A Course in:
LONG QT SYNDROME (LQTS) &
LQTS Induced Adverse Drug Reactions

An overview of LQTS and its relevance in the clinical setting for:

- **Pharmacists**
- **Physicians**
- **Nurses**

Short Course in:
LONG QT SYNDROME (LQTS)

This course is an excerpt from the Sudden Arrhythmia Death Syndromes (SADS) presentation given by:

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All underscored blue font (except on this page) indicates an HTML web link to additional resources.

Long QT Syndrome (LQTS) is one of several conditions known to cause SUDDEN CARDIAC DEATH (SCD).

List of Common SCD Conditions:

- Hypertrophic Cardiomyopathy (HCM)
- Long QT Syndrome (LQTS)
- Short QT Syndrome (SQTS)
- Brugada Syndrome (BrS)
- Arrhythmogenic Right Ventricular Dysplasia (ARVD)
- Catecholaminergic Polymorphic Ventricular Tachycardia (CPVT)
- Wolff-Parkinson-White (WPW) Syndrome
- Commotio Cordis
- Less-common conditions (e.g. Marfans, Ehlers-Danlos, Loeys-Dietz Syndromes)

In this abbreviated course, we focus solely on LQTS . . .

Short Course in LQTS contents:

- Prevalence
- LQTS & Risk Management
- Etiology
- Pathophysiology
- Common Dysrhythmia Associated with Mortality: Torsades de Pointes (TdP) – with ECG examples.
- TdP Triggers
- Common Characteristics of Patients with LQTS
- ECG Indicators of Long QT Syndrome
- Intervention – When LQTS is suspected / noted
- Medication Induced QT Prolongation
- Intervention – Torsades de Pointes
- Protocol to Reduce Adverse Drug Reactions to QT prolonging medications.

Prevalence

Adverse Drug Reactions: Torsades de Pointes secondary to QT prolonging medications:

- Occur in and out of hospital
- Underreported
- Medical community undereducated
- 7,000 in-hospital ADRs / year (all cause)
- Major issue with pharmaceutical industry, many drugs removed from market due to high incidence of TdP and TdP associated mortality

Estimated SADS Prevalence from LQTS in the United States:

1/2,500 Lenhart,SE et al, 2007 AHA Circ

Compared to sudden death from Coronary Artery Disease, SADS mortality prevalence is low.

HOWEVER . . . .

- ***Many SADS victims are infants, children and young adults who are otherwise healthy.***
- **Sudden death is often the first symptom of SADS**
- ***Diagnosed and managed properly, most SADS patients can lead productive lives with minimal concessions and normal lifespans.***
- **Nearly EVERY SADS death is a NEEDLESS TRAGEDY that could have been AVOIDED with appropriate screening and management.**

LQTS and Risk Management

Due to the

- ***prevalence of LQTS in the patient population,***
- ***its associated MORBIDITY and MORTALITY,*** and
- ***the abundance of published evidence-based material that is currently available***,

it is in a hospital's best interest to have STAFF EDUCATION as well as POLICIES and PROCEDURES in place to IDENTIFY and APPROPRIATELY MANAGE incidence of QT Prolongation and reduce Adverse Drug Reactions (ADRs) caused by medications known to prolong the QT Interval.

LQTS and Risk Management

A reasonable program includes:

- Staff education (this course at a mimimum),
- Implementation of QT Interval Monitoring Policies and Procedures:
  - ECG Criteria
  - QT Prolonging Medications
- Emergency Department and Admission order sets for Syncope, near-syncope, Palpitations and Seizures that include diagnostic pathways for ruling out SADS conditions

Common Etiology of LQTS:

- **Congenital** (Inherited and New Mutation – 14 subtypes)
- **Acquired:**
  - **Medication Induced (**susceptibility may have genetic component**)**
  - **Electrolyte abnormalities**
    - **Hypokalemia**
    - **Hypocalcemia**
    - **Hypomagnesemia**
  - **Anorexia**
  - **Low Energy / Liquid Protein Diets**
  - **Intracranial Hemorrhage / CNS disorders**
  - **Hepatic Disorders**
  - **Coronary Artery Disease**
  - **Mitral Valve Prolapse**

Pathophysiology of LQTS:

Physiologic Mechanism: Ion Channelopathies (malformation / malfunction of Sodium, Potassium, and/or Calcium channels**) in Ventricular muscle tissue resulting in abnormal delay of cellular repolarization. This delay, possibly through dyssychrony of repolarization of the total ventricular cellular mass, results in a brief interval *during each cardiac cycle (heartbeat)* when the heart is susceptible to the disruption of synchronized depolarization, and may trigger the lethal dysrhythmia,**

"Torsades de Pointes."

Dysrhythmia Associated with Mortality, Triggered by LQTS: *Torsades de Pointes*

Torsades de Pointes **(TdP)**

French term for: "*Twisting of the Points.***"**

It's a form of POLYMORPHIC VENTRICULAR TACHYCARDIA . . . .

Dysrhythmia Associated with Mortality, Triggered by LQTS: *Torsades de Pointes*

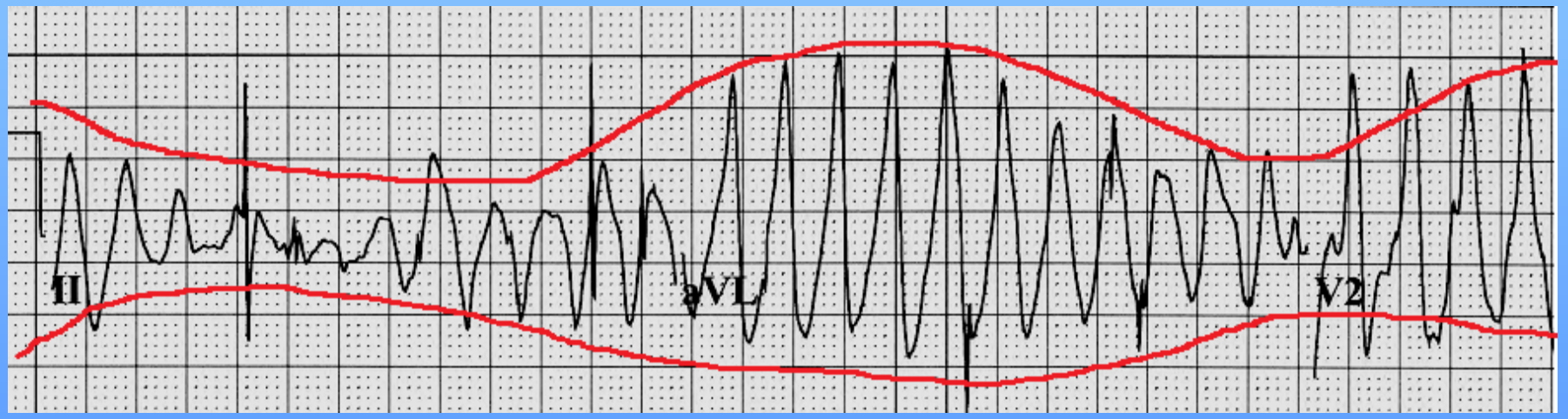
Torsades de Pointes (TdP) – HEMODYNAMICS:

- **Decreased – to – NO Cardiac Output**
- **Often patient PULSELESS during episode**
- **Patients often report SYNCOPE when TdP self-terminates.**
- **May DETERIORATE into VENTRICULAR FIBRILLATION and CARDIAC ARREST. ("Sudden Death")**

ECG Characteristics of TdP: The QRS Pattern of *Torsades de Pointes*

resembles . . . . .

a piece of Twisted Ribbon !



ECG Characteristics of TdP: The QRS Pattern of *Torsades de Pointes:*

QRS Axis: constantly changing. QRS alternates between positive deflection (pointing up) to negative deflection (pointing down).

Patients with LQTS – Common Dysrhythmia (Torsades) Triggers:

- QT Prolonging Medications / Substances
- **Physical Exertion** (Predominantly LQTS Type 1)
  - **Athletes**
  - **Military Personnel**
  - **Anyone who engages in physically demanding activity**
- **Emotional Duress** (predominantly LQTS Type 2)
- **Adrenergic Stimulation**
- **Premature Ventricular Contraction (PVC)**

Patient Evaluation

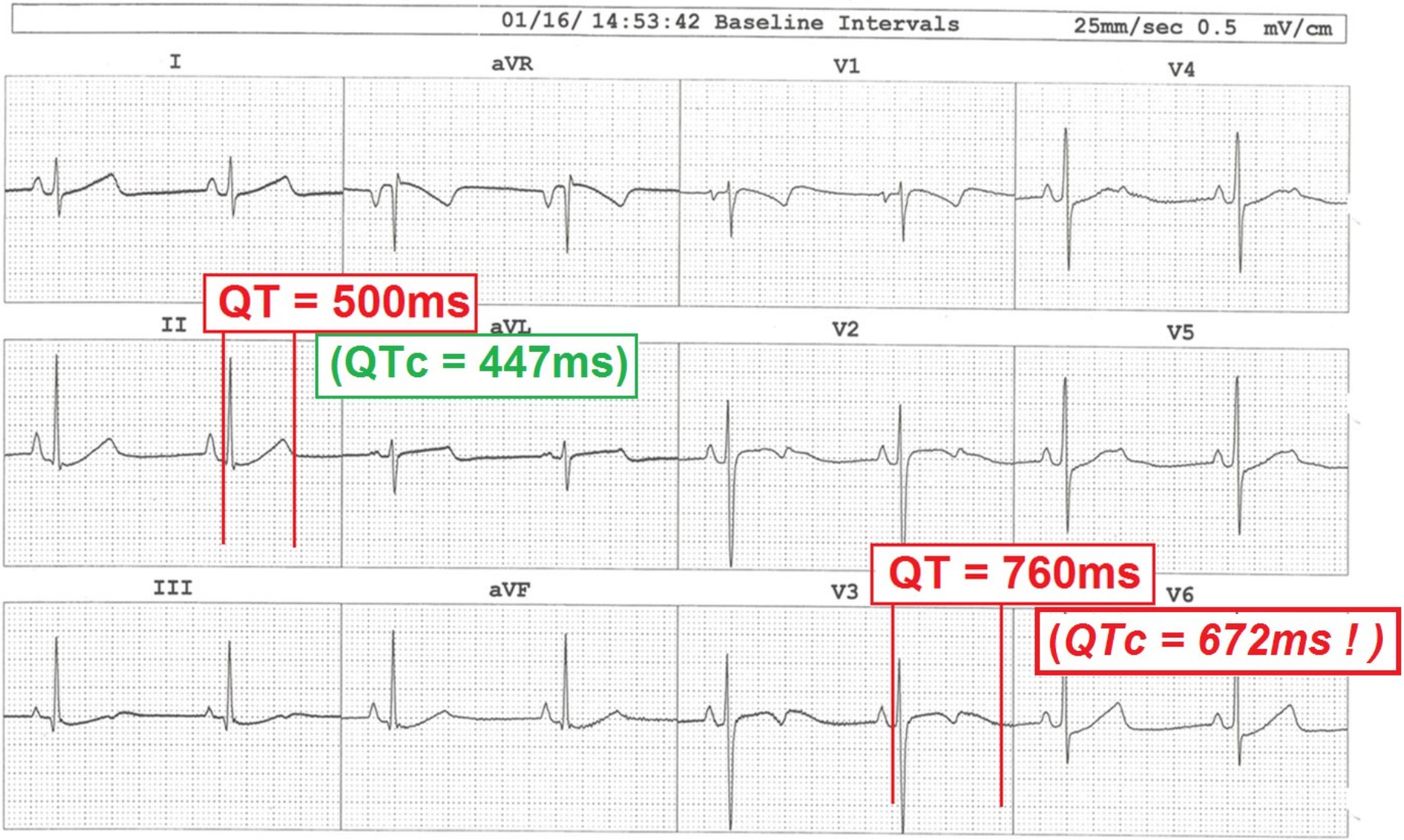
- When to suspect LQTS: Common Complaints and History of Patients with LQTS.
- ECG Evaluation and Indicators of LQTS

Common Complaints / Histories of Patients with LQTS:

- May present with complaints of "*transient episodes of* ***syncope, seizures*** *(no history of epilepsy),* ***lightheadedness*** *and/or* ***palpitations.***"
- May have **family history of "sudden death."** ***Specific etiology of death often not known.***
- **ECG typically exhibits QT prolongation and/or T/U wave abnormalities**.
- Some patients have other known genetic conditions, such as Marfan's or Andersen-Tawil Syndromes
- **May be taking medication(s) known to prolong the QT interval.**

ECG Evaluation / LQTS Indicators:

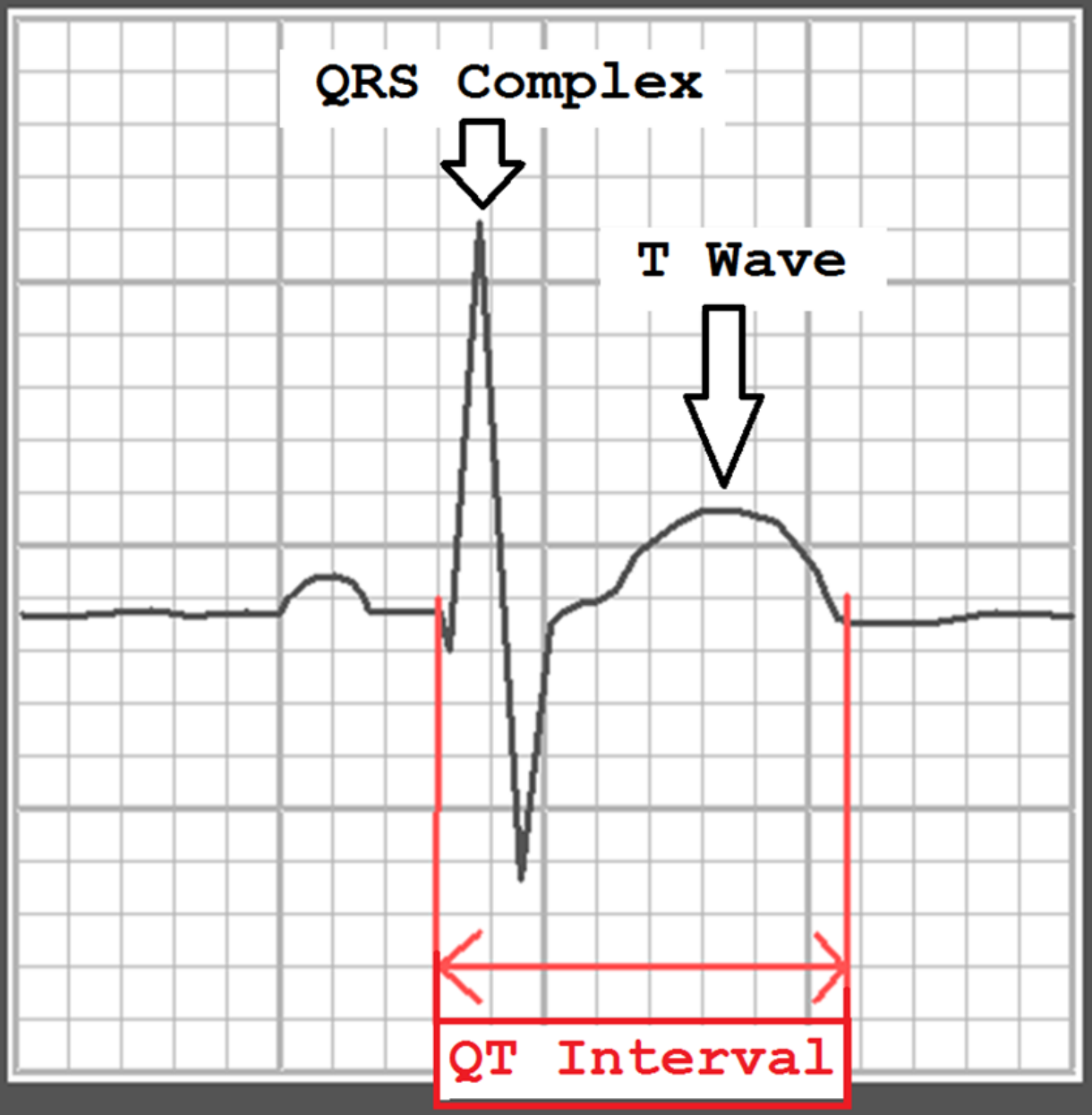
1. **Obtain ECG**. ***12 Lead ECG is recommended due to QT Dispersion*** ***(****QT Interval variations noted in different leads. See next slide for example* ***).***
2. ***Measure lead with longest QT interval***. (V2 & V3 typically display longest QT Interval).
3. **Calculate "Corrected QT Interval"** (QTc). This is explained on slides # 36 – 45.
4. **Determine if QTc value is abnormal**. Compare to the values found in the table on slide # 46.



This ECG illustrates the degree of variation that can be noted between different leads on the 12 Lead ECG. ALWAY measure the QT Interval in the lead with the GREATEST value.

Q - T INTERVAL

- Measured from the beginning of QRS to end of the T Wave.
- Varies based on Heart Rate.
- Varies from lead -to- lead on the 12 Lead ECG. Greatest QT Values typically noted in Leads V2 / V3
- Measure lead with longest QT interval.

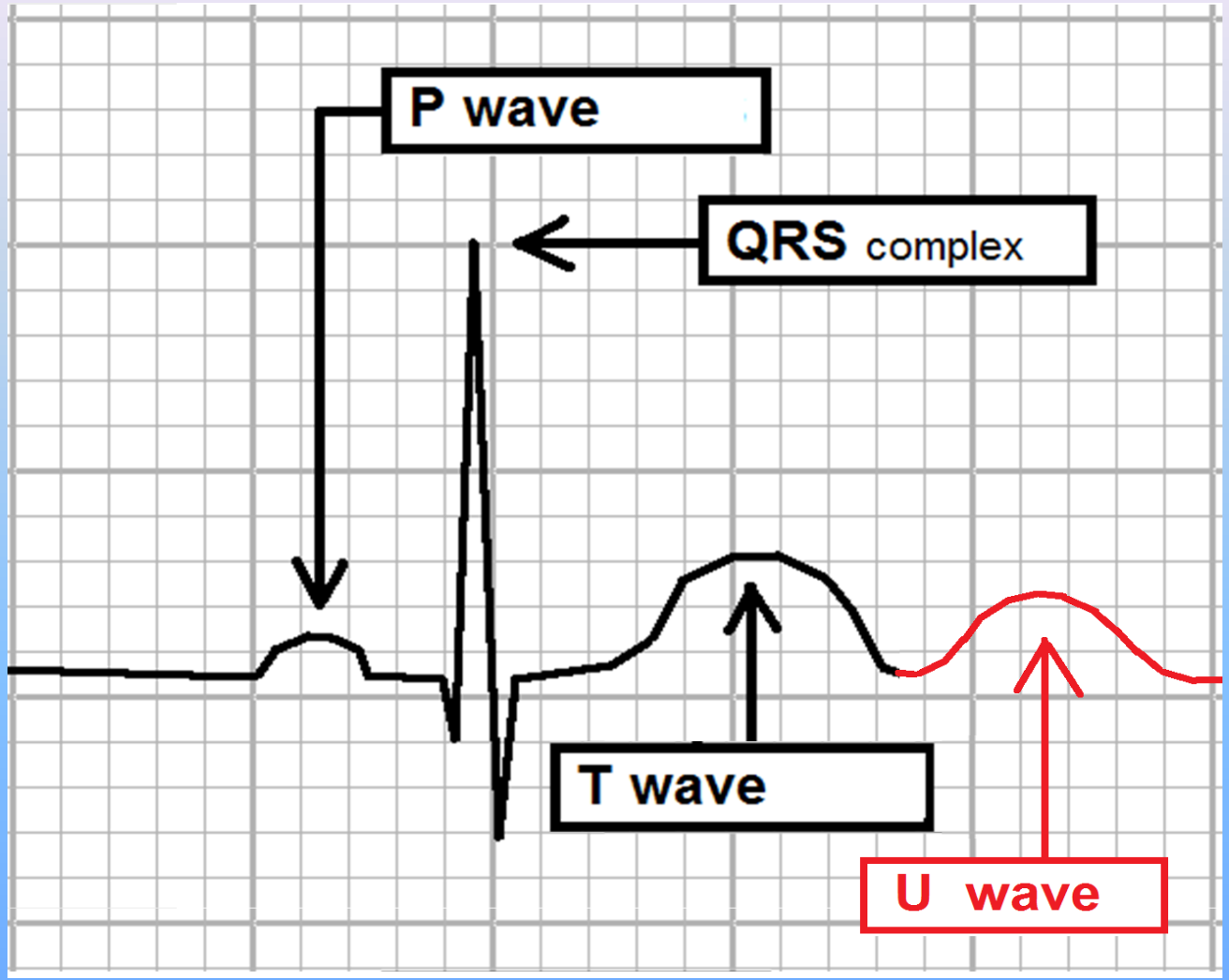


U Waves

Occasionally an extra wave is noted after each T wave.

It typically resembles

"a secondary T wave."



When present on the ECG, this "extra" waveform is referred to as a " U Wave."

U Waves . . .

- Occasionally seen on the patient's ECG
- Often seen in bradycardias
- ***Typically most predominant in Leads V2, V3***
- Are not completely understood. Three common theories of U wave origin include:
  - Prolonged repolarization of mid-myocardial "M cells."
  - Delayed repolarization of Purkinje fibers
  - After-potentials resulting from mechanical forces of ventricular wall

U Waves . . .

- Common U wave Etiology:
  - **Hypomagnesemia***
  - **Hypokalemia***
  - **Hypocalcemia***
  - **QT prolonging medications***
  - **Increased intracranial pressure***
  - **Hypothermia***
  - **Digitalis** (usually *shortens* the QT Interval)

**** These are also causes of QT interval prolongation.***

U Waves . . .

Are generally considered benign and not measured as part of the QT Interval ***UNLESS they are ABNORMALLY PREDOMINANT*** (too large!).

Abnormal U Waves

INCLUDE the U Wave in the QT Interval measurement **when any one or more criteria are present:**

- **U wave 100% (or more) the size of the T wave.**
- **U wave is INVERTED (opposite polarity of T wave)**
- **U wave merged with the T wave**

EVIDENCE SOURCE:
ACC/AHA/HRS Recommendations for the Standardization and Interpretation of the Electrocardiogram Part IV: The ST Segment, T and U Waves, and the QT Interval.

The Normal QT Interval

- Normal QT Interval limits vary based on the patient's HEART RATE and GENDER.
- Slower Heart Rates have LONGER QT intervals, and faster heart rates have SHORTER QT Intervals.
- FEMALES normal QT Intervals are *slightly longer* than MALES.
- There subtle are age-related differences in QT intervals (Pediatrics vs. Adult), however these differences are not addressed in this course.

UPPER LIMITS of the QT Interval - in MilliSeconds (mSec)

HEART RATE	MALE	FEMALE
150	250	280
125	260	290
100	310	340
93	320	350
83	340	370
71	370	400
60	400	440
50	440	480
43	470	510

Annals of Internal Medicine, 1988 109:905.

Determining Normal QT Intervals:

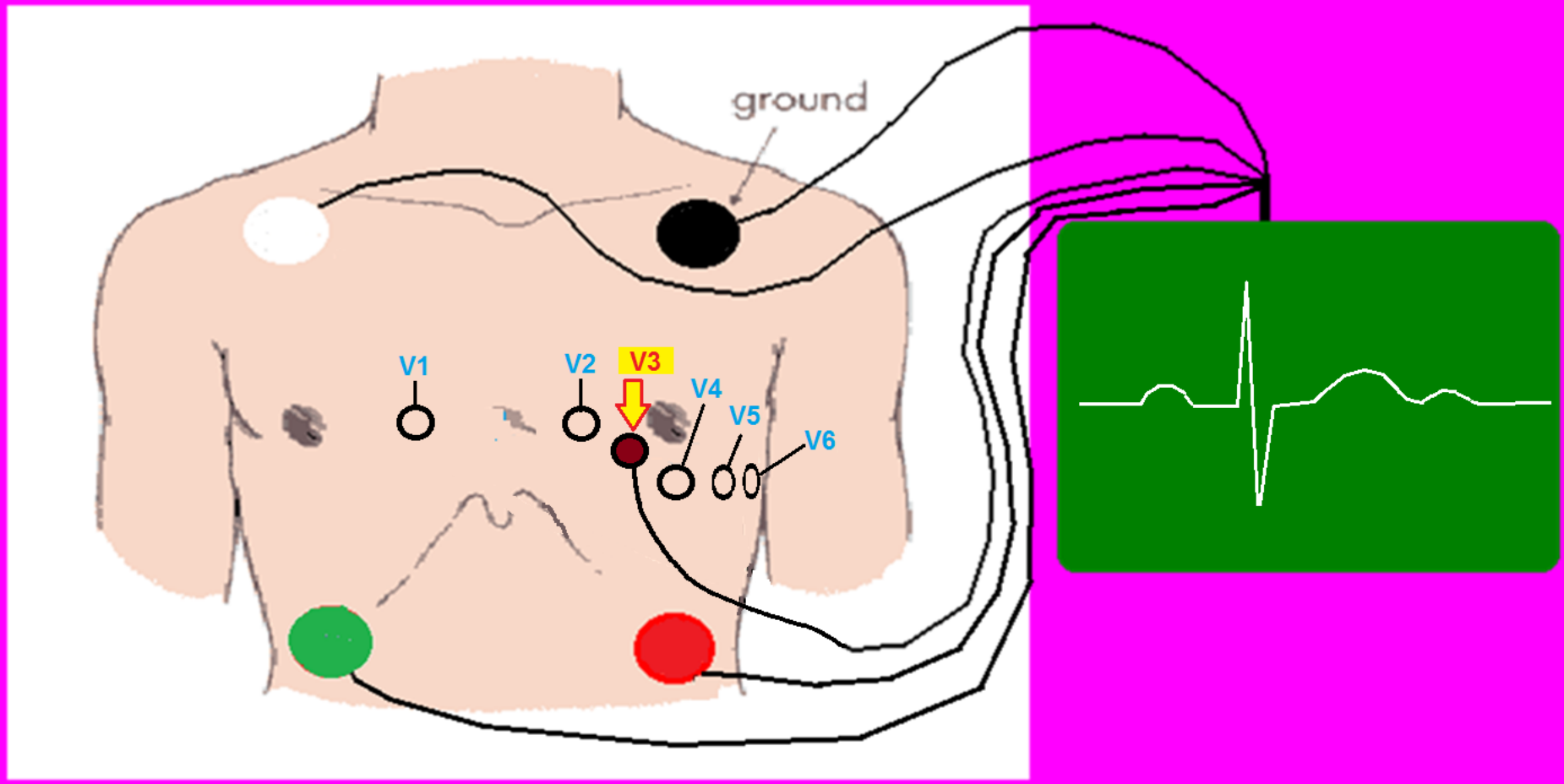
- To compensate for the QT Interval's ***variations associated with heart rate,*** we calculate a "Corrected QT Interval."
- The ***"corrected QT interval"*** is known as the "**QTc**," and is obtained by factoring the patient's ***measured QT interval*** and ***HEART RATE*** into a mathematical formula.

☞ ***If you obtain a 12 Lead ECG, the computerized report provides the QT Interval and the QTc. You should manually confirm the computer's findings.***

Determining Normal QT Intervals

- **If you have a BASELINE 12 Lead ECG**, select the lead with the LONGEST QT Interval for your Rhythm Strip . . . .
- **If you DO NOT have a Baseline 12 Lead ECG**, Obtain ECG rhythm strip of Chest Lead V2 or V3 (see next slide for ECG lead placement).
- Count the number of small (1mm) boxes starting at the beginning of the QRS complex through the END of the T wave.
- Multiply the “number of 1mm boxes” in the QT Interval x 40 to determine how many Milliseconds the QT Interval is.

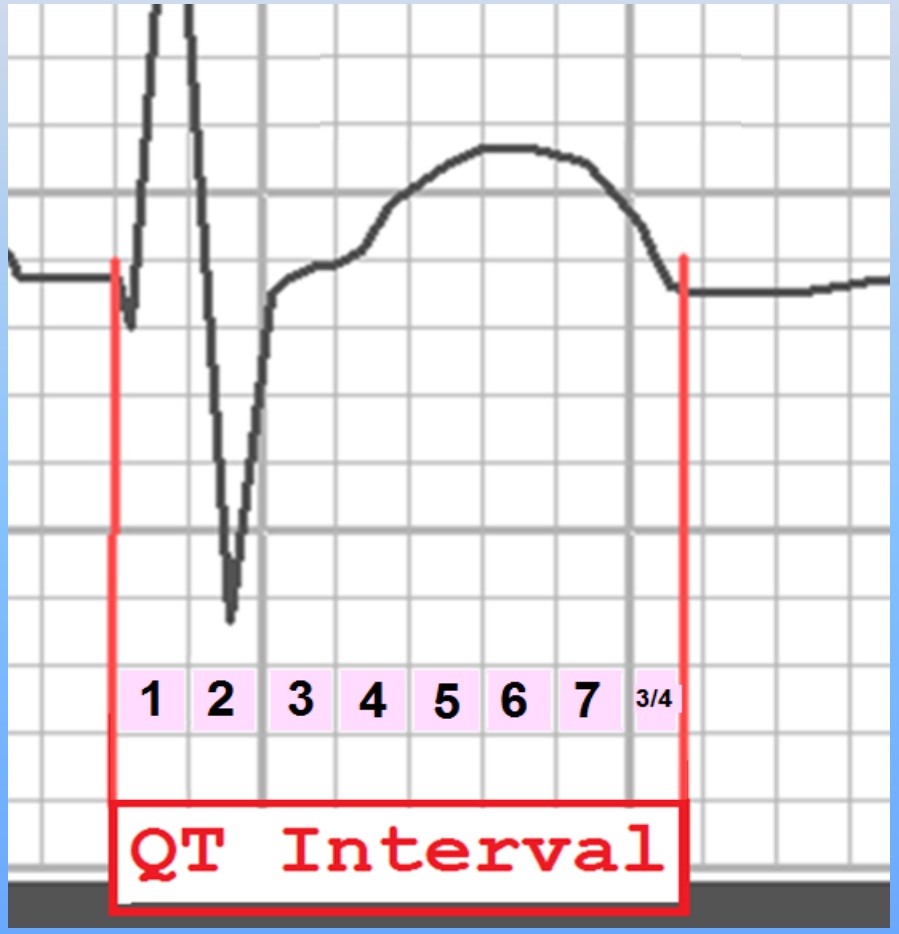
LEAD PLACEMENT - V3



5 WIRE TELEMETRY UNIT

Determining Normal QT Intervals

(when recorded at standard adult ECG speed of 25mm/sec) :



1. QT interval = 7 ¾ little boxes (1mm=40ms).
2. 7 ¾ = 7.75
3. **7.75 x 40 = 310 ms**

This patient's QT Interval is: 310 milliseconds.

Determining The QTc (corrected QT):

- After we know the QT Interval measurement and the heart rate (R-R interval), we can determine the QTc by one of the following three methods, as indicated on the next several slides:
  1. 12 Lead ECG report (not always accurate – requires manual confirmation)
  2. Manual Calculation (using mathematical formulas)
  3. Web-based Apps ☺
  4. Smartphone Apps ☺

Determining the QT / QTc

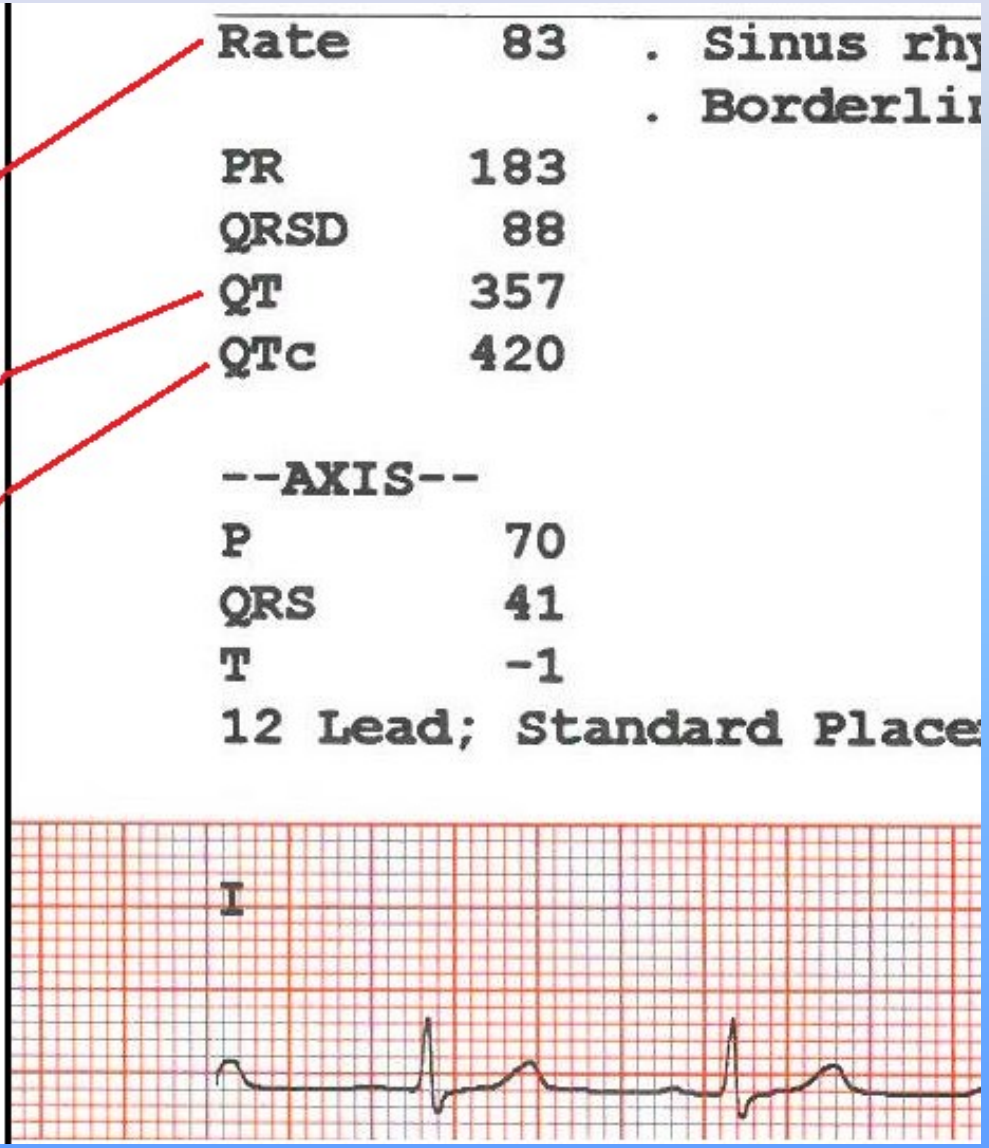
Method 1 – 12 Lead ECG Report:

Standard 12 Lead ECG printout . . .

Heart Rate = 83

QT Interval = 357

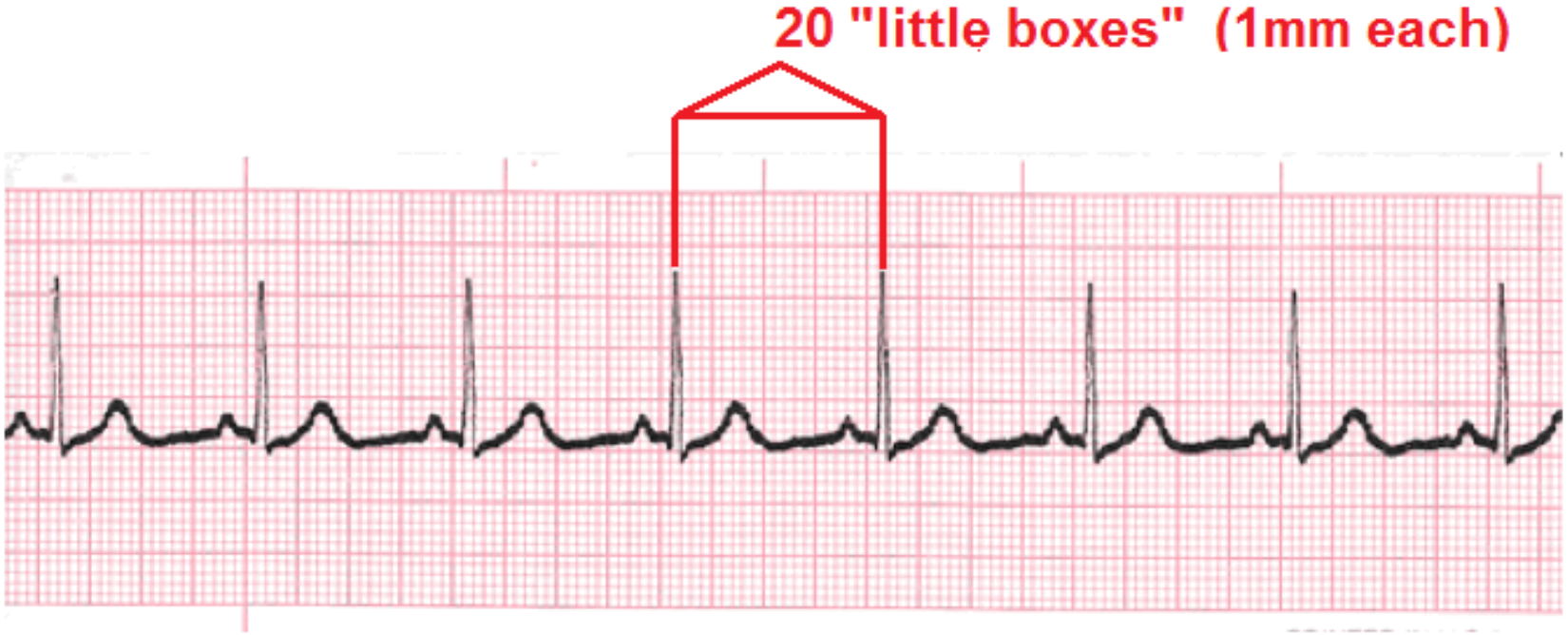
QTc = 420



Determining The QTc (corrected QT):

IF you are calculating the QTc manually (not using a smartphone or computer based app), you must know what the patient's R-R Interval is. To determine the R-R Interval, simply count the number of 1mm boxes between two consecutive QRS complexes and multiply by 40. This will give you the R-R interval in Milliseconds. The next slide demonstrates this:

Determining R-R Interval:



20 x 40 = 800

R-R Interval = 800 ms

Determining the QTc

Method 2, manual calculation:

QT CORRECTION FORMULAS:

Bazett's	$QTc=QT/\sqrt{RR}$
Fredericia	$QTc=QT/(RR)1/3$
Framingham	$QTc=QT+0.154(1-RR)$
Rautaharju	$QTp=656/(1+HR/100)$

Determining the QTc

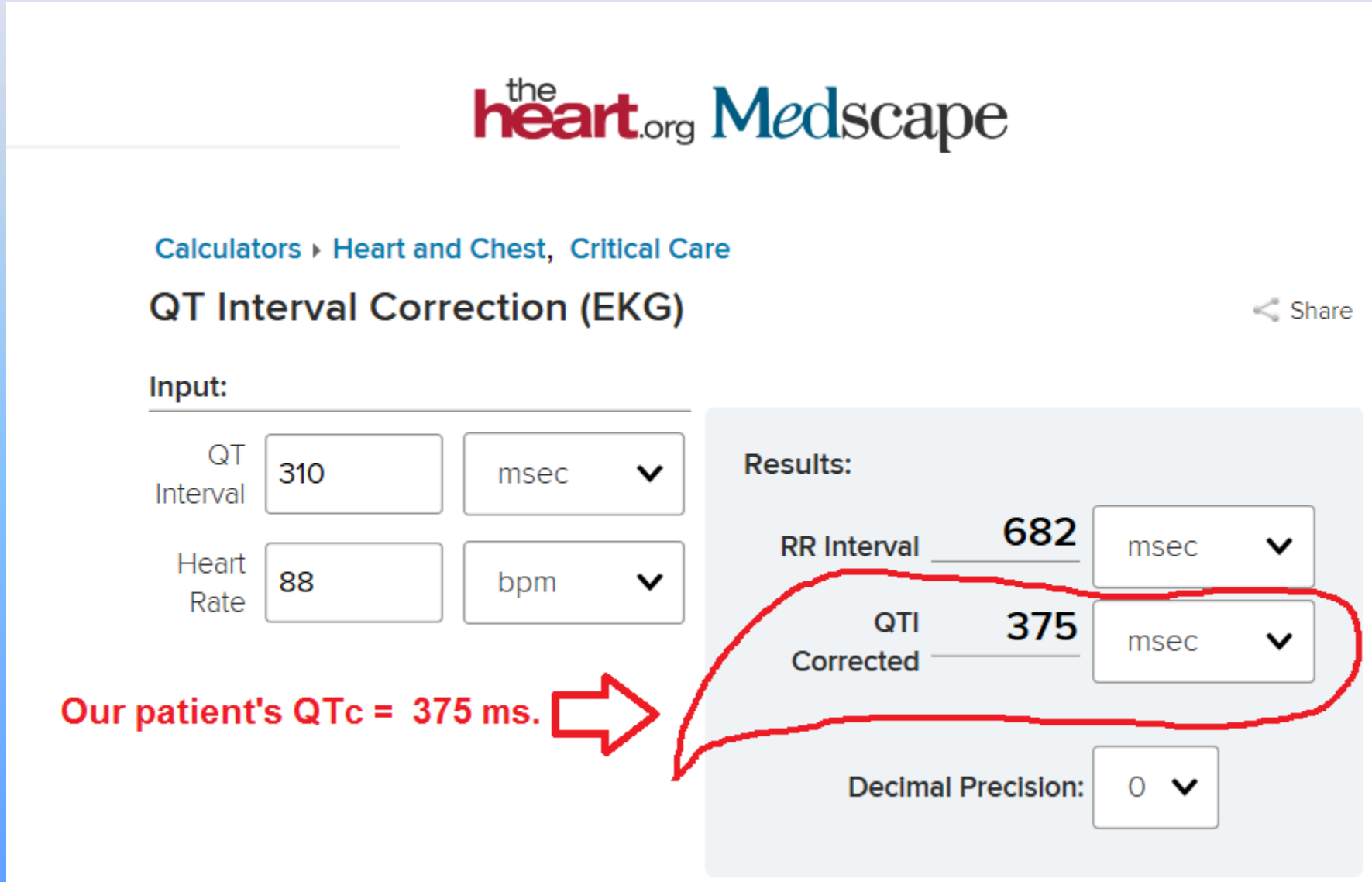
Method 3, Use a Web-based App:

- **Some Websites** (try them!) . . .
  - http://www.medcalc.com/qtc.html
  - https://reference.medscape.com/calculator/qt-interval-correction-ekg
  - Bazett's Formula - https://www.medical-calculator.nl/calculator/QTc/

☞ You'll just OPEN THE WEB PAGE, and PLUG IN the patient's QT Interval and Heart Rate. The calculator will do the rest, as seen on the NEXT PAGE . . . .

Determining the QTc

Method 3, Use a Web-based App:

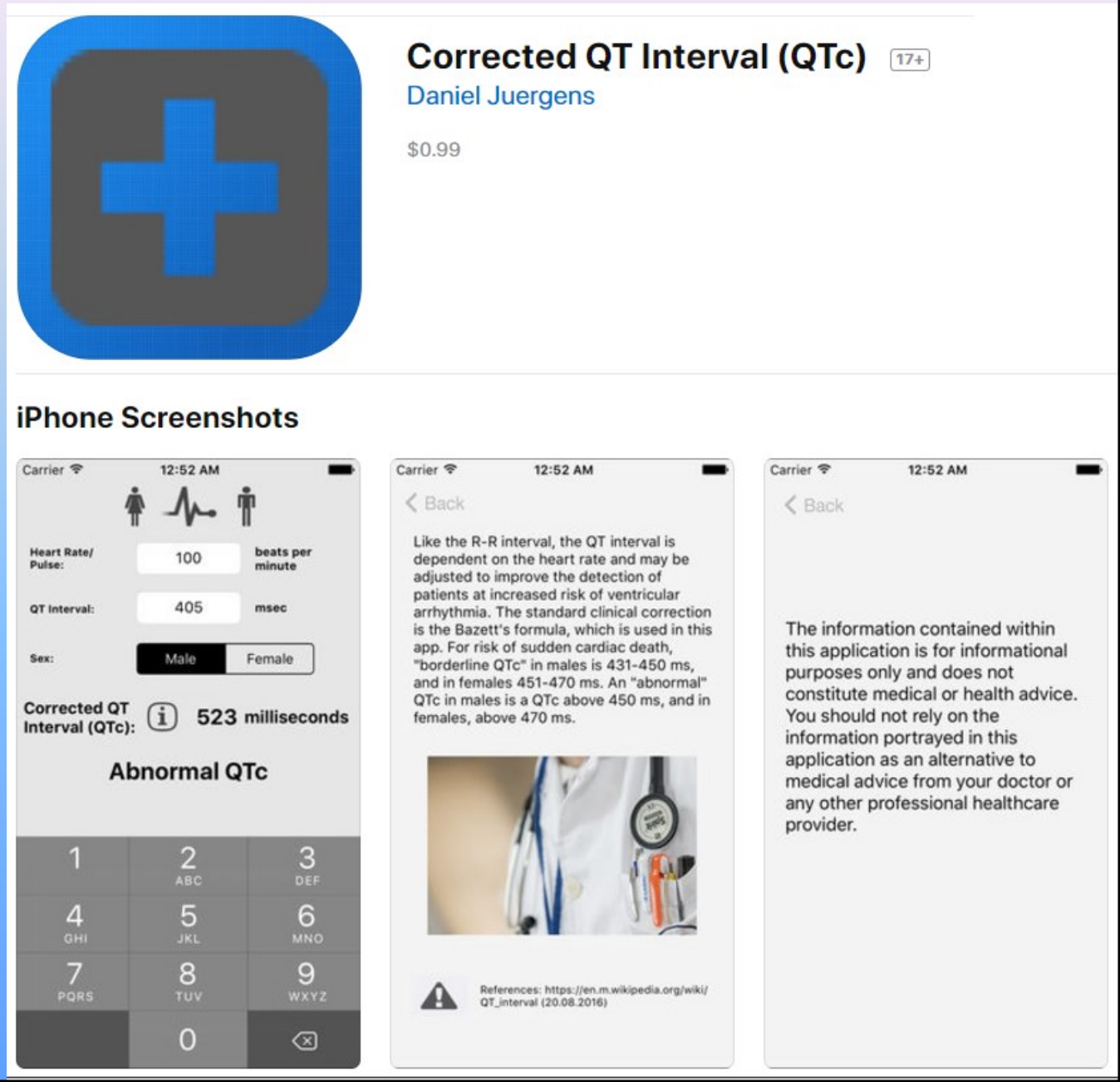


Determining the QTc

Method 4, Use a Smartphone App:

- **iPhone**
  - https://itunes.apple.com/us/app/corrected-qt-interval-qtc/id1146177765?mt=8
- **Android**
  - https://play.google.com/store/apps/details?id=com.medsam.qtccalculator&hl=en

“There’s an APP for that!”



[LINK to preview EP tools on iTunes website – click here]

//itunes.apple.com/us/app/eptools/id430201878?mt=8

App Store Preview

epTools 17+

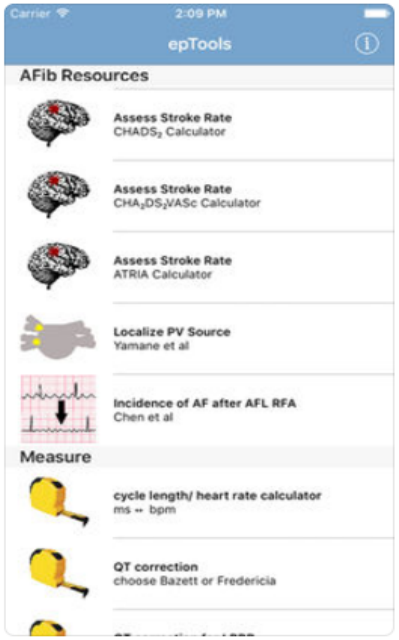
Resources for Cardiac EP

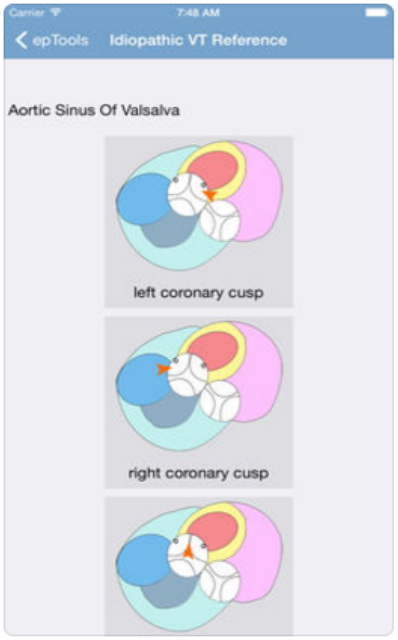
Busy Being Born Solutions, LLC

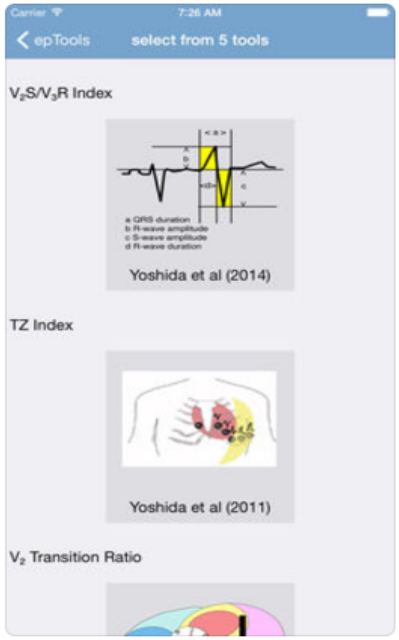
$5.99

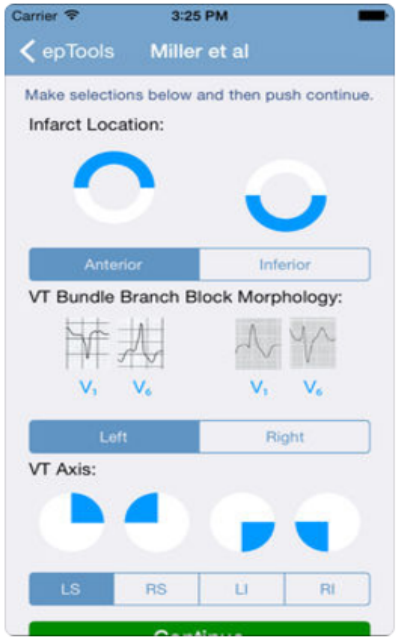
My favorite ECG / Cardiology iPhone APP:
- **has updated list of QT prolonging meds from AZ University (AZCERT)**
- **QTc calculation tools (Bazett's & Fredericia)**

Screenshots iPhone iPad









QTc Values:

Males:

Too Short:	<390 ms
Normal:	390 - 450 ms
Borderline High:	450 - 500 ms
Critical High:	> 500 ms

Females:

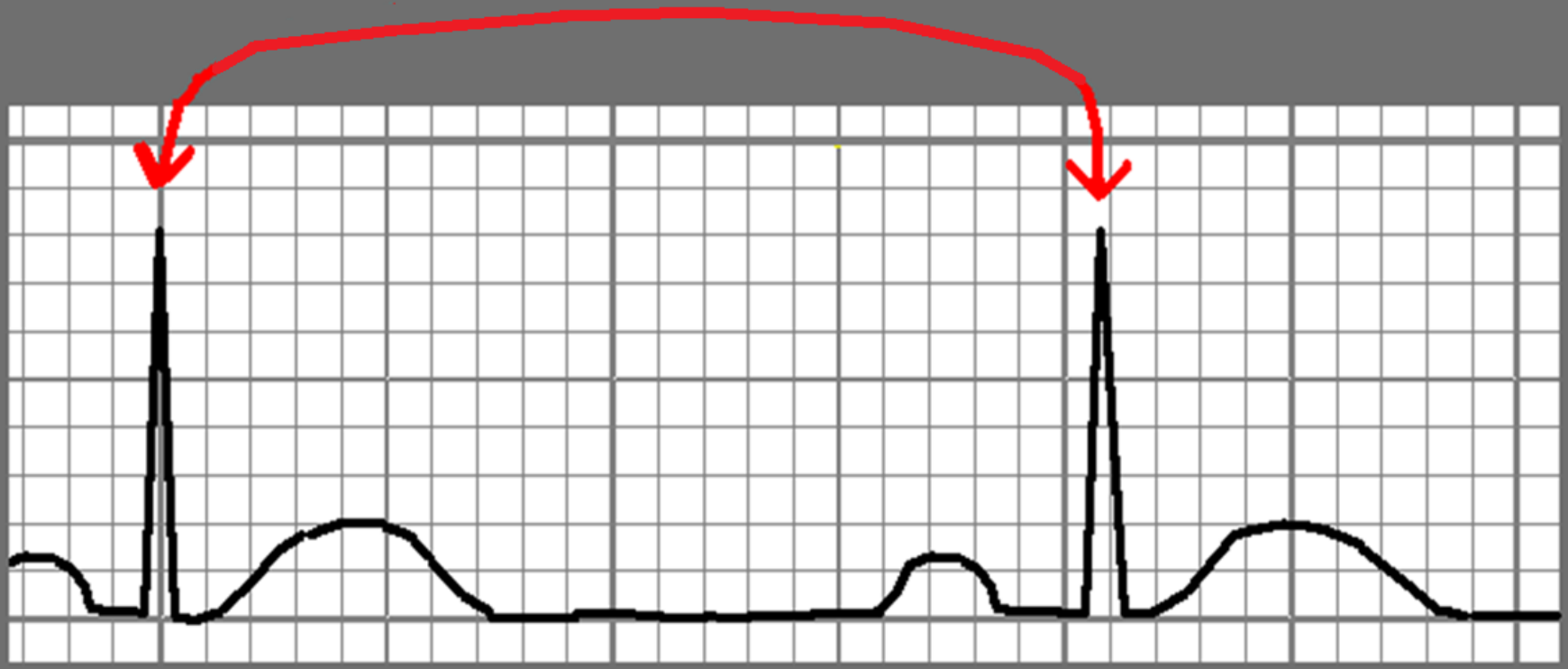
Too Short:	<390 ms
Normal:	390 - 460 ms
Borderline High:	460 - 500 ms
Critical High:	> 500 ms

SOURCE: "ACC/AHA/HRS Recommendations for Standardization and Interpretation of the ECG, Part IV: The ST Segment, T and U Waves, and the QT Interval" Rautaharju et al 2009

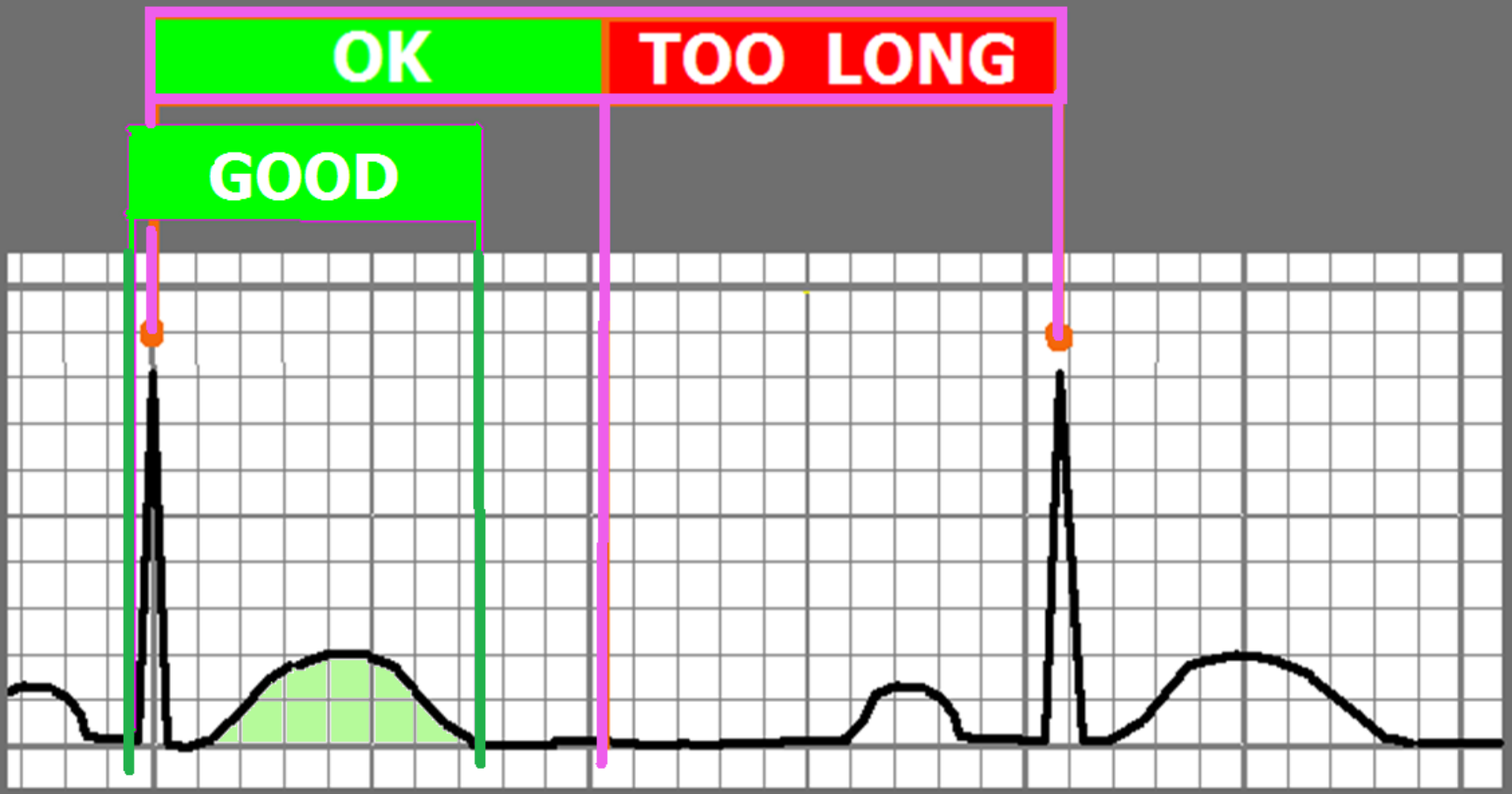
DETERMINING Q-T INTERVAL LIMITS

THE "QUICK PEEK" METHOD

- Relatively accurate method to quickly identify patients with abnormal QT Intervals.
  - Applies to patients with normal heart rates (60-100) and narrow QRS (QRSd <120ms)



The Q - T Interval should be LESS THAN 1/2 the R - R Interval



The Q - T Interval should be LESS THAN 1/2 the R - R Interval

From: **What Clinicians Should Know About the QT Interval**
JAMA. 2003;289(16):2120-2127. doi:10.1001/jama.289.16.2120

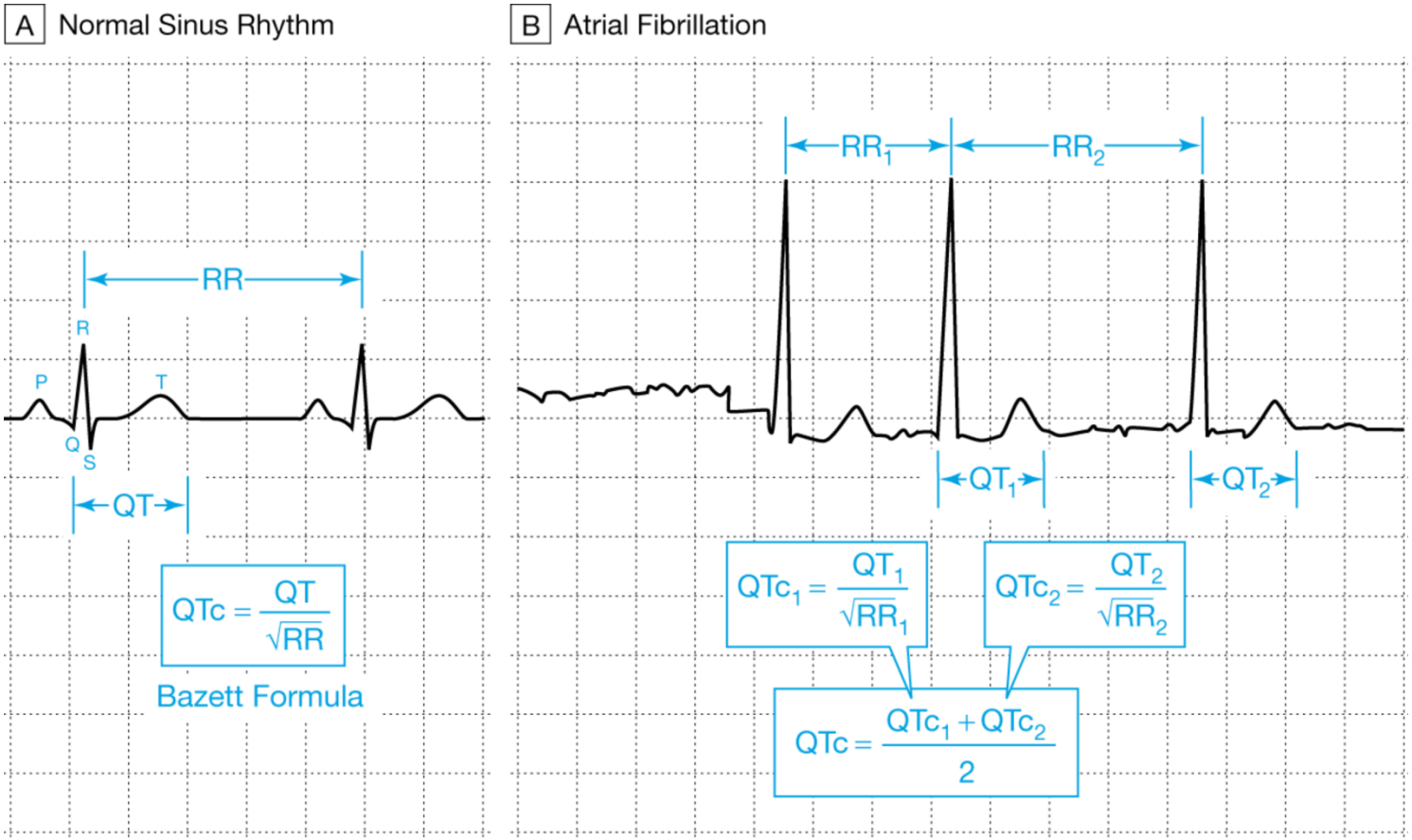


Figure Legend:

QTc indicates corrected QT interval; RR, R-R interval. A, Normalsinus rhythm; the Bazett formula is used to correct the QT interval for theheart rate. B, Atrial fibrillation; QT interval is calculated by taking theaverage of QT intervals with shortest and longest preceding R-R intervals.

QT Prolongation -- *STAT Intervention:*

- **Evaluate patient's meds list for meds that prolong the QT Interval.**
- **Discontinue any medication(s) known to prolong the QT Interval**
- **Consult pharmacist and the patient's physician to determine alternate medications that do not prolong the QT interval.**
- **Obtain a thorough patient history, to rule out incidence of syncope, seizures (**of unknown etiology**), and family history of sudden death/ near sudden death.**
- **Rule out hypothermia**
- **Rule out CVA / intracranial bleed**
- **Evaluate the patient's electrolyte levels**
- **Continuously *MONITOR PATIENT'S ECG FOR RUNS OF TORSADES***
- **Consider "expert consult" (electrophysiologist) to rule out LQTS**

QT Prolongation -- *STAT Intervention:*

☞ ***Avoidance of Meds that are known to prolong the QT Interval. Click here for current list from CREDIBLEMEDS.ORG***

Commonly used QT prolonging meds include:

-Amiodarone
-Procainamide
-Levaquin
-Erythromycin
-Norpace
-Tequin
-Benadryl
-Ritalin
-Pseudophedrine
-Haloperidol
-Thorazine
-Propulcid
-Zofran
-Ilbutilide

and MANY more!

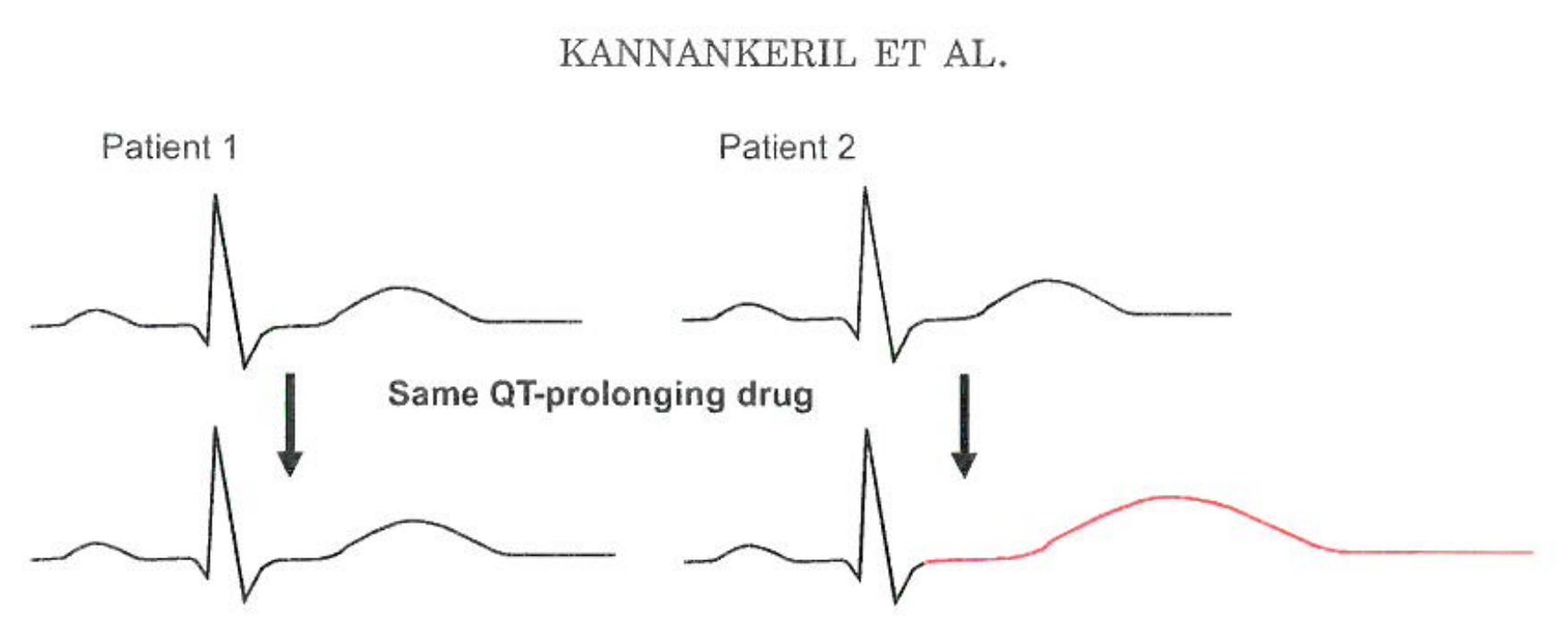
Genetic Susceptibility *to QT Prolonging Meds:*

A small subset of the population is genetically susceptible to QT Prolonging Medications. These patients typically have NORMAL QT intervals, but when given QT prolonging medication(s), the QT interval becomes prolonged over a (variable) period of time.

If left unnoticed and uncorrected, the QT Interval will frequently progress to “panic levels” (QTc >500), with possible development of Torsades de Pointes, Cardiac Arrest and Death.

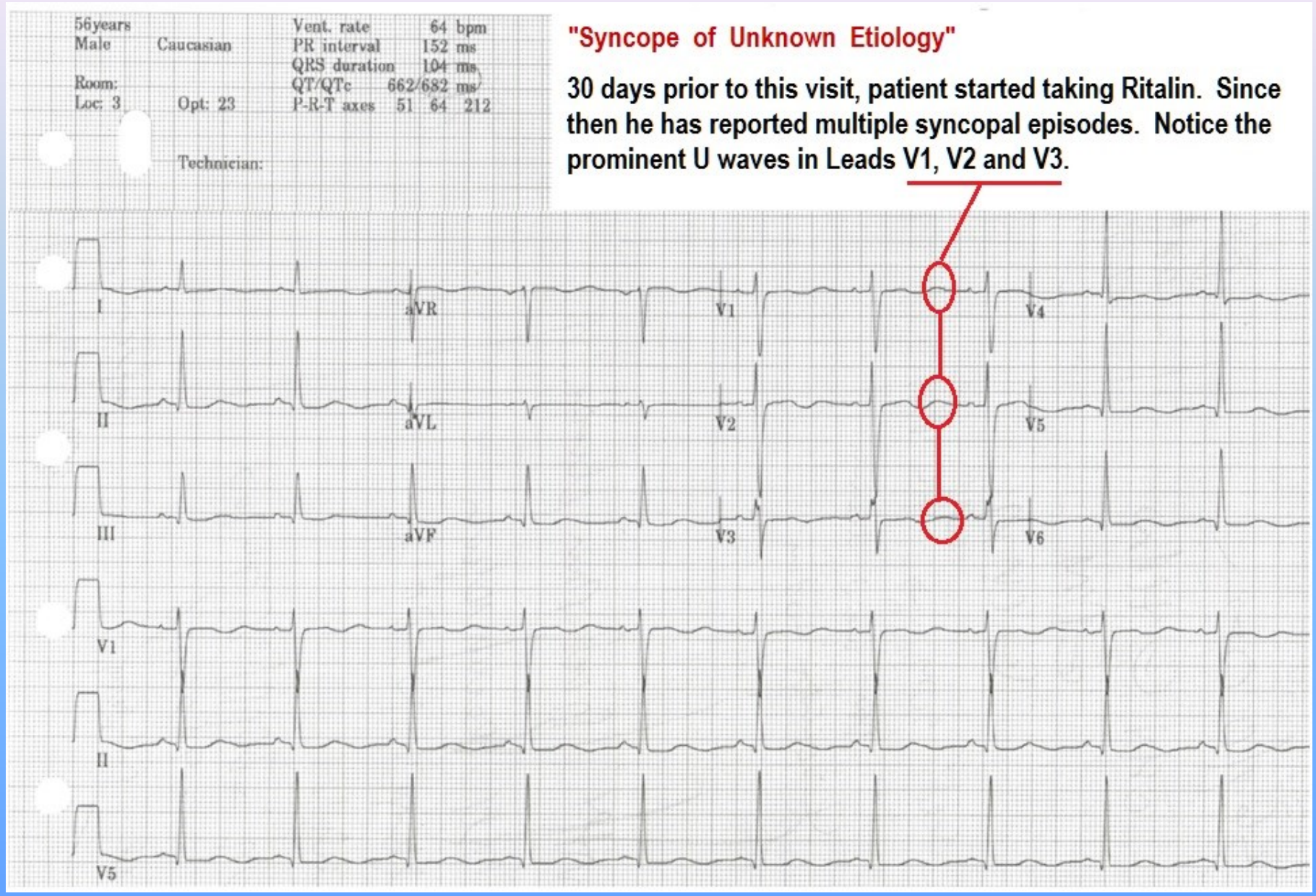
PATIENT 1: NORMAL

PATIENT 2: Genetic susceptibility; sensitivity to QT prolonging drugs:



Click here for link to paper by Kannankeril et al (2010 Pharmacological Reviews) that describes genetic susceptibility described above.

Medication induced LQTS with TdP and Cardiac Arrest - Case Study: 56 year old male



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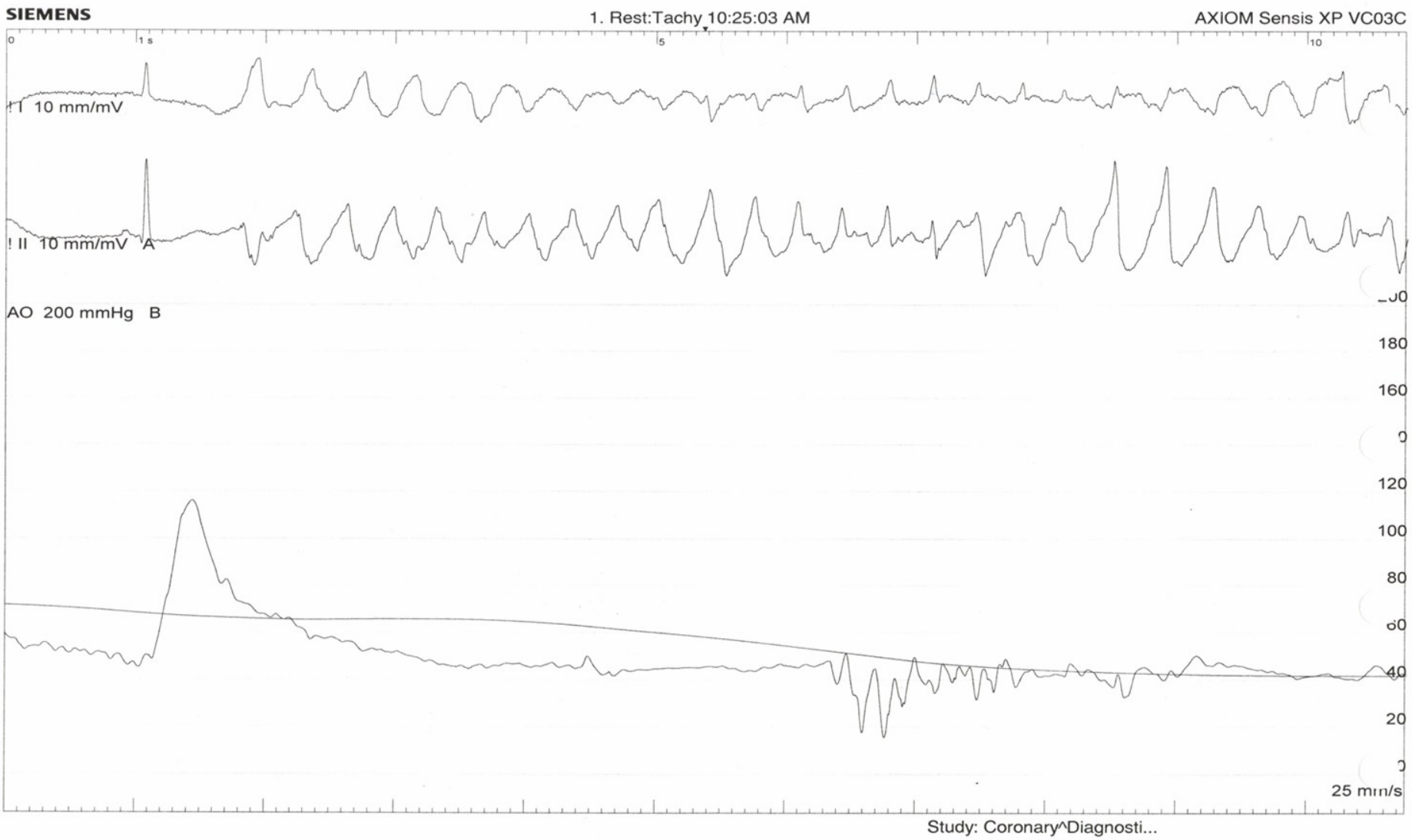
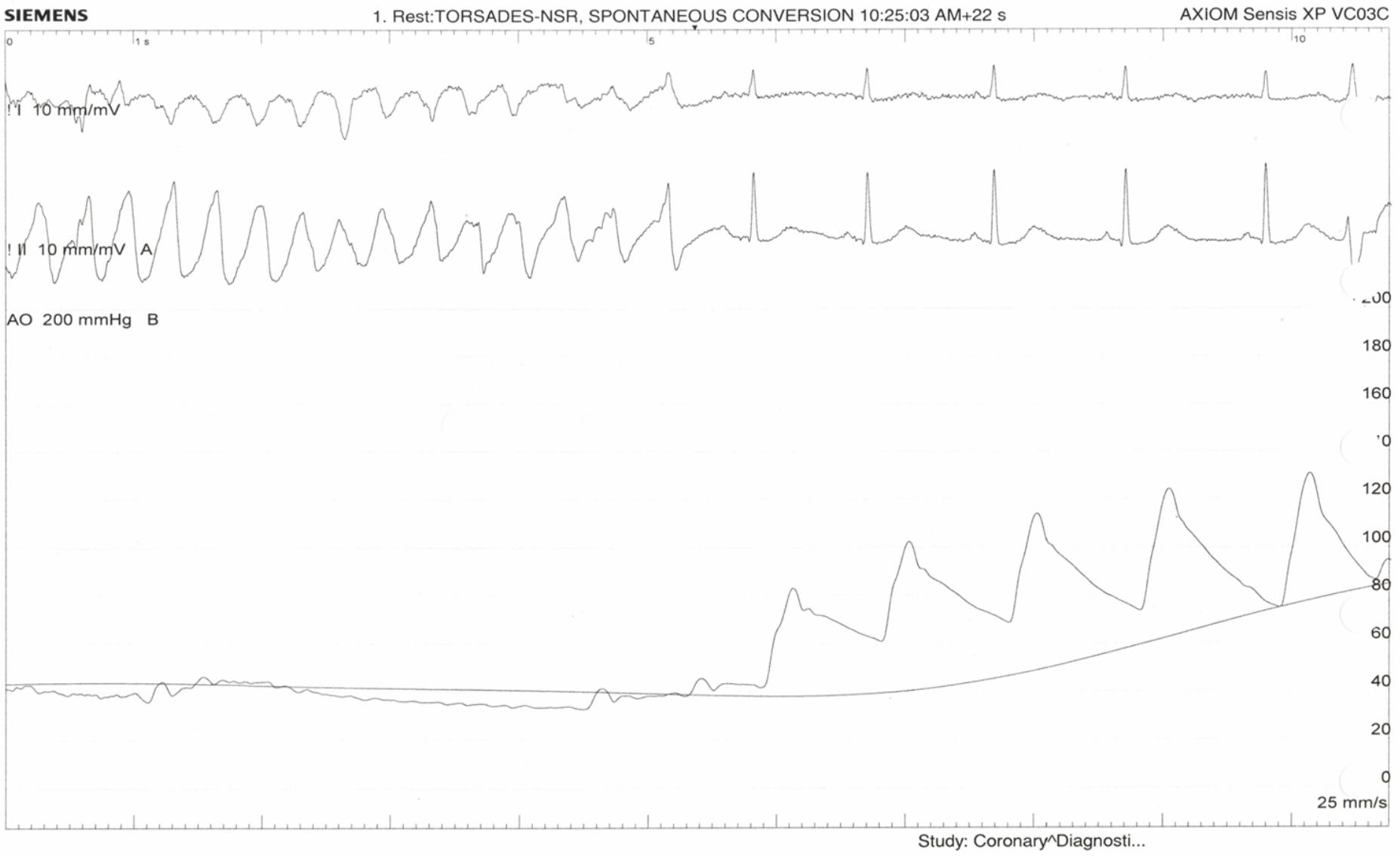


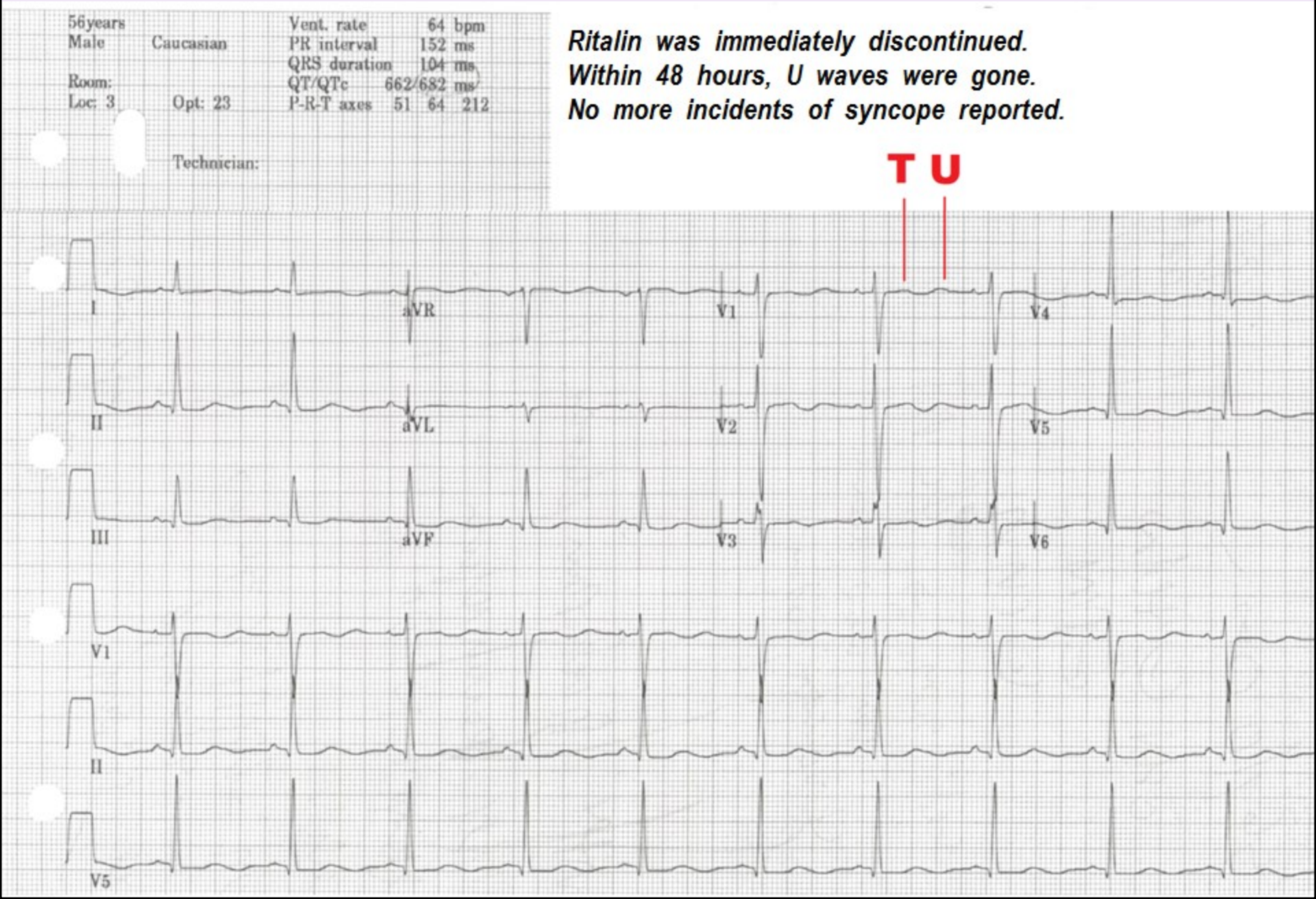
Run of Torsades de Pointes occurred during Cardiac Catheterization . . .

Medication induced LQTS with TdP and Cardiac Arrest - Case Study: 56 year old male



Torsades de Pointes self-terminates just before aborted Defibrillation

Medication induced LQTS with TdP and Cardiac Arrest - Case Study: 56 year old male



EMERGENCY MANAGEMENT
of
Torsade de Pointes

. . . Measures should be implemented at the first indication of Torsades de Pointes. This includes "noting a short, self-terminating run of TdP."

Emergency Management of Torsades de Pointes (Transient or Persistent, patient hemodynamically stable):

1. **DISCONTINUE all QT Prolonging Meds.**
2. **Administer 1-2 Grams of Magnesium Sulfate IV over 5 – 60 minutes** *

* American Heart Association (AHA) Advanced Cardiac Life Support (ACLS) 2015 Standards

Specific Treatment OF TORSADES de POINTES per AHA ACLS 2015:

-TRANSIENT: MAGNESIUM SULFATE 1 – 2 gm IV infusion over 5 – 60 minutes.

-PERSISTENT, PATIENT UNSTABLE: DEFIBRILLATION

-CARDIAC ARREST: FOLLOW Ventricular Fibrillation Algorithm. Consider Mag Sulfate as your Antiarrhythmic of choice.

WIDE COMPLEX TACHYCARDIA
TORSADES de POINTES

(QRS > 120 ms)

ABC s

NO PULSE	PULSE - UNSTABLE	PULSE - STABLE
GO TO V - FIB ALGORITHM !	▪ IMMEDIATE DEFIBRILLATION START IV CONSIDER SEDATION	▪ O2 / IV / EKG ▪ MAGNESIUM INFUSION 1 - 2 gm OVER 5 - 60 min,

DO NOT give PROCAINAMIDE, AMIODARONE, or SOTALOL to patients with TORSADES or POLYMORPHIC VT !!!

OTHER CONSIDERATIONS:

- EVALUATE BASELINE ECG RHYTHM FOR PRONGED Q-T INVERVAL.
- EVALUATE PATIENT'S MEDS FOR Q-T PROLONGING DRUGS
  . . . if PATIENT HAS BEEN RECEIVING ANY Q-T PROLONGING DRUGS, IMMEDIATELY DISCONTINUE AND CONTACT PHYSICIAN STAT.
- EVALUATE PATIENT HISTORY FOR PREVIOUS EVENTS OF "SYNCOPE OF UNKOWN ETIOLOGY"
- EVALUATE PATIENT FOR FAMILY HISTORY FOR SUDDEN CARDIAC DEATH

REPORT ANY ABNORMAL FINDINGS TO PHYSICIAN.

Strategy to Reduce Adverse Drug Reactions (ADRs) from LQTS:

Implementation of QT Interval Monitoring Protocol for all patients receiving two or more medications known to prolong the QT Interval. **(click here to download protocol).**

- Developed in conjunction with Cardiology and Pharmacy Departments at Bayfront Health Dade City
- In its first month of operation, it identified 5 patients who developed CRITICAL QT Prolongation (QTc > 500ms) after receiving QT prolonging Meds.
- When Critical QTc Prolongation noted, QT prolonging meds discontinued, physician and pharmacist decide on alternate medication therapy.

Bayfront Health
Dade City

Results of QTc Monitoring Protocol - Trial - March 8 - March 22

In patients with QTc 500 or more (indicated by red arrow ➔), QT prolonging drugs were discontinued and substituted with non-QT prolonging medications.

	3/8/2016	3/9/2016	3/10/2016	3/11/2016	3/14/2016	3/15/2016	3/16/2016	3/17/2016	3/18/2016	3/21/2016	3/22/2016
PATIENT:											
A	389	400									
➔ B	425	437									
C	469	479	528	470	630	500	480				
D	465	426	400	370	470						
➔ E	559	495	480								
F	418										
G			370	420	460	420	460				
H			390	420							
I			416	430							
J			400	400							
K			435								
L			410	400	430	410	440	420	478	430	
➔ M					510						
N					480						
O					470						
➔ P					500						
Q						400	420	400	413		
R						440					
S						430	440	460			
T							400	480			
U								430			
V									491		
W									441	440	440
➔ X											530
Y											460
Z											390

QTc	Men	Women
Abnormal	>450	>460
Panic	500+	500+

QTc Medications - Monitoring Protocol
developed by: William Parker, Director of Pharmacy, Bayfront Health Dade City
Derek Harmeson, Director of ICU/CPCU
Wayne Ruppert, Cardiovascular Coordinator, Bayfront Health Dade City

Bayfront Health Dade City is a 120 bed community hospital with an accredited chest pain center and an interventional cardiac catheterization program in Dade City, Florida.

Additional ADR-Prevention Resources for Pharmacists / Physicians:

Click for link to: "Predicting the Unpredictable; Drug-Induced QT Prolongation and Torsades de Pointes: *J Am Coll Cardiol*. 2016;67(13):1639-1650

Click for link to "AHA ACC Scientific Statement: Prevention of Torsades de Pointes in the Hospital Setting," AHA Circulation 2010;

Thank you for taking this course.

You are now ready to take the test.

The following OPTIONAL slides contain supplemental material you may find helpful:

- Case Studies
- SIDS Correlations to LQTS
- LQTS Genotype Driven Beta Blocker Therapy
- LQTS Risk Assessment Score (Schwartz Score).
- Understanding Genetic Transmission
- Additional Web Resources
- Author's Contact Information

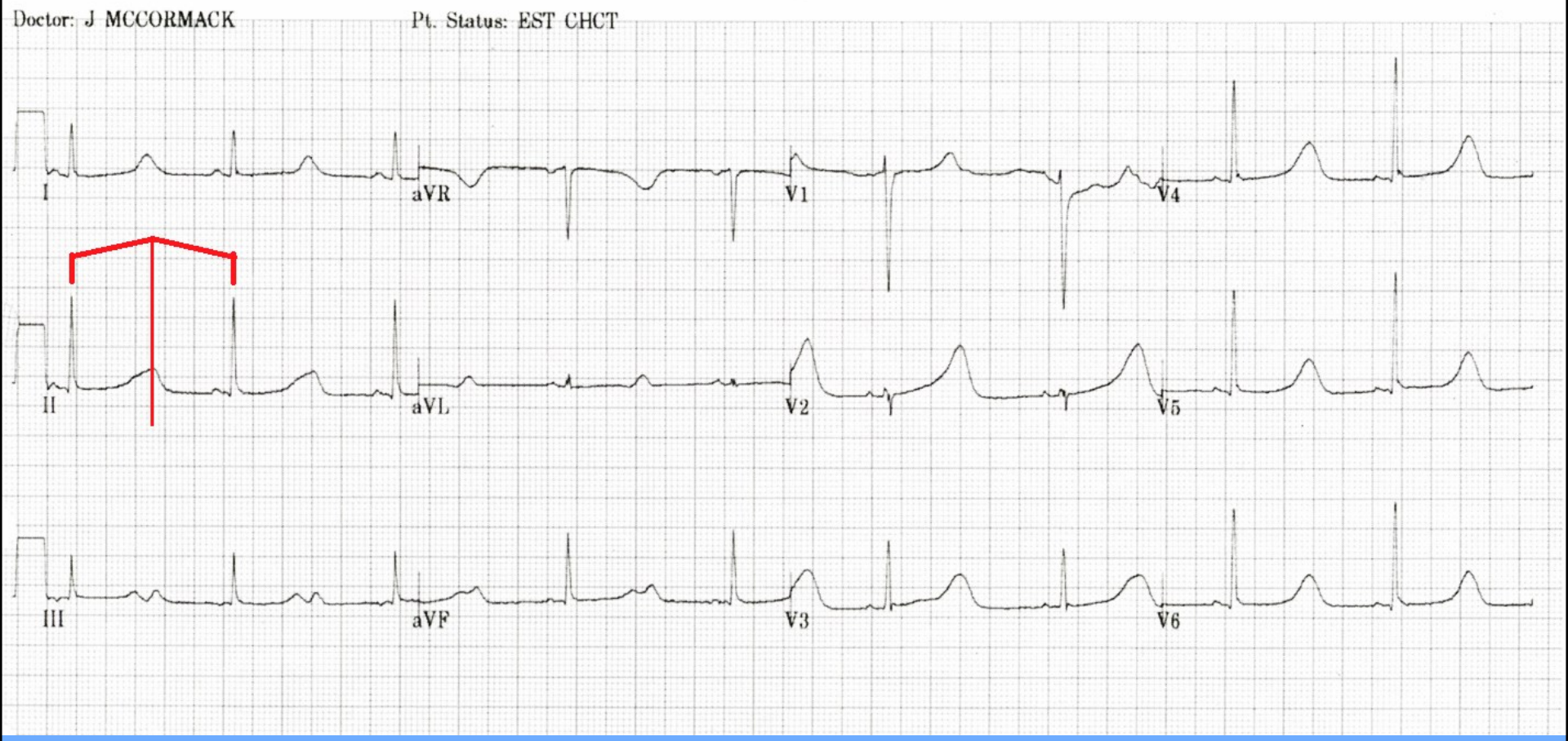
CASE STUDY 1:

The next ECG is that of a 22 year old female with “seizures of unknown etiology.” An astute cardiologist noted her prolonged QT interval. During exercise stress testing at the cardiologist’s office, she suffered Torsades de Pointes and cardiac arrest.

22 y/o FEMALE

Vent. rate	53 bpm
PR interval	110 ms
QRS duration	84 ms
QT/QTc	678/636 ms
P-R-T axes	25 60 48

PEDIATRIC CARDIOLOGY ASSOCIATES



WHEN THE "QUICK PEEK" METHOD for QT INTERAL EVALUATION IS APPLIED TO THE ABOVE ECG, WHAT IS THE RESULT?

CASE STUDY 1, cont'd:

During her run of Torsades, she had collapsed and exhibited grand-mal type seizure activity. Most likely, TdP was the cause of all previous "seizure episodes." She was resuscitated and diagnosed with Congenital Type 1 LQTS..

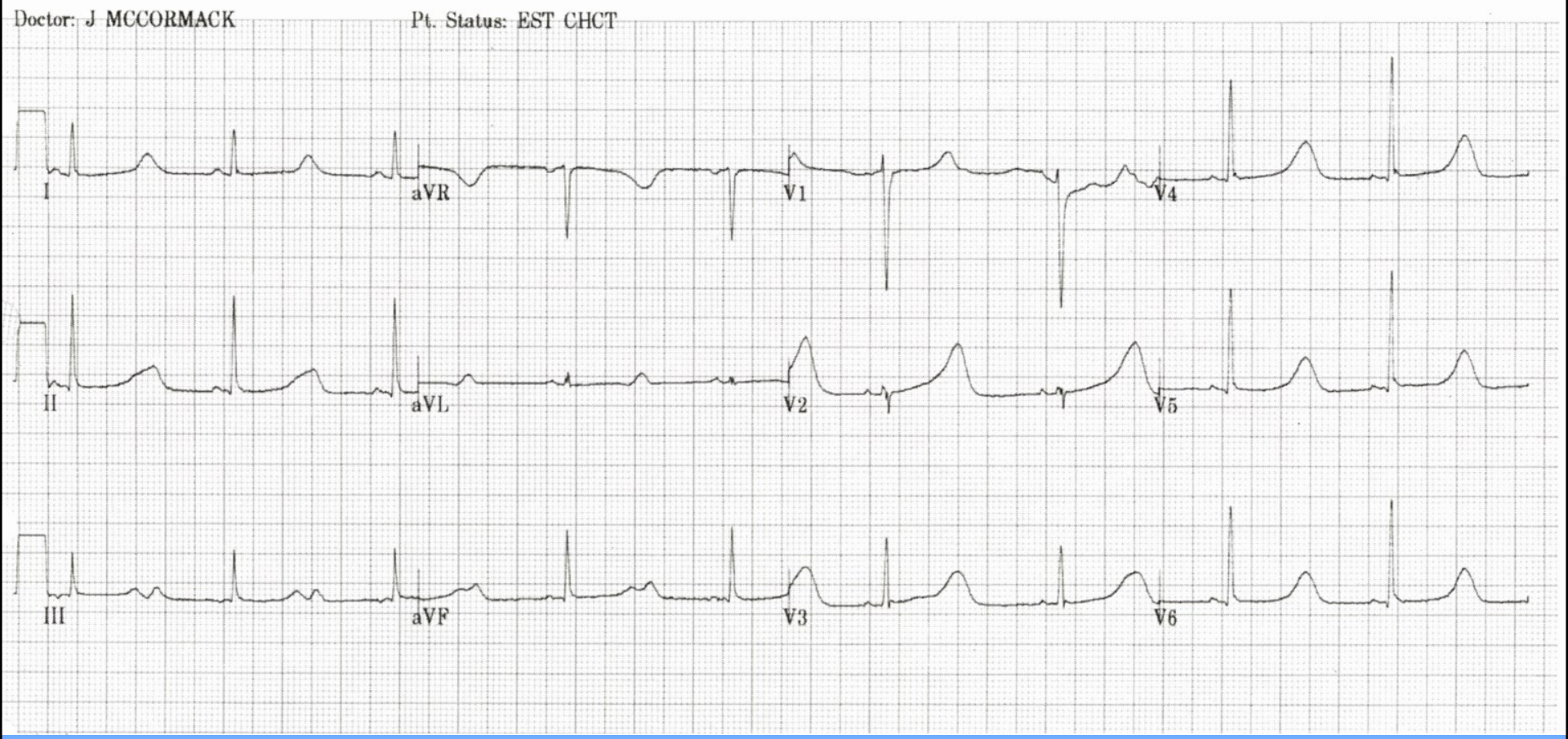
CASE STUDY 1, cont'd:

I met the patient when we implanted her ICD in the EP lab. Because she had a small child, we performed an ECG on him. He, too had a prolonged QT Interval, and received an ICD

22 y/o FEMALE

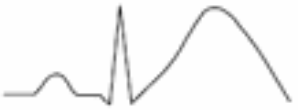
Vent. rate	53 bpm
PR interval	110 ms
QRS duration	84 ms
QT/QTc	678/636 ms
P-R-T axes	25 60 48

PEDIATRIC CARDIOLOGY ASSOCIATES



Note the shape and size of the T waves on this ECG, and then compare them to the examples on the next slide . . . .

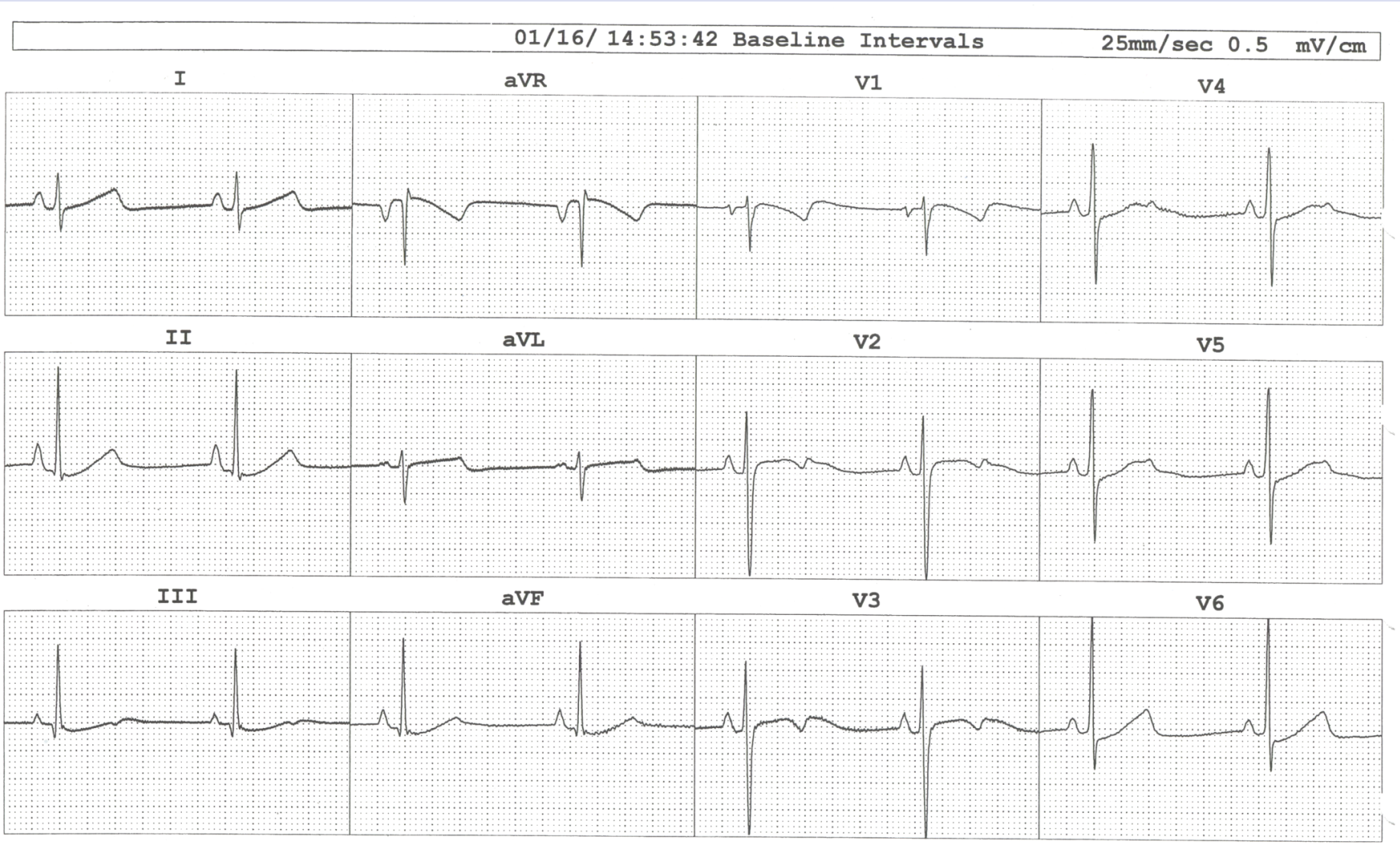
GENETICALLY ACQUIRED LONG QT SYNDROMES:
ECG PATTERNS of 3 MOST COMMON VARIATIONS:

Type	Current	Functional Effect	Frequency Among LQTS	ECG[12,13]	Triggers Lethal Cardiac Event[10]	Penetrance*
LQTS1	K	↓	30%-35%		Exercise (68%) Emotional Stress (14%) Sleep, Repose (9%) Others (19%)	62%
LQTS2	K	↓	25%-30%		Exercise (29%) Emotional Stress (49%) Sleep, Repose (22%)	75%
LQTS3	Na	↑	5%-10%		Exercise (4%) Emotional Stress (12%) Sleep, Repose (64%) Others (20%)	90%

CASE STUDY 2:

The young man whose ECG is featured on the next page, a 15 year old male, suffered sudden cardiac arrest while at a shopping mall in Tampa, FL. His mother, an off-duty RN, started CPR. Mall security applied an AED. He was successfully resuscitated. I met him when I assisted with his ICD implantation in the EP Lab.

15 year old male with undiagnosed LQTS. He suffered out-of-hospital sudden cardiac arrest; it was the first indication of his condition. His ECG is shown below. T waves consistent with LQTS Type 2 can be seen in Leads V2 and V3:



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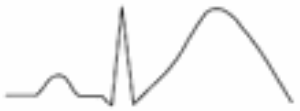
LQTS1	K	↓	30%-35%		Exercise (68%) Emotional Stress (14%) Sleep, Repose (9%) Others (19%)	62%
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LQTS3	Na	↑	5%-10%		Exercise (4%) Emotional Stress (12%) Sleep, Repose (64%) Others (20%)	90%

Look at the T waves in Leads V2 and V3 of the ECG on the previous page. Compare them to the T waves in this chart. What Genotype LQTS does it favor?

SIDS Correlation to LQTS

Schwartz et al instituted ambitious screening studies with 12-lead ECGs of >30,000 healthy neonates in the first week of life, who were followed up for 1 year and subsequently a study of almost 45 000 neonates at 15 to 25 days of life (1). A prolonged QT interval was strongly associated with SIDS, and LQTS mutations in the sodium channel (2).

1. Schwartz PJ, Priori SG, Dumaine R, et al. A molecular link between the sudden infant death syndrome and the long-QT syndrome. N Engl J Med. 2000;343:262–7.
2. Arnestad M, Crotti L, Rognum TO, et al. Prevalence of long-QT syndrome gene variants in sudden infant death syndrome. Circulation.2007;115:361–7

SIDS Correlation to LQTS

- Stillbirths, Sudden Infant Deaths, and Long-QT Syndrome AHA Circulation, 2004: Schwartz, Peter
- A Molecular Link between the Sudden Infant Death Syndrome and the Long-QT Syndrome, P Schwartz et al, NEJM 2000; 343:262-267

- Click here for PDF version of above article

LQTS genotype driven therapy

- Beta blocker therapy indicated for LQTS type 1 and type 2.
- Beta blocker therapy CONTRINDICATED for LQTS type 3: LQTS type 3 patients exhibit excessive further prolongation of the QT interval at slow heart rates.

LQTS Risk Assessment Score

Developed by Peter Schwartz, MD

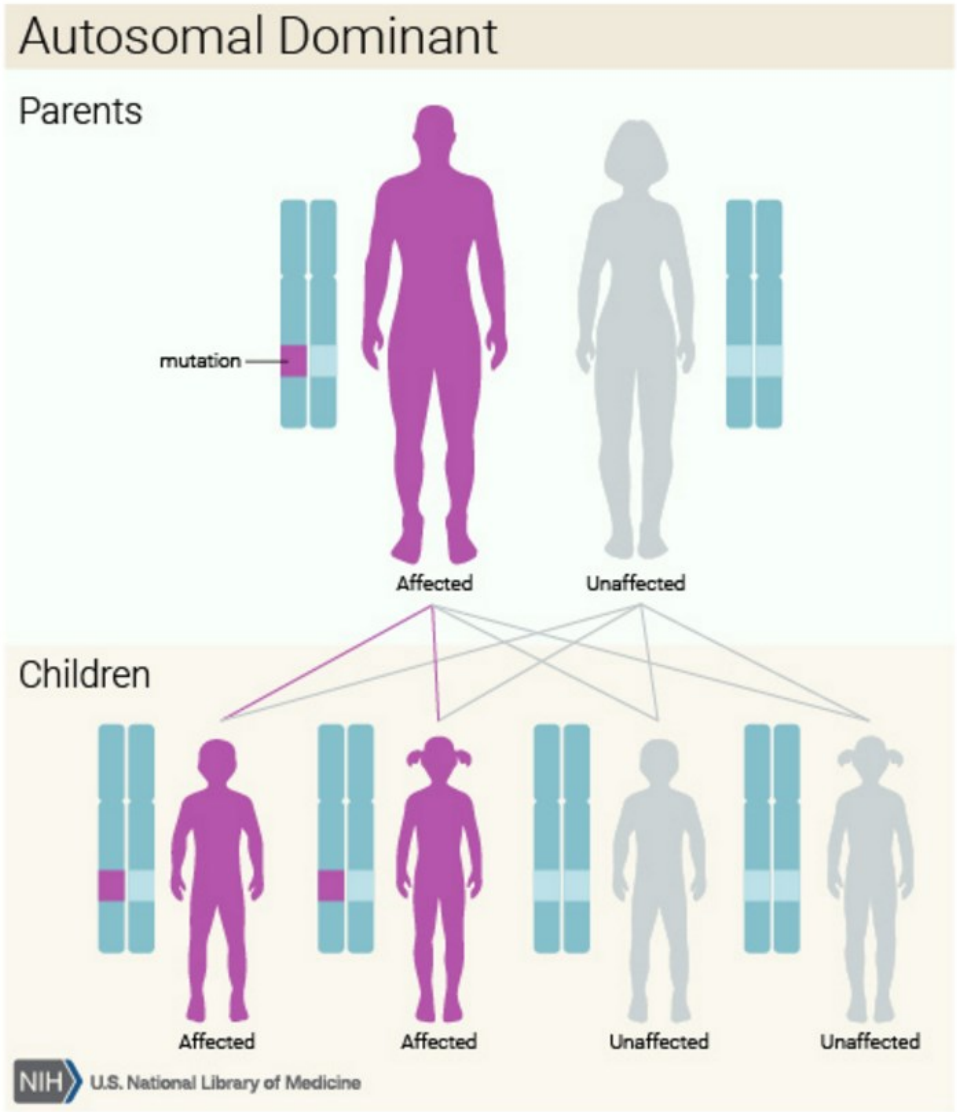
	Points
Electrocardiographic findings	
A QTc	
≥480 ms	3
460–479 ms	2
450–459 ms (in males)	1
B QTc 4th minute of recovery from exercise stress test ≥480 ms	1
C Torsade de pointes	2
D T wave alternans	1
E Notched T wave in 3 leads	1
F Low heart rate for age	0.5
Clinical history	
A Syncope	
With stress	2
Without stress	1
B Congenital deafness	0.5
Family history	
A Family members with definite LQTS	1
B Unexplained sudden cardiac death below age 30 among immediate family members	0.5

SCORE: ≤1 point: low probability of LQTS.

1.5 to 3 points: intermediate probability of LQTS.

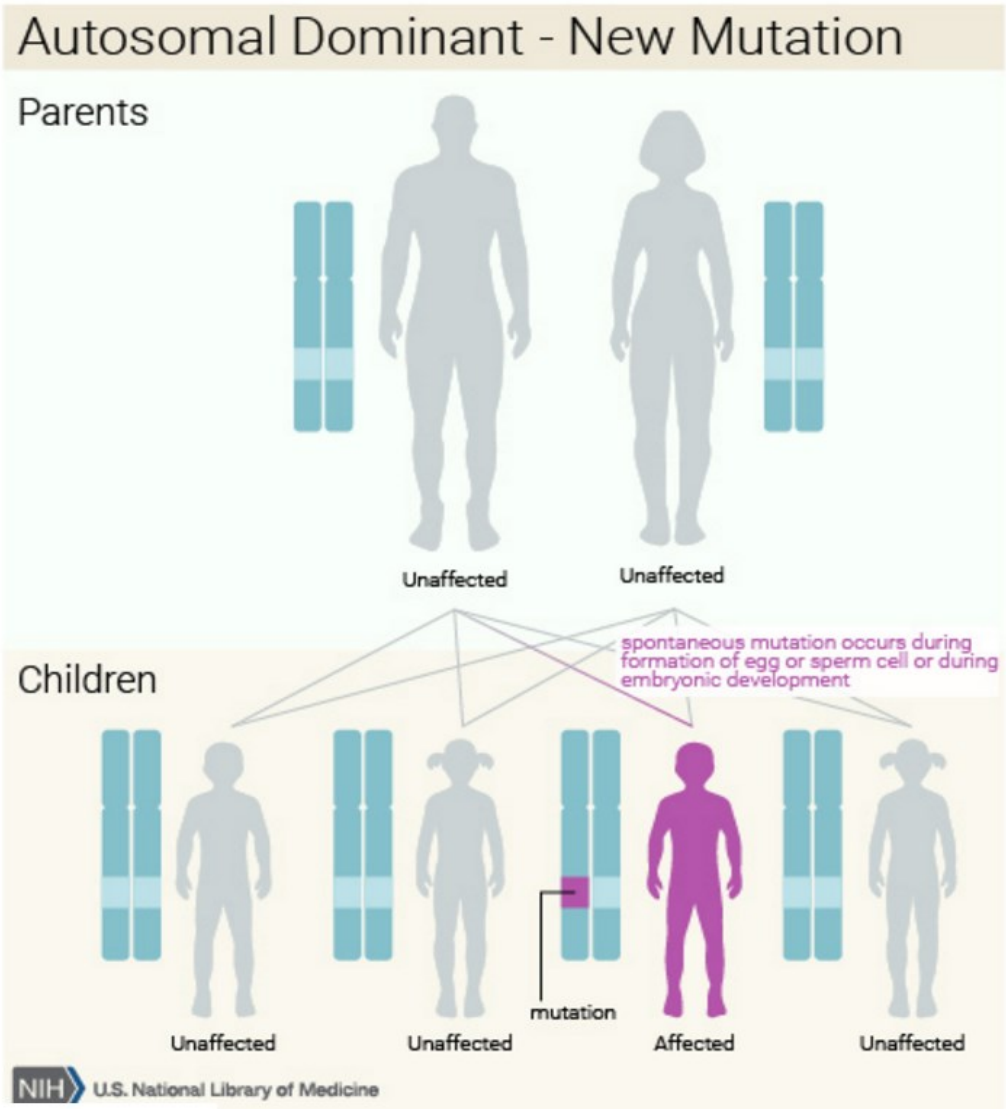
≥3.5 points high probability.

Understanding Genetic Transmission



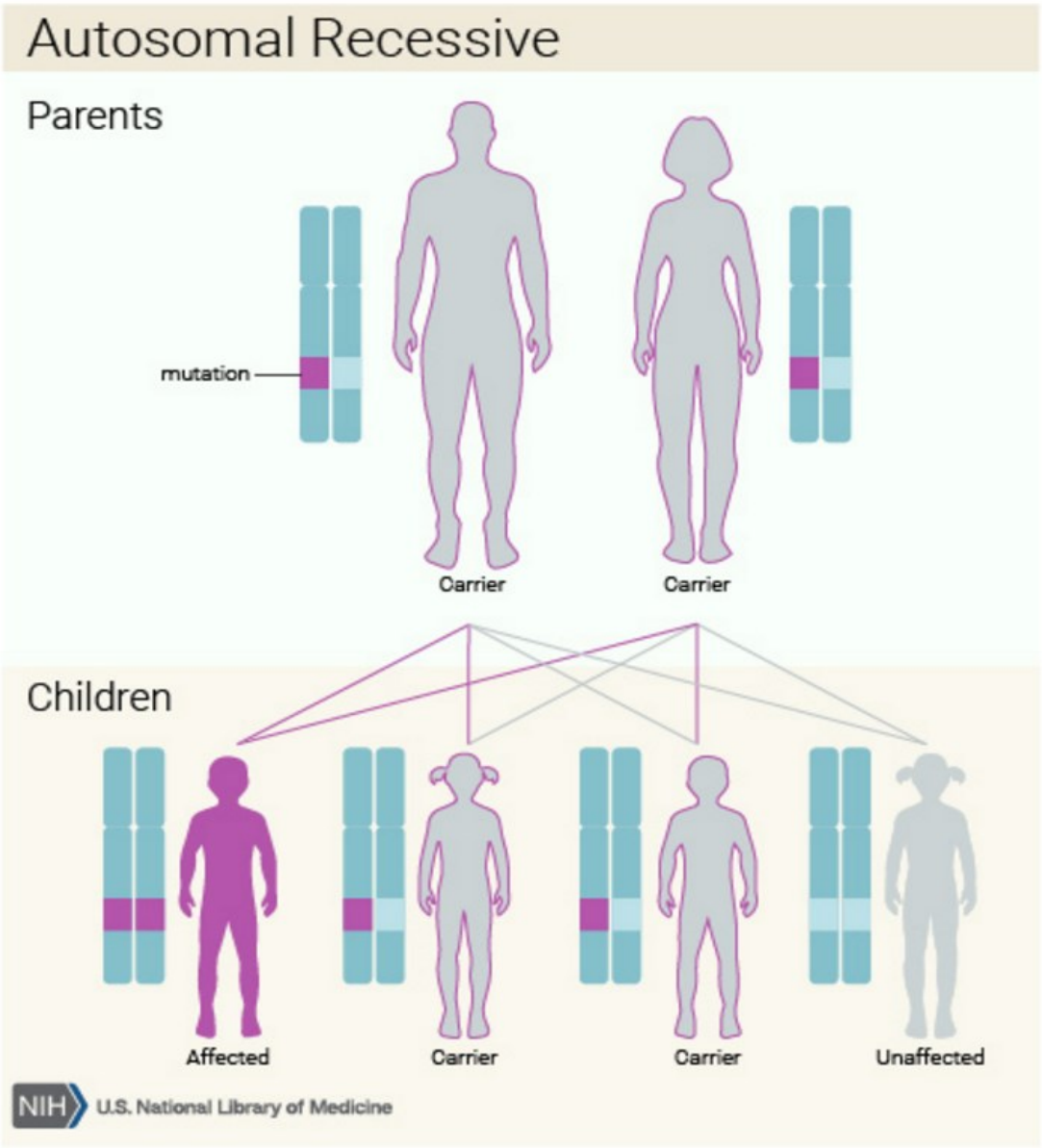
Credit: U.S. National Library of Medicine

Understanding Genetic Transmission

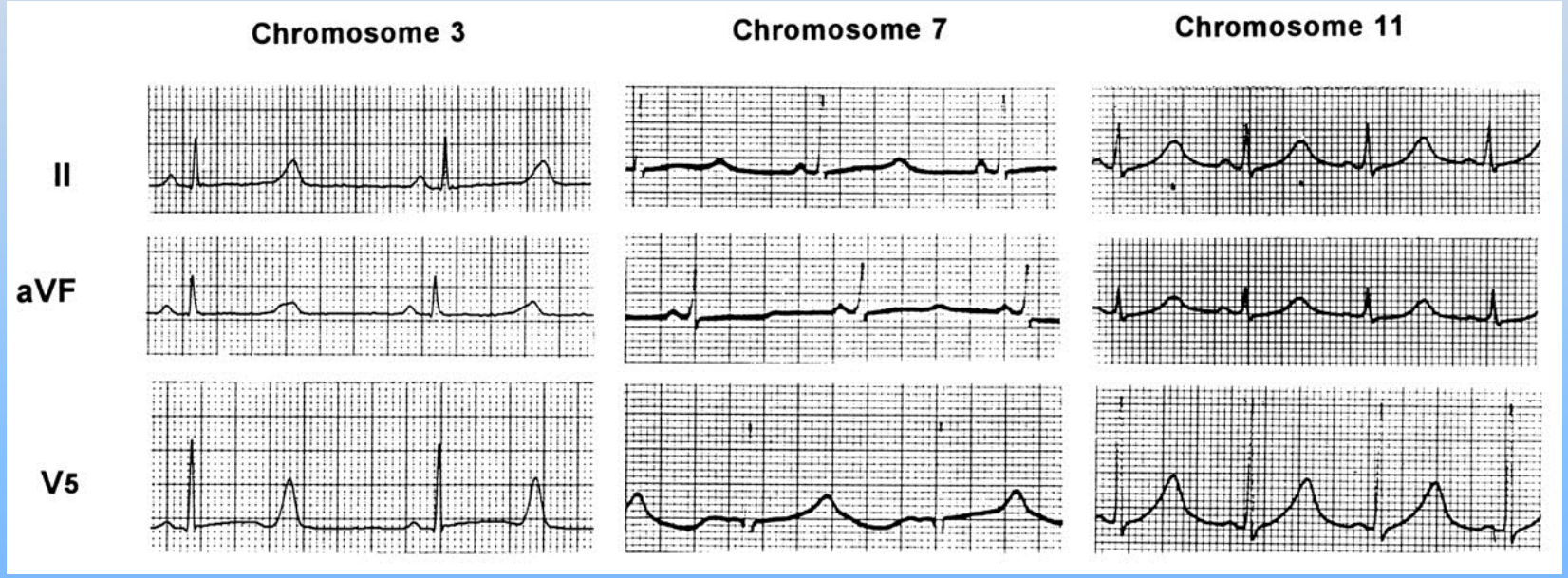


Credit: U.S. National Library of Medicine

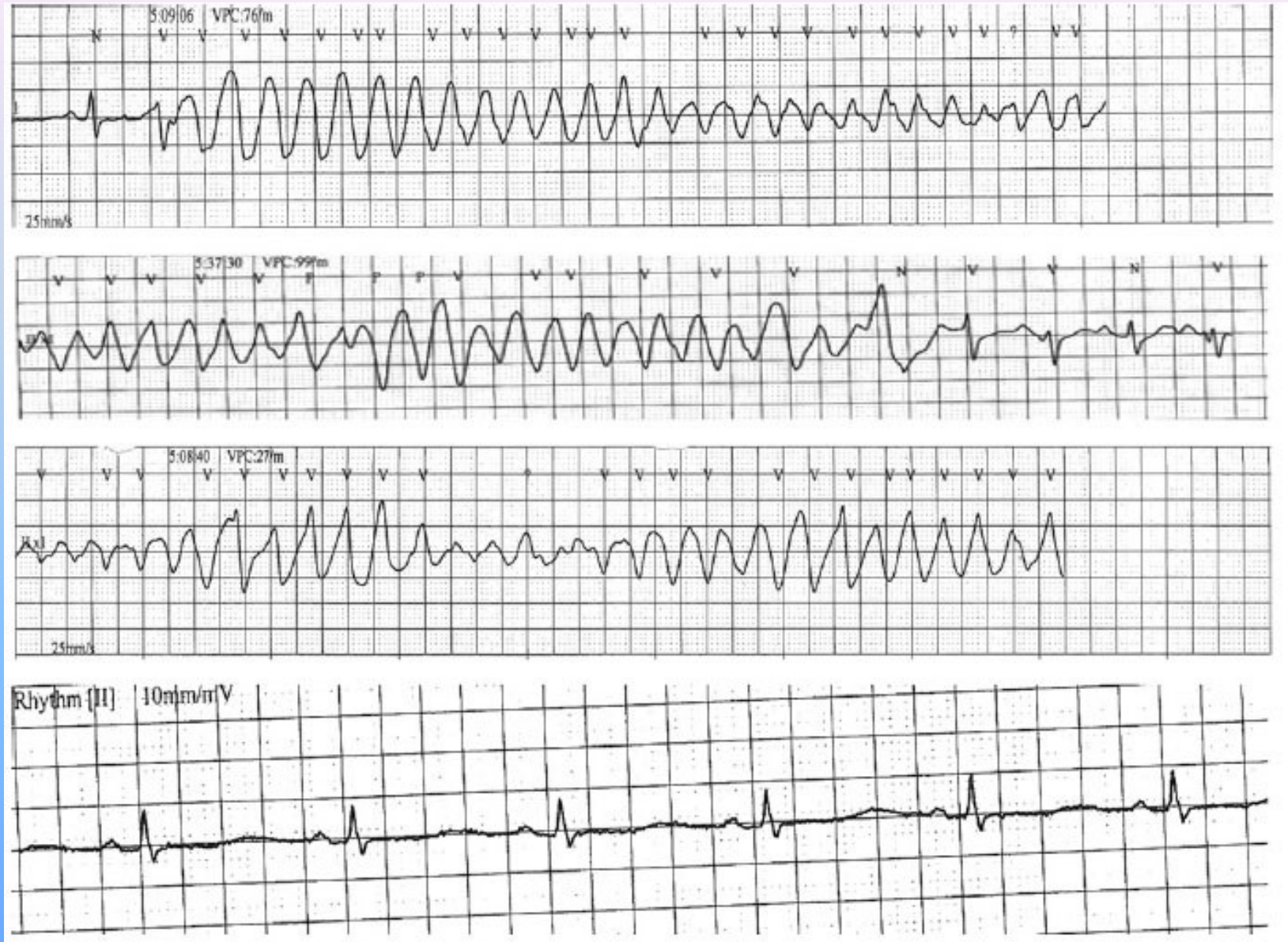
Understanding Genetic Transmission



ECG recordings from leads II, aVF, and V5 in three patients from families with long QT syndrome linked to genetic markers on chromosomes 3, 7, and 11.

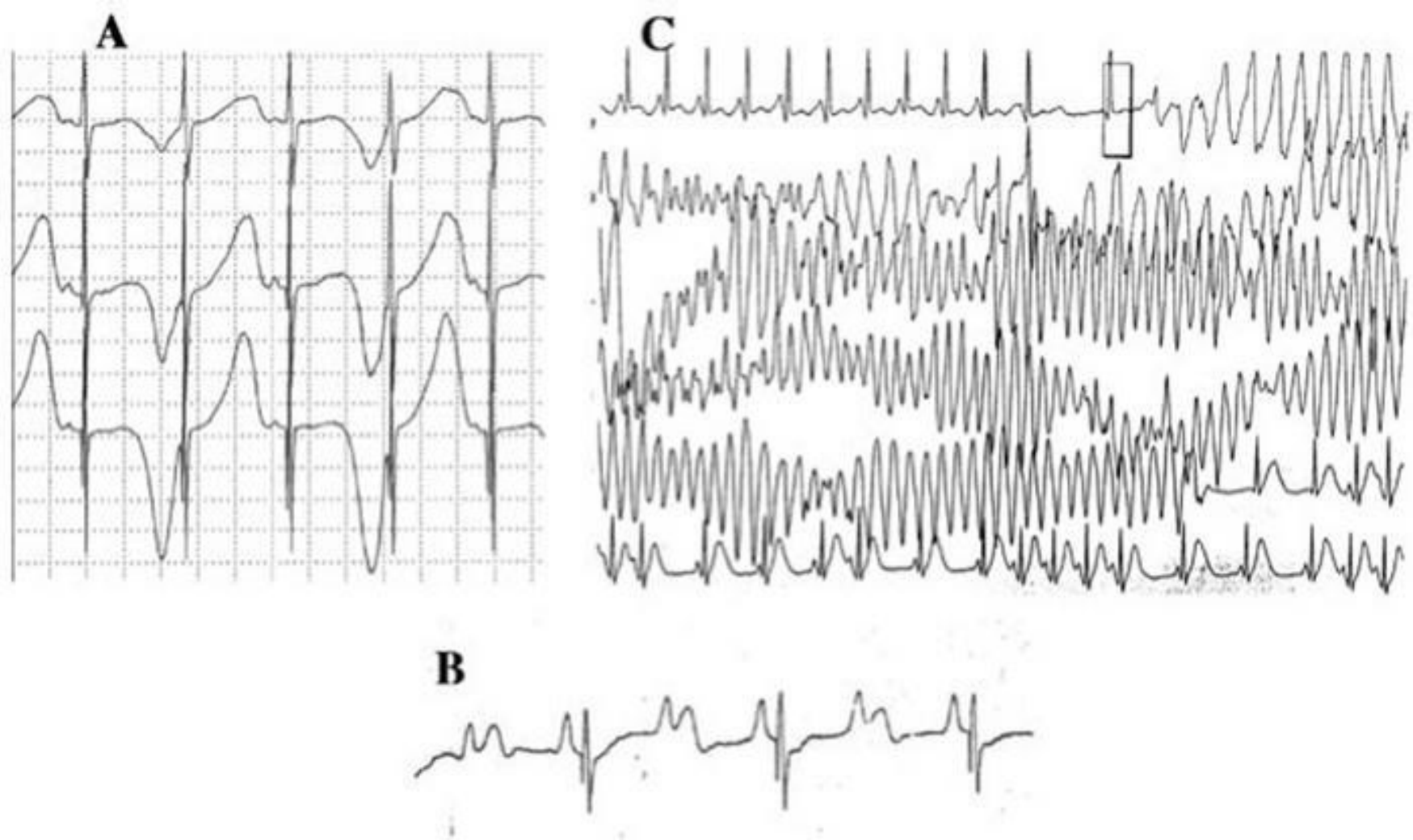


Moss A et al. Circulation 1995;92:2929-2934



Rhythm strip of II showing QTc of 720 msec at admission

A. T WAVE ALTERANS
B. LQTS TYPE 2 (NOTCHED T WAVES)
C. PATIENT WITH LQTS ecg = run of Torsades, reverts to NSR



For more SPECIFIC information about ECG indicators for the following conditions, click on the associated link:

- Long QT Syndrome
- Short QT Syndrome
- Hypertrophic Cardiomyopathy
- Brugada Syndrome
- Arrythmogenic Right Ventricular Dysplasia
- Wolff-Parkinson-White Syndrome

QT Prolonging Meds: Resources

http://www.sads.org/living-with-sads/Drugs-to-Avoid#.Vwm1yqQrI2w

http://www.brugadadrugs.org/

https://crediblemeds.org/pdftemp/pdf/DrugsToAvoidList.pdf

- 2014 AHA ACC Assessment of 12 Lead ECG as Screening for SADS

Additional Resources

- AHA Circulation: Impact of Laboratory Molecular Diagnosis on Contemporary Diagnostic Criteria for Genetically Transmitted Cardiovascular Diseases: Hypertrophic Cardiomyopathy, Long-QT Syndrome, and Marfan Syndrome

- Trends in Sudden Cardiovascular Death in Young Competitive Athletes After Implementation of a Preparticipation Screening Program

This presentation has been prepared by:

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