Digital implantable loop recorders in the investigation of syncope in children: Benefits and limitations

Darshan S. Kothari, DNB, DCH, FCPS,* Fiona Riddell, NZCS, COP(SCT),† Warren Smith, MB, FRACP,‡ Jamie Voss, MBBS,* Jon R. Skinner, MBChB, FRCPCH, FRACP, MD*

*From *Greenlane Pediatric & Congenital Cardiac Services, Starship Children, Auckland, New Zealand, †Cardiac Physiology, Auckland City Hospital, Auckland, New Zealand, ‡Cardiology, Auckland City Hospital, Auckland, New Zealand.*

BACKGROUND Conventional diagnostic methods for detecting arrhythmogenic causes of syncope in children are poor. Digital implantable loop recorders are of proven value in adults.

OBJECTIVES The purpose of this study was to evaluate digital implantable loop recorders in the investigation of syncope in children.

METHODS We reviewed the clinical and technical records of 18 consecutive patients (6 female and 12 male; age ≤16 years) who received an implantable loop recorder from 1999 to 2005.

RESULTS Median age at implantation was 11.3 years (range 4.6–16.5 years). Median duration of the device *in situ* was 18 months (range 5–36 months). Median time to diagnosis was 6 months (range 1 day to 17 months). Two patients had a congenital heart defect. Ten children (56%) had an event, 9 (50%) of whom had diagnostic information; 5 (28%) had profound bradycardia or asystole; 2 (11%) had polymorphic ventricular tachycardia (VT); and 1 child had supraventricular tachycardia. One patient died, but the automatically activated recording was recorded over again after death. One child had sinus rhythm during syncope. One child with polymorphic VT had no auto-activation on two occasions, and the third activation was triggered by asystole after VT terminated. Sixteen patients (89%) had false-positive activations as a result of either artifact or sinus tachycardia.

CONCLUSION The digital implantable loop recorder is a useful diagnostic modality in children with unexplained syncope. However, the automatic detection algorithm is imperfect, missing genuine polymorphic VT and frequently interpreting muscle tremors as VT. Because of continuous overwriting by automatic detection, genuine arrhythmias may be over-recorded by artifact.

KEYWORDS Syncope; Loop recorder; Children; Catecholaminergic polymorphic ventricular tachycardia; Neurocardiogenic syncope; Asystole

(Heart Rhythm 2006;3:1306–1312)

Introduction

The primary role of the pediatric cardiologist in the evaluation of syncope in children is identifying arrhythmogenic causes. The diagnostic dilemma frequently is challenging, and there may be considerable concerns and anxiety among patients and their parents.

Syncope in the pediatric population accounts for 1% to 6% of all hospital admissions and 3% of emergency room visits every year.[1–4] Because syncope can herald a potentially fatal ventricular arrhythmia,[5,6] accurate diagnosis is urgent and imperative.

The most common cause of syncope in young patients is neurocardiogenic. This cause often is diagnosed by a detailed history alone, but differentiation from arrhythmogenic causes based on history alone can be difficult. Symptoms may be mimicked using a head-up tilt table test[7]; however, this test has poor specificity and sensitivity. Twelve-lead ECG is valuable for detecting some cases of long QT syndrome, Brugada syndrome, or Wolff-Parkinson-White syndrome. Other tests, such as ambulatory Holter monitoring, electrophysiologic study, treadmill exercise test, and echocardiography, have low diagnostic yield. Transtelephonic event monitors have increased diagnostic yield when events occur frequently with short intervals between them.

Use of an implantable loop recorder was first reported in 1997.[8–10] The implantable loop recorder allows long-term evaluation of infrequent symptoms when a detailed history and baseline investigations are inconclusive. Implantable loop recorders have been shown in adults to be superior to conventional methods in the diagnosis of recurrent syncope.[11] Implantable loop recorders may be particularly advantageous in children because many children cannot themselves provide a clear history, may have events witnessed only by other children, and may be less patient or compliant with repeated and often inconclusive investigations.

Because data in the pediatric population are limited, we report here our experience with the use of implantable loop recorders in children.

Materials and methods

Eighteen patients (6 female and 12 male; age ≤16 years) with a history of syncope received an implantable loop recorder between 1999 and 2005 at our institution, the New Zealand National Centre for Pediatric and Congenital Heart

Address reprint requests and correspondence: Dr. Jon R Skinner, Starship Children, Greenlane Pediatric & Congenital Cardiac Services, Park Road, Grafton, Auckland, New Zealand. E-mail address: jskinner@adhb.govt.nz. (Received May 21, 2006; accepted July 14, 2006.)

1547-5271/$ -see front matter doi:10.1016/j.hrthm.2006.07.018

Table 1 Clinical characteristics, symptom–rhythm correlation, and conventional tests performed

Patient no.	Age (yr)	Sex	No. of syncopal episodes prior to implantable loop recorder placement	Syncope at rest (R) or with exercise (E)	24-hour Holter	Tilt-table test	Electrophysiologic study	Rhythm	Type of activation
1	16	F	20	R + E	Yes	Yes (Neg)	No	Asystole (18 s)	Automatic
2	12	M	4	R + E	Yes	Yes (Pos)	Yes (Neg)	Polymorphic VT	Manual
3	16	F	5	R + E	Yes	No	No	No event	
4	9	F	1	R + E	Yes	No	Yes (Neg)	No event	
5	11	M	7	E	No	No	No	No event	
6	15	M	8	R + E	Yes	No	No	Death	Automatic
7	4	M	11	R + E	Yes	No	No	No event (CHD + pacemaker)	
8	10	M	21	R + E	Yes	No	No	No event	
9	9	M	6	E	Yes	No	No	Asystole (39.4 s)	Automatic
10	10	M	4	E	Yes	No	No	No event	
11	15	M	4	R + E	No	No	No	Asystole (9.4 s)	Manual + Automatic
12	15	M	7	R	Yes	No	No	No event (borderline long QT interval prior to implantable loop recorder placement)	
13	11	M	9	R + E	Yes	No	No	Asystole (8.5 s)	Automatic
14	9	F	2	R + E	Yes	No	Yes (Neg)	Normal in spite of activation (CHD)	Manual
15	12	F	9	R + E	Yes	Yes (Neg)	No	No event	
16	10	F	5	R + E	Yes	Yes (Neg)	No	Asystole (15 s)	Automatic
17	15	M	2	R + E	Yes	No	No*	Supraventricular tachycardia (HR 165–180 bpm)	Automatic
18	10	M	4	E	Yes	No	Yes (Neg)	Polymorphic VT (auto-activation triggered during subsequent asystole)	Automatic

CHD = congenital heart disease; HR = heart rate; Neg = negative; Pos = positive.
*Electrophysiologic study after implantable loop recorder diagnosis was positive for atrioventricular nodal reentrant tachycardia.

Disease, which serves a population of 4.2 million people. Of these patients, two were surgically operated cases with a primary congenital diagnosis of L-looped transposition of the great arteries. Detailed and thorough clinical and family histories were taken by a consultant arrhythmia specialist in all cases.

Conventional tests done when indicated are as follows: standard 12-lead surface ECGs (n = 18), treadmill exercise test (n = 13), ambulatory 24-hour Holter monitor (n = 16), head-up tilt table test (n = 4), echocardiography (n = 17), and invasive electrophysiologic study (n = 5).

The implantable loop recorder device used was a Medtronic Reveal Plus (Medtronic Inc., Minneapolis, MN; 61 mm long, 19 mm wide, 8 mm thick; weight 17 g). The device was implanted subcutaneously in all patients by a specialist cardiologist or pediatric cardiac surgeon with the patient under local or general anesthesia. Preimplant mapping was performed to optimize the position and orientation of the device. Four ECG electrodes approximately 4 cm apart, forming four corners of a square, were placed at the upper left sternal border. By pairing two of the electrodes sequentially, the orientation giving the largest QRS complex with a small T wave and visible p wave was sought. For most patients, the best orientation was upper left to lower right (approximating to lead III on the surface ECG). All implantable loop recorders were programmed for manual and automatic activation. Programming options for automatic activation are quite limited, as follows: bradycardia detection <30 or <40 bpm, asystolic pause >3 or >4.5 seconds, and tachycardia either "off" or a cut-off rate of >115, >125, >145, >165, >180, >210 or >230 bpm. The number of consecutive beats to trigger activation can be 16 or 32. We generally started with limits at <40 bpm, pause >3 seconds, and heart rate >180 bpm in those younger than 14 years (given the high sinus rates common in children) and >165 bpm in older teenagers, and 16 beats to trigger.