Advances in Arrhythmia Monitoring

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Conflict of interest

None
Remote cardiac telemetry was developed to allow home ECG monitoring of patients with suspected cardiac arrhythmias.

It was first introduced by the American biophysicist Norman J. Holter (1914–1983) in the 1940s.

The rapid expansion of ambulatory monitoring technologies affords the clinician the obvious diagnostic advantage of more comprehensive and real-time data.
Indications of Ambulatory arrhythmia Monitoring
Indications for AECG Monitoring

The fundamental premise of AECG monitoring is the potential to capture real-time rhythm recordings that can be used to:

- Provide an explanation for an unexplained prior or recurrent symptomatic event; or
- Capture arrhythmic events that aid in assessing prognosis or treatment effect.
AF indications

Diagnosis of AF
- Unexplained arrhythmic symptoms
- Cryptogenic stroke

Evaluation of known AF
- Differentiate paroxysmal vs. persistent pattern
- Compare heart rate in sinus rhythm vs. AF in SSS pts
- Evaluate adequacy of ventricular rate control
- Document pattern at initiation and termination of AF
- Assess efficacy and complications of AAD or ablation
Non-AF indications

Unexplained symptoms
- Palpitations
- Pre-syncope or syncope
- Recurrent unexplained falls

Risk stratification
- T-wave alternans
- Heart rate variability and heart rate turbulence
- NSVT in patients at risk of SCD (e.g., ICM, HCM, ARVD)
Non-AF indications

Miscellaneous

- Quantify burden and morphology of repetitive monomorphic ventricular ectopy
- Assess device function (i.e., sensing and pacing)
- Ensure effective biventricular capture in patients with CRT
- ST-segment analysis
- QT interval
Ambulatory Monitoring Technologies for the Assessment of Cardiac Rhythm Abnormalities
Ambulatory Monitoring Technologies

- Continuous Monitors (Holters)
- Intermittent External Patient or Event Recorders (Event monitors)
- Implantable Loop Recorders
- Continuous Real Time Telemetry Monitors
- Patch type monitors
- Remote monitoring of pacemakers & ICDs
A. Holter monitoring

Patient wears monitor (typically 24-48 hours)

Patient keeps diary of symptoms and times when they occur

Patient returns monitor to technician to be scanned after recording period

Technician gives physician final report

B. Event monitoring

Patient carries monitor (typically 30 days)

Patient places monitor on chest to record during symptom

Patient transmits data over telephone to monitoring station

Monitoring station sends data to physician

C. Loop monitoring

Patient wears monitor (typically 30 days)

Patient activates monitor during symptom (some devices auto-trigger if arrhythmia is detected and alert patient)

Patient transmits data over telephone to monitoring station

Monitoring station sends data to physician
The current state of Holter technology uses smaller recorders with flashcard memory to record and store data from 2 to 3 ECG leads attached to the patient’s chest and collected continuously over 24 to 48 hours.

Stored data are analyzed in digital format and downloaded to local work station or transmitted over internet to central work station.

Patients are asked to keep a diary of their symptoms and event its timing. The recorders use patient-activated markers (annotations) specified for the time.
Continuous Monitors (Holters)
Continuous Monitors (Holters)

Advantages:
- Cheap
- The ability to continuously record ECG data
- Does not need pt. participation in data transmission.

Limitations:
- The short duration of monitoring can be inadequate if infrequent symptoms.
- Frequent noncompliance with keeping a log of symptoms and using event markers.
- The absence of real-time data analysis.
Intermittent External Patient– or Event–Activated Recorders (Event Monitors)

- Pre event continuous loop recorders:
  - Patient activated event recorder
  - External loop recorder
    - Patient activated ELR
    - Auto triggered ELR
    - Both

- Post event non looping recorders (Non looping ELR)
Continuous loop recorders are attached to the patient through chest electrodes or a wrist band and record (save) data only when activated by the patient, or when auto triggered that recognize slow, fast, or irregular heart rates.

Once activated, data are stored for a programmable fixed amount of time before the activation (looping memory) and a period of time after the activation.
Patient activated event recorder and ELR
Post event recorder

These devices are not worn continuously (non-looping) but instead are applied directly to the chest area once a symptom develops. Therefore, they have no memory to allow recording of the rhythm before the device is activated.

Event monitors are generally used for 14- to 30-day monitoring periods. The data are transmitted transtelephonically to a central monitoring station.
Post event recorder
Event Monitors

Advantages:

- Small size
- Allow ECG monitoring for longer time periods
- Can provide nearly real-time data analysis when the patient transmits a recording in proximity to the symptomatic event.
Event monitors

Limitations:

- The patient has to be awake and coherent enough to activate the device unless automatic trigger is built into the monitor.
- Need the patient to transmit stored data by phone using acoustic coupler modem.
- Limited storage capacity, so once an event is recorded it needs to be immediately transmitted.
- Doesn’t provide data about asymptomatic episodes.
Implantable Loop Recorders

They are subcutaneously implanted leadless devices that record a single-lead ECG signal through 2 electrodes within the device. The device can be triggered automatically or by patient activation via placement of an activator over the device.

The newest generations of these devices allow remote transmission of data and have a battery life in excess of 24 months.
Implantable Loop Recorders
Continuous Real-Time Telemetry Monitors

They represent the newest form of external ambulatory monitors, developed to combine the benefits and to overcome the limitations of Holter monitors and standard ELRs:

- Real time 24/7 data access
- Long term monitoring up to 30 days
- Ability to capture information about symptomatic and asymptomatic arrhythmic events
Continuous Real-Time Telemetry Monitors

They are worn continuously and are similar in size to the standard ELR.

Three electrodes attached to battery powered sensor that is held by the patient.

They automatically record and transmit arrhythmic event data to an attended monitoring station. Stored data are either directly transmitted to central station via cell phone network coverage or wirelessly to a portable monitor that has a built-in cell phone.
A. Patch-Type Extended Holter monitoring

Patient wears monitor patch (up to 7-14 days)

Patch monitor records all ECG data during period

Patient mails back monitor after recording period to central receiving station

Technician reviews data and sends report to physician

B. Ambulatory Telemetry monitoring - (Non-Real Time)

Patient wears monitor (up to 30 days)

Monitor sends all ECG data to a handheld device

The handheld device transmits ECG data to a central monitoring station

Physicians are notified by technician if significant arrhythmia is detected

C. Ambulatory Telemetry monitoring - (Real Time)

Patient wears monitor (up to 30 days)

Monitor sends all ECG data continuously to central monitoring station

Physicians are notified by technician if significant arrhythmia is detected

Physicians can also log onto secure web server at any time to view real-time ECG data
Continuous Real-Time Telemetry Monitors

- Biomedical (Truvue)
- Cardionet (MCOT)
- Life watch (ACT)
- Medinet (ECAT)
- Scott care (Telesentry)
Continuous real time telemetry monitor

Mobile Cardiac Outpatient Telemetry (MCOT)

Heartbeat by Heartbeat Surveillance

At home

Automated event detection/transmission

Or away

24/7/365 Cardionet analysis, response, reporting

MD daily and urgent telemetry reports internet, phone, fax, mail
Continuous real time telemetry monitor
Continuous Real-Time Telemetry Monitors

Advantages:

- Continuous real-time ECG monitoring
- Extended period of monitoring (up to 30 days)
- No need for patient activation or transmission of data.
- The data are transmitted and analyzed immediately by technicians who can contact the patient and/or the physician if an urgent intervention is needed
Small, light weight water resistant patch placed over left pectoral area that can store up to 2 weeks of continuous single lead ECG with a button on it that can be pressed by the patient to mark symptomatic episode, then at the end of 2 weeks patch is mailed back to central station for reporting.
Zio Patch
Remote Monitoring of Pacemakers and ICDs

Through continuous rhythm monitoring, modern devices provide data about arrhythmia burden with a detailed arrhythmia log that contains the number, duration, delivered device therapy and dates of arrhythmia episodes, as well as the maximal atrial and ventricular rates associated with these episodes.

These data can be transmitted via telemonitoring using wireless technology for remote follow up e.g. Carelink (Medtronic), House call (SJM), Latitude (Boston)
Remote monitoring of PM& ICD
How should these technologies be used
How should these technologies be used

With all the available technology, it can be difficult to choose the right device for a particular indication.

The choice of a monitoring modality depends on

- The presenting symptom,
- Symptom frequency,
- Degree of suspicion of a life-threatening arrhythmia

The optimal duration of monitoring largely depends on symptom frequency.
Patients who experience daily symptoms can be evaluated with a Holter monitor.

More often, palpitations are sporadic and require longer monitoring period.
Is 48 hours a sufficient period of monitoring

- In a study in which patients with palpitations were prescribed an event monitor, the highest diagnostic yield was within the first week ~ 80% of patients transmitted at least 1 rhythm strip corresponding to their symptoms.

- During the next 3 weeks of a standard 1-month monitoring period, only an additional 3.9% of patients received a diagnosis, and no patients received a diagnosis after week 2.

In a study directly comparing a 48 hr Holter and a 30 days of a loop recorder, the diagnostic yield of a loop recorder was up to 83% compared with a diagnostic yield of 39% for Holter monitoring for patients with palpitations.

In a study of patients with infrequent palpitations (< 1 episode per month lasting > 1 minute), ILRs provided a diagnostic yield of 73% compared with 21% in the group evaluated with standard conventional approach (48 hr Holter, 30 days ELR and EPS).

Evaluation of Palpitations

**Palpitations**

- Able to activate a monitor and transmit the data

  - Y
    - Episodes last long enough to activate the monitor reliably
      - Non looping ELR
      - Real time continuous telemetry device
    - N
      - Continuous looping ELR
  - N
    - Episodes occur daily
      - Short term Holter
      - Real time continuous telemetry device
Syncope, in contrast, typically requires a significantly longer monitoring period, and the diagnostic yield of ambulatory monitors of any sort is extremely low.

The value of arrhythmia monitoring for syncope is not only to identify an arrhythmia as a cause for syncope and to document a syncopal event without a corresponding arrhythmia, thus suggesting a nonarrhythmic cause.
ILRs, which allow a prolonged monitoring period, have been demonstrated to improve the diagnostic yield for syncope, up to 85% for a period of monitoring up to 2 years.

Krahn AD et al, J Cardiovasc Electrophysiol. 2003;14(suppl):S70 –S73
Evaluation of Syncope

Syncope or symptoms associated with syncope occur at least once a month

Y  |  N
---|---
Real time continuous telemetry device | Insertable loop recorder
Circumstances in which a 48-hour monitoring period is preferred include:

- Assessment of rate control in patients with AF and the identification of chronotropic insufficiency in patients with suspected sinus node dysfunction.

- Ventricular ectopy in patients with increased risk for SCD (e.g. HCM, DCM, Post MI WITH LVD, LQTS, surgically repaired complex congenital heart diseases) and congenital AVB
The identification of AF is one of the commonest indications for monitoring of asymptomatic episodes. Monitoring is also done in patients who are on AAD or after AF ablation for recurrences which are often asymptomatic and may not be detected unless an aggressive monitoring strategy is undertaken.

Patients with cryptogenic stroke often undergo rhythm monitoring to identify asymptomatic AF as a potential cause.
Choosing a device with the ability to pick up asymptomatic episodes of AF is highly needed. These include event recorders with AF triggers, continuous telemetry devices, 2-week Holters, or ILRs with automatic triggers.

Implanted devices (PMs, ICDs, and ILRs) afford the greatest opportunity for continuous and comprehensive monitoring of AF.
Evaluation of AF

Atrial Fibrillation

Rate control

AF surveillance post PVI or Maze

Monitoring after AAD initiation

Short term Holter

Long term Holter or Real time continuous telemetry device

Real time continuous telemetry device

ELR with atrial fibrillation triggers

ELR with daily asymptomatic tracings to monitor QT interval and identify brady and tachyarrhythmias as well as transmission of symptomatic arrhythmias
THANK YOU