clinical setting
- Informed contribution to the generation of guidelines for good ethical practice
- Education of health care professionals in health care ethics.

What follows is a brief critical account of the establishment, composition, and function of the CEF, which might be useful to others contemplating forming similar groups.

Establishment, composition, management, and accountability

The title "forum" was used to avoid the bureaucratic connotations of "committee", and to emphasise the intention

to provide a facility for considered, informed, and reflective discussion.⁹ The forum's confidential, advisory, supportive, and non-prescriptive role safeguards clinical autonomy, protects the doctor-patient relationship, and facilitates participation and free discussion. Consultation is optional and there is no obligation to follow recommendations, although evidence suggests that those who seek advice would be likely to take it.¹⁰ Although accountable to the Trust Board, the forum's independence is important for its integrity and in gaining confidence of clinicians. Administrative support is essential for proper record keeping and has been provided from the research and development office at the Institute of Child Health.

The ideal size and composition of HECs depends on their intended functions. Prospective case review is best accomplished by small groups,¹¹ but for more complex issues a larger membership is desirable,⁵ although group dynamics may be more problematic.¹² The forum's membership includes physicians, surgeons, nursing staff, a social worker, and a chaplain, with 30% lay membership. The last's contribution is especially valuable because of differing perspectives and experience; lack of detailed scientific knowledge has not proved a barrier, rather it has emphasised the need for effective communication skills to presenting clinicians. Both chairman and vice chairman are elected by members; one of these officers is a lay member. No formal qualifications are required but 20% of serving members have formal training in moral analysis and two have postgraduate qualifications in ethics and law. No difficulties have been encountered in recruiting and retaining lay members but turnover of medical staff has been high, largely because of competing clinical or other commitments.

Some Trusts have developed HECs as part of a clinical ethics service⁷ and have employed clinical ethicists, usually