Advances in In-Hospital Cardiac Monitoring

Lessons learned over the past 40 years of hospital monitoring

Presenter Disclosure Information
Barbara Drew has received research funding or honoraria from:
- GE Healthcare
- Medtronic-Physio-Control
- Mortara Instruments
- Philips Healthcare

A Little History...
- Hospital ECG monitoring was introduced by Dr. Day in Kansas City.
- Goals of monitoring: track heart rate & detect ventricular standstill.

In a fibrillation...
- Is it standing?
- Has it started?
Early monitors recorded only one ECG Lead: I, II, or III

Lead V₁ was considered the most valuable for diagnosis of wide QRS rhythms; it was not available

Marriott's modified V₁ (MCL₁)


Can WCT be accurately diagnosed using V₁ criteria when monitoring in MCL₁?
Research Findings:
MCL₁ is often not the same as V₁ during WCT

ECG Criteria to Distinguish Between Aberrantly Conducted Supraventricular Tachycardia and Ventricular Tachycardia: Practical Aspects for the Immediate Care Setting

Lesson Learned...
1. ECG criteria developed using one lead configuration cannot be generalized to modified lead configurations
Wrong Electrode Placement in the PULSE Trial (n=1,164 patients from 17 hospitals)

NASA used Reduced Lead Set technology to monitor astronauts in Skylab II in 1973

3 leads recorded in space; 12 leads reconstructed on earth
Commercially-available Reduced Lead Sets to derive 12-lead ECGs

Reduced Lead Set #1 Philips
EASI 12-lead (5 electrodes)

Reduced Lead Set #2 GE
(6 electrodes)

Reduced Lead Set #3 Dräger-Siemens
(6 electrodes)

Commercially-available Reduced Lead Sets to derive 12-lead ECGs

STAMPEDE Study

Simultaneous standard 12-lead ECG & reduced lead set (EASI 12-lead) with twin ECG machines

STAMPEDE Study

Patient presenting to the ED with chest pain

What if?
Recorded in cath lab after PCI
What if?
Recorded in CCU after procedure

Lessons Learned…

1. ECG criteria developed using one lead configuration cannot be generalized to modified lead configurations.

2. Reduced lead ECGs are practical but they come at the expense of lack of comparability to the standard ECG.

ST-segment (ischemia) monitoring became available in the late 1980’s

ST monitors measure ST amplitude at a single point

ST level = 0.0 mm  4.0 mm  - 4.0 mm
Random survey of cardiac unit nurse managers

“Too many false monitor alarms!”

Setting ST alarm parameters appropriately around the patient’s baseline ST level

Patient with chronic ST depression due to LVH

Setting ST alarm parameters incorrectly will cause false ST alarms

Patient with chronic ST depression due to LVH
Two deleterious consequences of False Monitor Alarms

1. Unnecessary diagnostic & therapeutic treatments

2. Alarm fatigue & silencing of alarms

The Boston Globe

‘Alarm fatigue’ linked to patient’s death
US agency says monitors went unheeded

By Liz Kowalczyk

Globe Staff / April 3, 2010

Federal investigators concluded that ‘alarm fatigue’ experienced by nurses working among constantly beeping monitors contributed to the death of a heart patient.

Investigators for the Centers for Medicare & Medicaid Services said that desensitization to alarms was a factor in the patient’s death.

Lessons Learned…

1. ECG criteria developed using one lead configuration cannot be generalized to modified lead configurations

2. Reduced lead ECGs are practical but they come at the high price of lack of comparability to the standard ECG.

3. Excessive monitor false alarms can result in over-treatment &/or alarm fatigue
### UCSF ST-Segment Monitoring Protocol

#### ST alarm

1. **Is there a noisy signal?**
   - Yes: False ST alarm
   - No: Check electrodes

2. **Due to position change**
   - ST monitoring may need to be discontinued

3. **Is there a change in rhythm that alters the ST segment?**
   - (new BBB, ventricular pacing, coarse atrial fib/flutter, ventricular rhythm)
   - Yes: False ST alarm
   - No: Print out "ST Review" of alarm condition versus baseline ECG to determine:
     - Is there criteria for ischemia?
     - Change in ST amplitude between alarm & baseline ECG ≥ 1mm in 2 leads?

4. **Are either of the following present?**
   - 1. ST changes accompanied by major change in size or shape of QRS?
   - 2. ST changes resolve when patient changed from side-lying to supine?
   - Yes: False ST alarm
   - No: False ST alarm

5. **Doesn’t meet criteria**
   - No: True ST alarm!
   - Yes: Does the patient have new symptoms? (chest pain, SOB, altered vital signs)

6. **Document ST alarm rhythm strip**
   - **Notify MD (anticipate STAT 12-lead ECG)**
   - Change ST alarm parameters from ±2 to ±1 mm around patient's current ST level for next 12 hrs

### Unit Default Settings:

1. ST-segment monitoring feature is "ON"
2. Measurement point is J+60
3. Alarm parameters are ±2 mm above & below the patient's baseline ST level

### Turn off ST monitoring for patients with:

1. LBBB
2. Ventricular pacing rhythm
3. Coarse atrial fib/flutter where atrial waves obscure ST segment
4. Agitated pts with noisy signals (make sure not poor electrode contact)
5. Post cardiac or thoracic surgery
6. Consider if appropriate for DNR status

### Lessons Learned...

1. ECG criteria developed using one lead configuration cannot be generalized to modified lead configurations
2. Reduced lead ECGs are practical but they come at the high price of lack of comparability to the standard ECG.
3. Excessive monitor false alarms can result in over-treatment &/or alarm fatigue
4. Wide-spread use of ST monitoring will not occur unless there are clear-cut nurse protocols
Methods to monitor QT intervals in hospital units

1. Standard 12-lead ECG
   Problem: not frequent enough

2. Continuous cardiac monitoring in an ICU or “step-down” unit with telemetry monitoring
   - manually with calipers; apply correction formula
   - e-calipers from Central Monitoring Station
   Problem: inter-rater differences

Potential advantages: no inter-rater differences; measures q 5 mins; audible alarm if ΔQTc ≥ 60 ms or QTc > 500 ms lasting 15 mins
Example of bedside monitor display with continuous QT interval monitoring

QT in Practice (Q-TIP) Study
Continuous QT monitoring installed in 5 hospital units at Stanford Univ Medical Center to investigate prevalence, predictors, & outcomes of QT prolongation

Preliminary results of the QT-TIP Study
67,648 hours of continuous QT monitoring data from 1,039 patients

- 24% of patients had QT_c prolongation >500 ms ≥15 mins
- Patients with QT_c prolongation were 3 times more likely to have in-hospital death than those without

Incidence of drug-induced events

- Rare
- Less common
- Common

**QT Prolongation**
- >460 ms, males
- >470 ms, females

**QTc >500 ms**

**Monitoring QT intervals is not enough**

**ECG signs of impending TdP**

*Don’t miss!*

PLENARY ADDRESS

Warning Signs of Torsade

Dr. Rory Childers

Thank-you!