



Ambulatory ECG Monitoring:

The Past and The Future

PediRhythm VII, February 2017

A bit of history

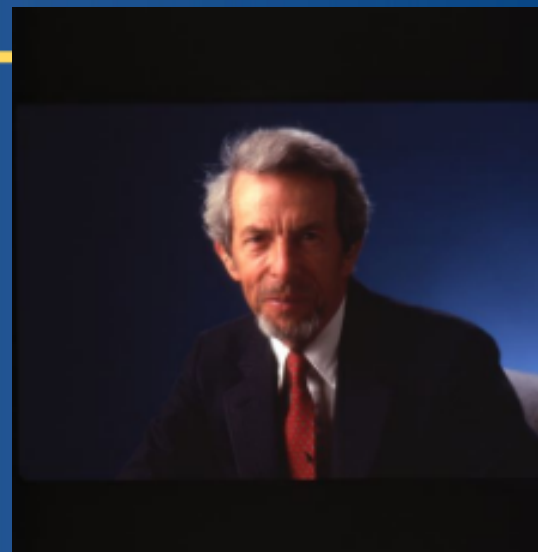


Norman "Jeff" Holter (1914-1983)

1st recording of radioelectrocardiogram (RECG) 1947. Original weight ~40 kg



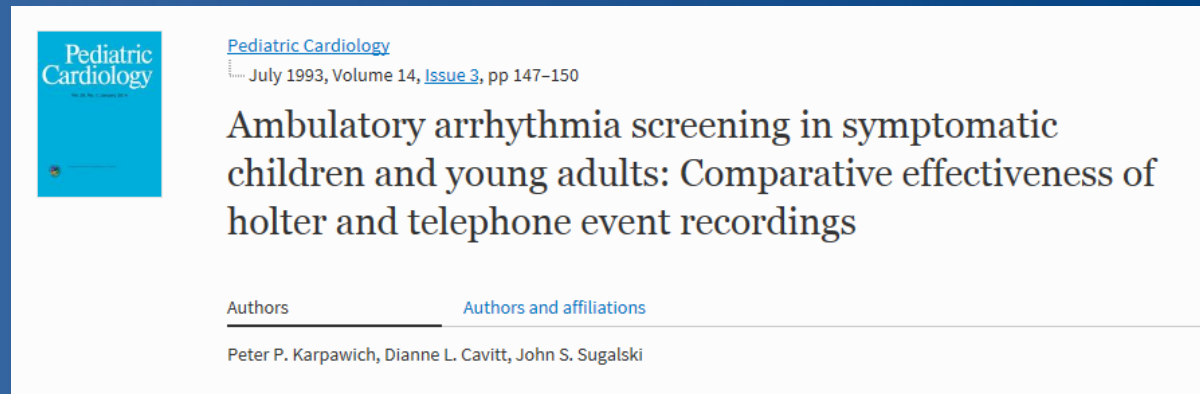
Holter monitor circa 1976



Bruce Del Mar,
Partner of Holter,
developed commercial
product

Next Generation: Event Recorders

- In late 1980s, longer term ambulatory “event recorders” were developed



- Karpawich et al showed event recorders had better correlation of symptomatic events with arrhythmias, Holters better at asymptomatic events
 - No autotriggering on event recorders

Transtelephonic Electrocardiographic Monitors for Evaluation of Children and Adolescents With Suspected Arrhythmias



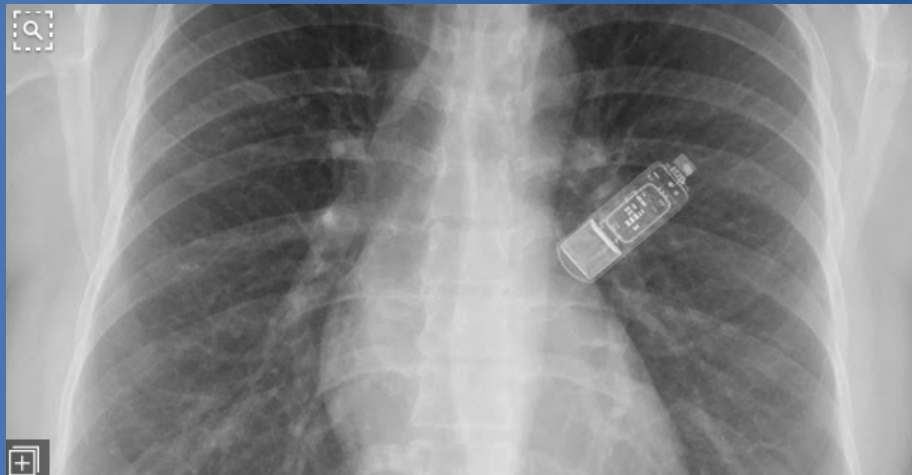
Elizabeth Vickers Saarel, MD; Christopher B. Stefanelli, MD; Peter S. Fischbach, MD;
Gerald A. Serwer, MD; Amnon Rosenthal, MD; and Macdonald Dick II, MD

Pediatrics 2004;113:248–251;

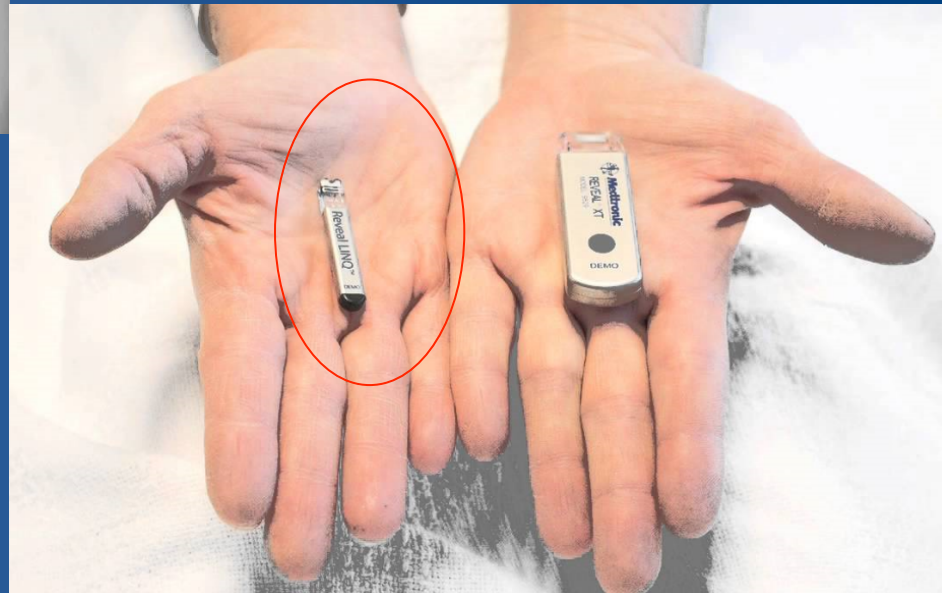
- 495 monitors used, 1-100 days duration
- ½ of children recorded nothing, ½ were symptomatic
 - Of symptomatic pts, 15% had SVT
 - Patients with chest discomfort, presyncope &/or syncope had no arrhythmias
- Most recordings are reassuring of no arrhythmia, and a small percentage uncover an arrhythmia

The New Century: Implantable loop recorders

1st generation



2nd generation



New commercial products: bypass medical professionals?

Two types:

- Recording of ECG rhythm
 - Patients can purchase “app”, own the product. Requires attachment to phone
 - Patient has immediate feedback, can store recording as PDF and send to physician
 - Downside: cost
- Using camera to detect pulsations
 - Cheaper, no extra equipment, no ECG

SmartPhone Applications: How well do they work?



The Journal of Pediatrics

Volume 164, Issue 5, May 2014, Pages 1133–1135



32051||

Original Article

Tachycardia Detection Using Smartphone Applications in Pediatric Patients

Philip Wackel, MD¹, Lee Beerman, MD¹, Laura West, BS², Gaurav Arora, MD¹  

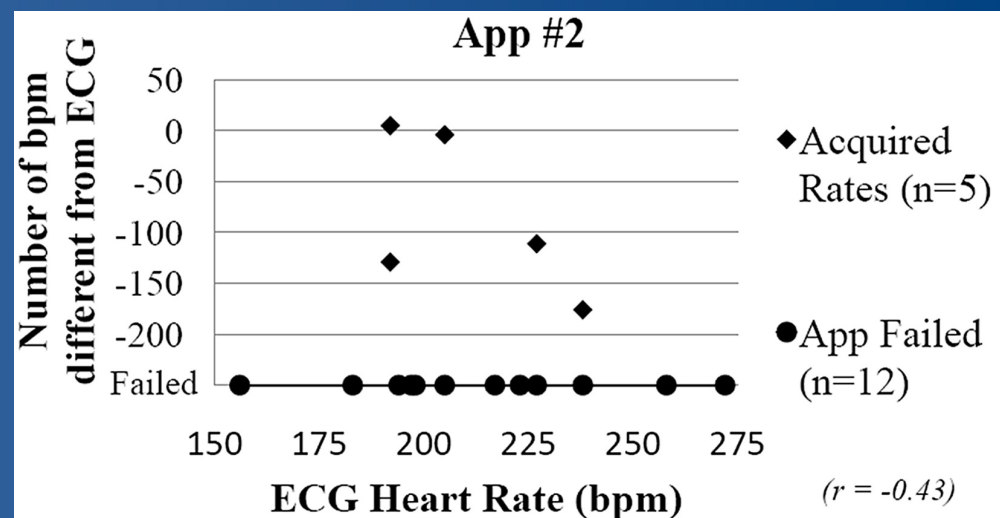
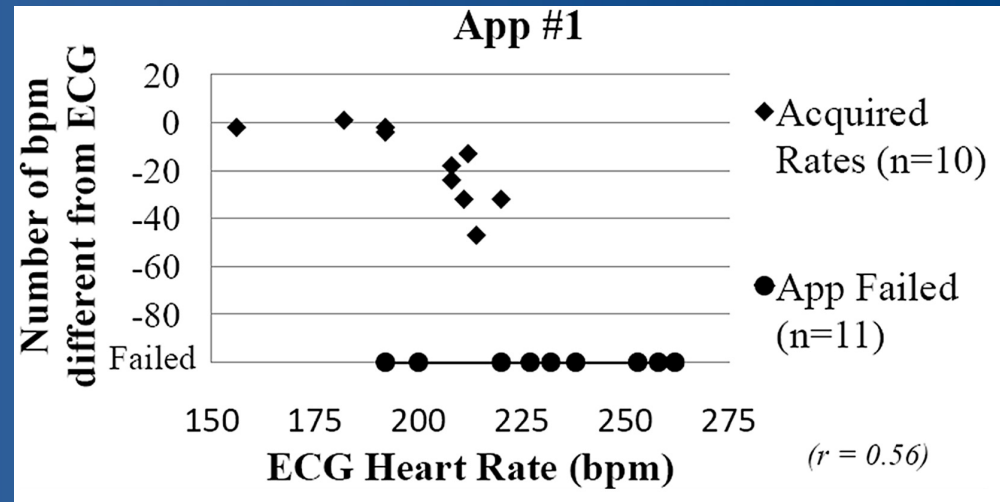
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<http://dx.doi.org/10.1016/j.jpeds.2014.01.047>

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Failure rate high for tachycardia detection in pulse-driven apps

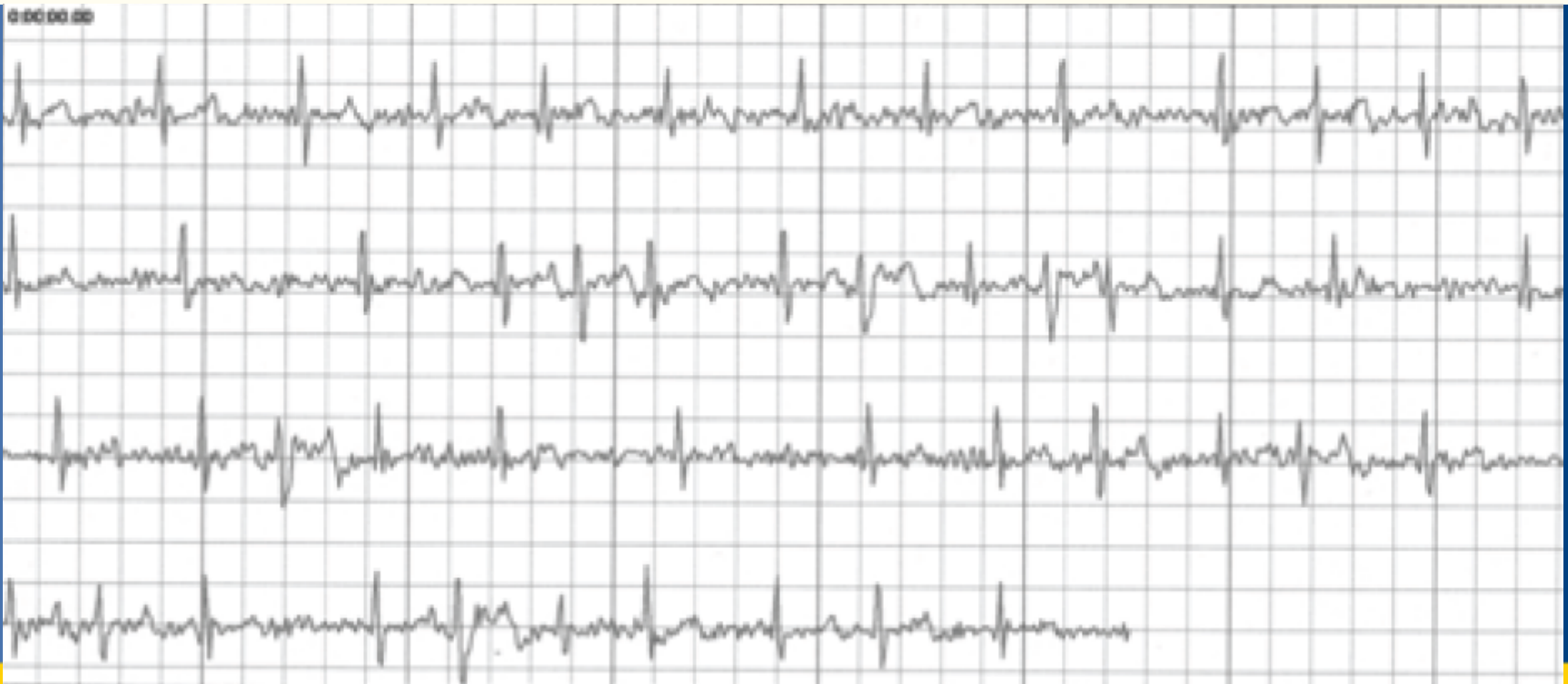
These 2 apps
both used light
sensors, not
ECG recordings



Patient-driven rhythm recordings

Symptom/Rhythm Correlation With Patient Owned Device: Insights Into Practice And Challenges

Mohammed Shurrab, MD,MSc,^{1,2} Anatoly Langer, MD,³ Eugene Crystal, MD,¹ David Newman MD¹



“DEBATE” AND CASES

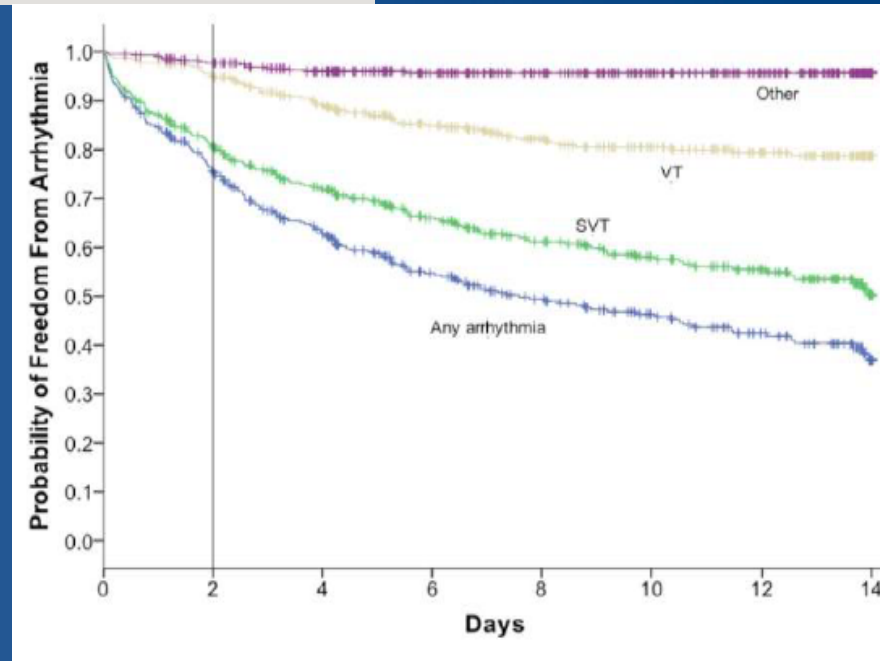
*Indications for use of Holters,
external loop recorders and
implantable loop recorders*

Is the Holter dead?

The Days of the Holter Monitor Are Numbered: Extended Continuous Rhythm Monitoring Detects More Clinically Significant Arrhythmias in Adults with Congenital Heart Disease

Karen E Schultz, MD;^a George K Lui, MD;^{a,b} Doff B McElhinney, MD;^a Susan M Fernandes, PA;^{a,b} Anne M Dubin, MD;^a Ian S Rogers, MD, MPH;^{a,b} Mohan N Viswanathan, MD;^b Anitra W Romfh, MD;^{a,b} Kara S Motonaga, MD;^a Scott R Ceresnak, MD^a

- 301 ACHD patients with symptoms or for monitoring had loop monitors placed
 - ½ had a significant arrhythmia; only ¼ of those were found in the 1st 48 hours



The Holter is not dead!

- Specific uses for 24-48 continuous monitoring:
 - Accurate 24 hr counts of PVCs are needed for otherwise normal patients with frequent PVCs, and for ARVC
 - Patients with heart block prior to pacing need accurate heart rate counts, best done with continuous monitors
- Disadvantages to 30 day loop monitors:
 - Patients (especially children) *despise* them
 - They are uncomfortable and inconvenient to wear

Utility of the 30 day event recorder

- For symptoms that do not occur every day
- For high risk patients who refuse or who don't quite warrant an implantable recorder

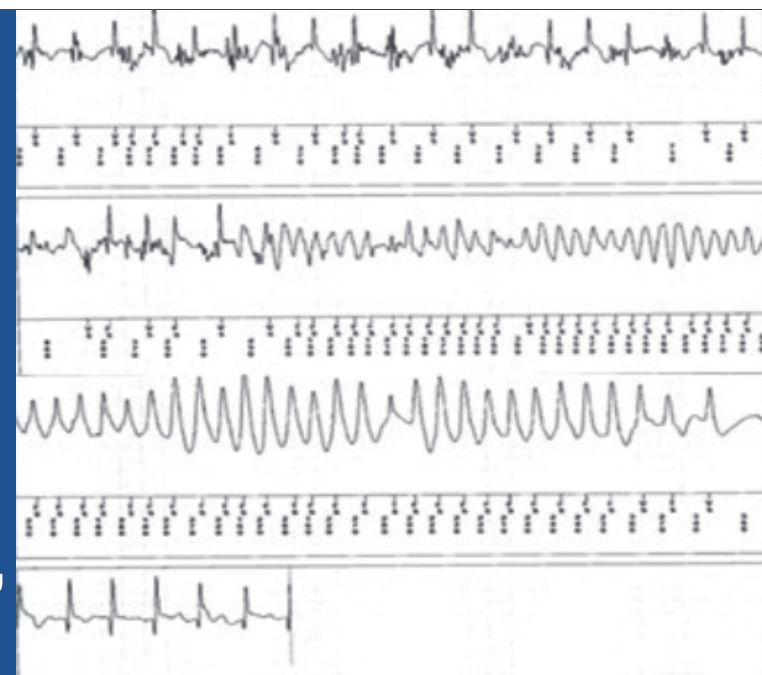
Common sense will dictate which device to use, depends on what information you want

ILR data in children sparse

Implantable Loop Recorder Monitoring for Refining Management of Children With Inherited Arrhythmia Syndromes

Jennifer N. Avari Silva, MD, FHRS; Burt I. Bromberg, MD; Fredrick K. Emge, MD; Tammy M. Bowman, CNP; George F. Van Hare, MD, FHRS

- 20 patients studied, 2008-2015
- Most implanted to monitor symptoms
- 7% yielded actionable data, escalated therapy in 30%



When to implant a loop recorder

- There are no clear criteria in children
- Some adult criteria set by ERAS position paper



Europace (2009) **11**, 671–687
doi:10.1093/europace/eup097

EHRA POSITION PAPER

Indications for the use of diagnostic implantable and external ECG loop recorders

Task Force members: Michele Brignole (Chairperson), Lavagna, Italy; Panos Vardas (Co-chairperson), Herakleion, Greece; Ellen Hoffman, Munich, Germany; Heikki Huikuri, Oulu, Finland; Angel Moya, Barcelona, Spain; Renato Ricci, Rome, Italy; Neil Sulke, Eastbourne, UK; Wouter Wieling, Amsterdam, The Netherlands

ERAS position paper on ILRs: Common sense points:

Key points for use of ILR and ELR

- Clinical evaluation is enough to establish a likely mechanism of syncope in the majority of patients
- Exclude high-risk patients, i.e. those with a clear indication for ICD, pacemaker, or other treatments independent of a definite diagnosis of the cause of syncope
- Be aware that the pre-test selection of the patients influences the subsequent findings. Include patients with a high likelihood of arrhythmic events
- Include patients with a high probability of recurrence of syncope in a reasonable time period
- Due to the unpredictability of syncope recurrence, be prepared to wait for a substantial time before obtaining such a correlation
- Your ideal goal should be to obtain a correlation between ECG findings and syncopal relapse. Weaker end-points are non-syncopal arrhythmias.

ERAS position paper on ILRs: Pediatric indications

In paediatric patients in whom a cardiac cause of syncope is suspected due to structural heart disease or electrocardiographical abnormalities;¹⁸ in pooled data on 89 patients from six small series,¹⁸ a diagnosis was achieved in 67% of patients: 33% of these had a bradycardia or asystole at the time of the recorded event, 23% had tachycardia and 43% had no arrhythmia

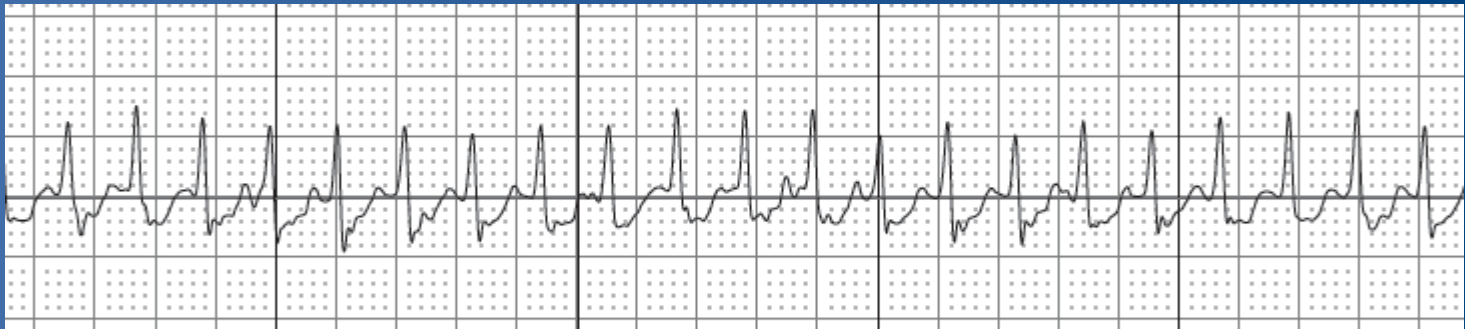
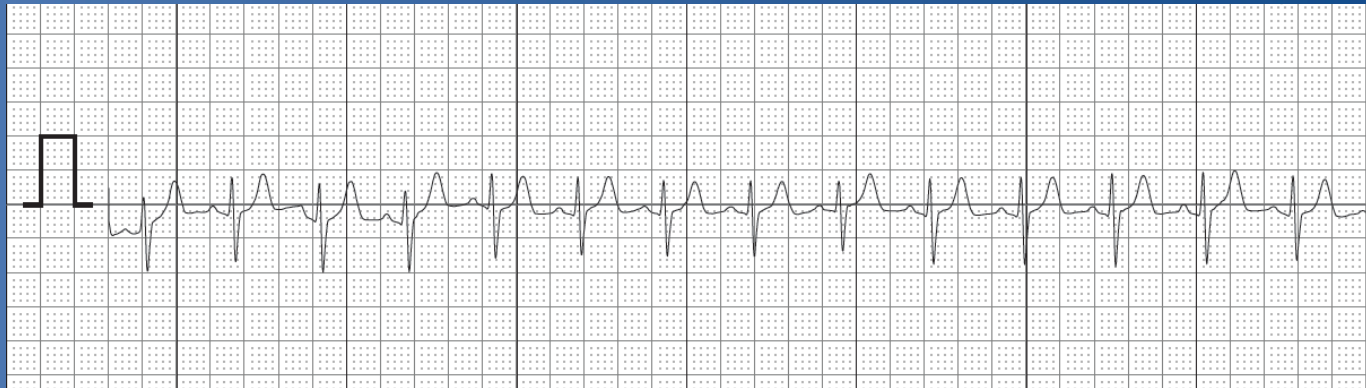
ERAS position paper on ILRs: When are they diagnostic

Interpretation of ILR and ELR findings in patients with syncope

Class I

- ILR and ELR findings are diagnostic when:
 - a correlation between syncope and an arrhythmia (brady- or tachyarrhythmia) is detected (*Level of evidence B*)
 - in the absence of such correlation, periods of Mobitz II or III degree AV block or a ventricular pause >3 s (with possible exceptions for young trained persons, during sleep, medicated patients or rate-controlled atrial fibrillation), or rapid prolonged (i.e. ≥ 160 bpm for >32 bpm) paroxysmal atrial or ventricular tachyarrhythmias are detected (*Level of evidence C*)
- ILR and ELR findings exclude an arrhythmic cause when there is no correlation between syncope and rhythm variation (*Level of evidence B*).

Case: 14 yo boy with palpitations: Score one for Smartphone products



Better quality than most event recorders?

Holter case:

11 year old girl with frequent PVCs, asymptomatic

142126 QRS complexes

32251 Ventricular ectopics which represent 22 % of total QRS complexes

0 Supraventricular ectopics which represent <1 % of total QRS complexes



Monomorphic PVCs, burden manageable

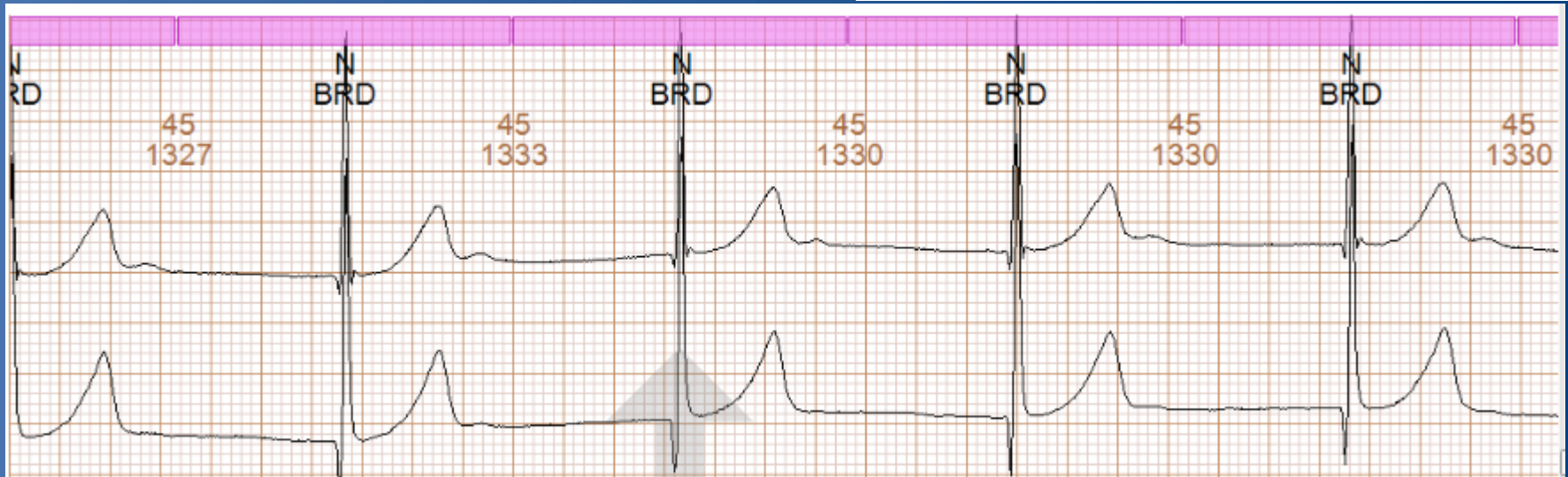
In conjunction with other normal testing, can continue
observation

Holter case:

7 year old boy with atrial standstill

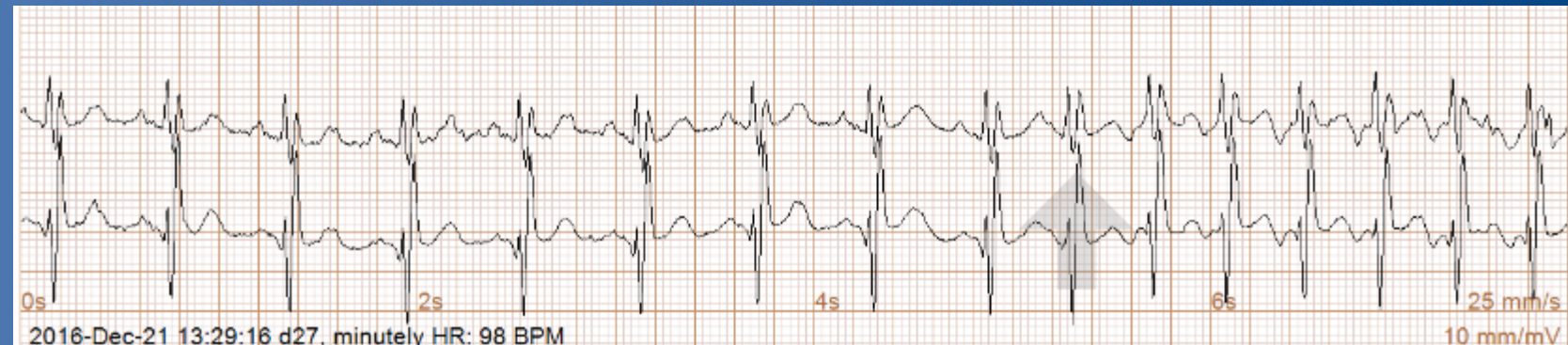
- Asymptomatic other than initial stroke that brought him to our attention
- What do we need to know?
 - Is his heart rate adequate?
 - Does he have ectopy?

"Sinus Rhythm"	71.64 %
Fastest minutely rate	66 BPM at 20:51
Average minutely rate	50 BPM
Slowest minutely rate	45 BPM at 02:36
Bradycardia	68.63 %

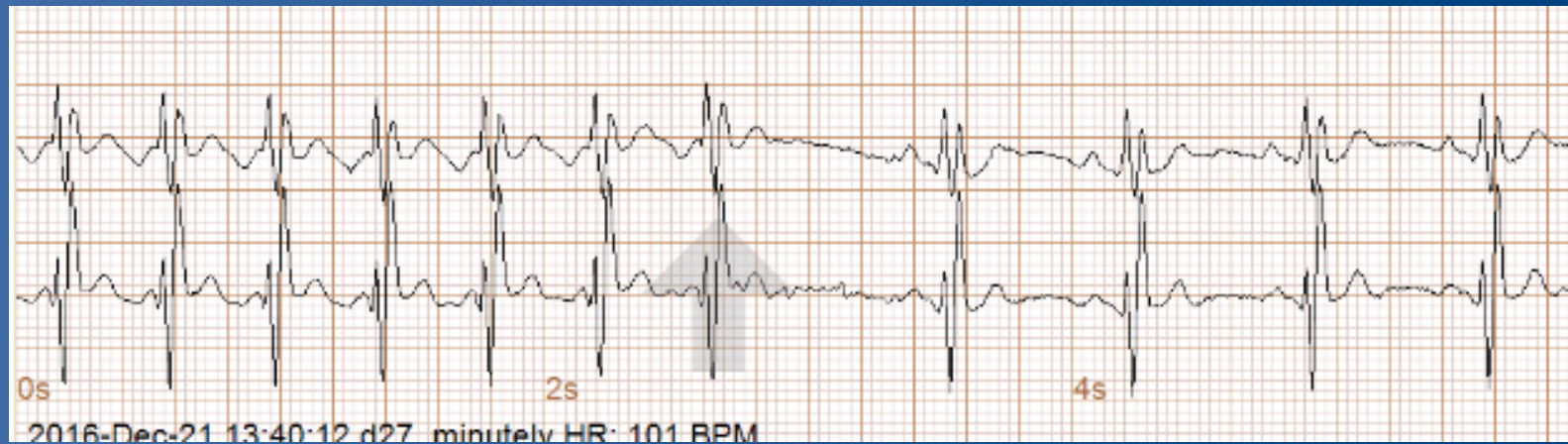


Event recorder Case: 30 yo recently repaired Ebstein anomaly with Maze

Complained of infrequent palpitations



Day 15: sustained SVT event, both onset and termination recorded



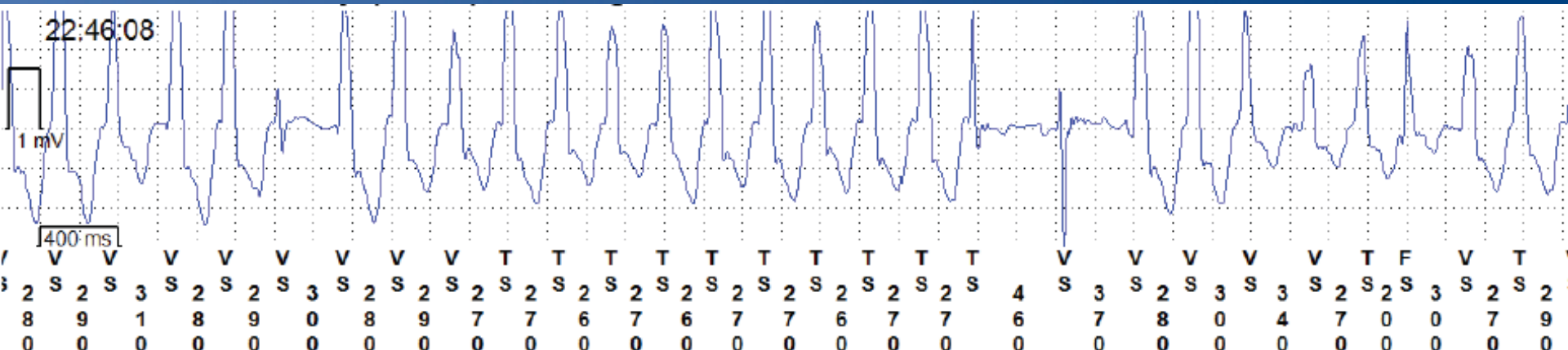
ILR Case

- 10 year old boy with neonatal coarctation, repaired with subclavian flap
- During routine, asymptomatic follow-up at 8 years of age, found to have biatrial enlargement and diastolic dysfunction, with no LVH and no recurrence of arch obstruction
- Cardiac catheterization revealed elevated end-diastolic pressures bilaterally (RVEDP 21 mmHg, LVEDP 28 mmHg), and presumptive diagnosis of restrictive cardiomyopathy
- MRI showed normal systolic function, no fibrosis
- Holter monitor showed no significant arrhythmias

ILR Case #1 continued

- No family history of cardiomyopathy
- Due to concerns of RCM, but in setting of incidental finding in asymptomatic patient, implantable loop recorder was recommended

One year later

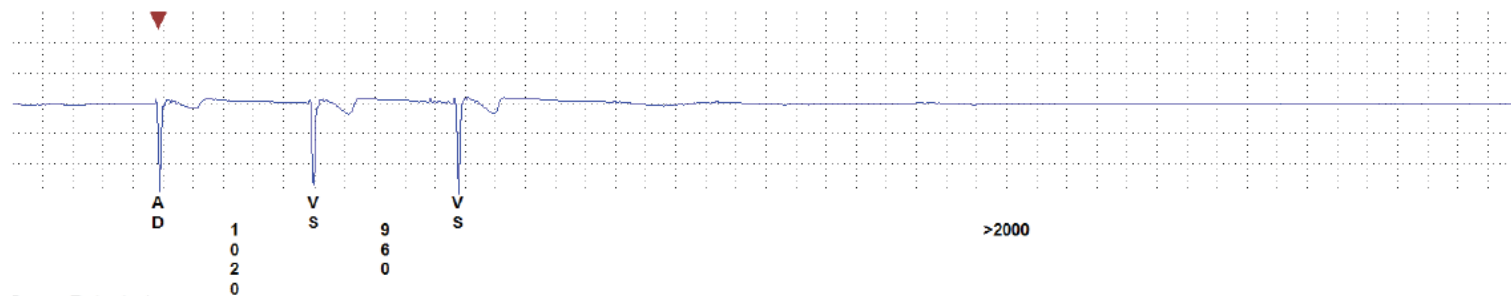
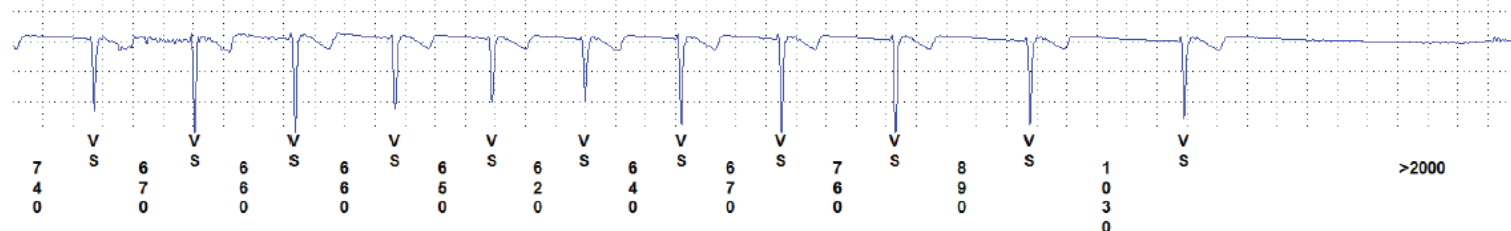


Change in management:
ICD implanted, activated on transplant list

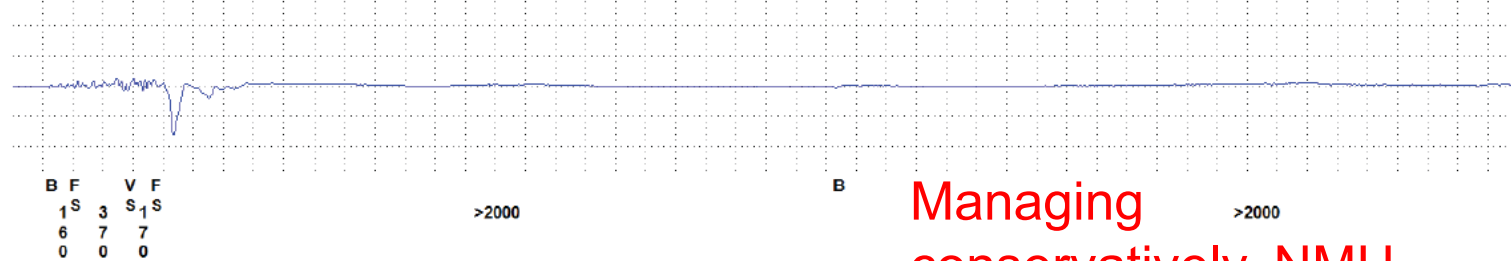
ILR Case

- At 7 years old presented with syncopal event at home. Mother states patient was grey and not breathing and CPR was started. Recovered by the time EMS arrived. No incontinence or seizure.
- LFTs elevated afterward
- Family history: father has had multiple syncopal events after exercise
- Initial workup with ECG, echo, exercise test, neuro work-up negative
- Negative EP study, including procainamide and high dose isoproterenol infusions, and ILR implanted

ILR Case #2, continued



Pause Detected



Managing conservatively, NMH with asystole

Conclusions

- *Use the right tool for the right job*
 - 24-48 hour Holter for short-term “counting”
 - 30 day event recorder for frequent but not daily symptoms
 - Consider implantable recorder for long-term monitoring
 - Consider ECG recording via SmartPhone apps; light sensor rates not accurate at higher rates