# ECG Interpretation for the CL Psychiatrist

Harvard Medical School
Medical Psychiatry: Comprehensive Update

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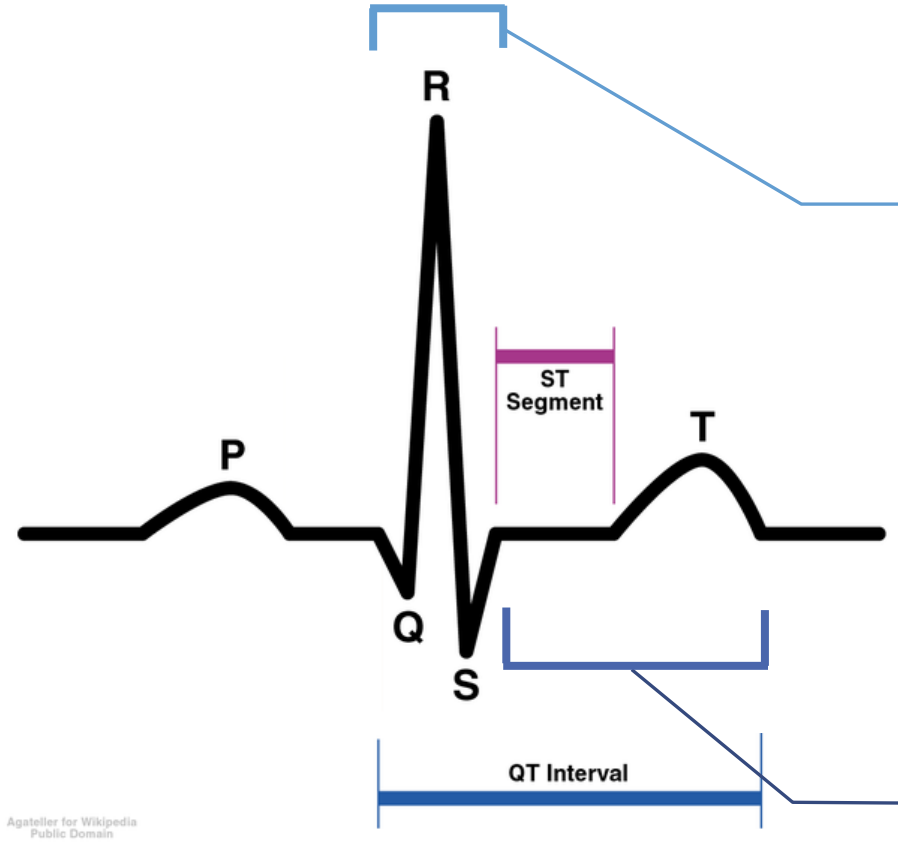
September 19, 2025

# Outline

- Physiology of the QT interval
- QTc interval measurement
- Risk factors for QTc prolongation
- Clinical Cases

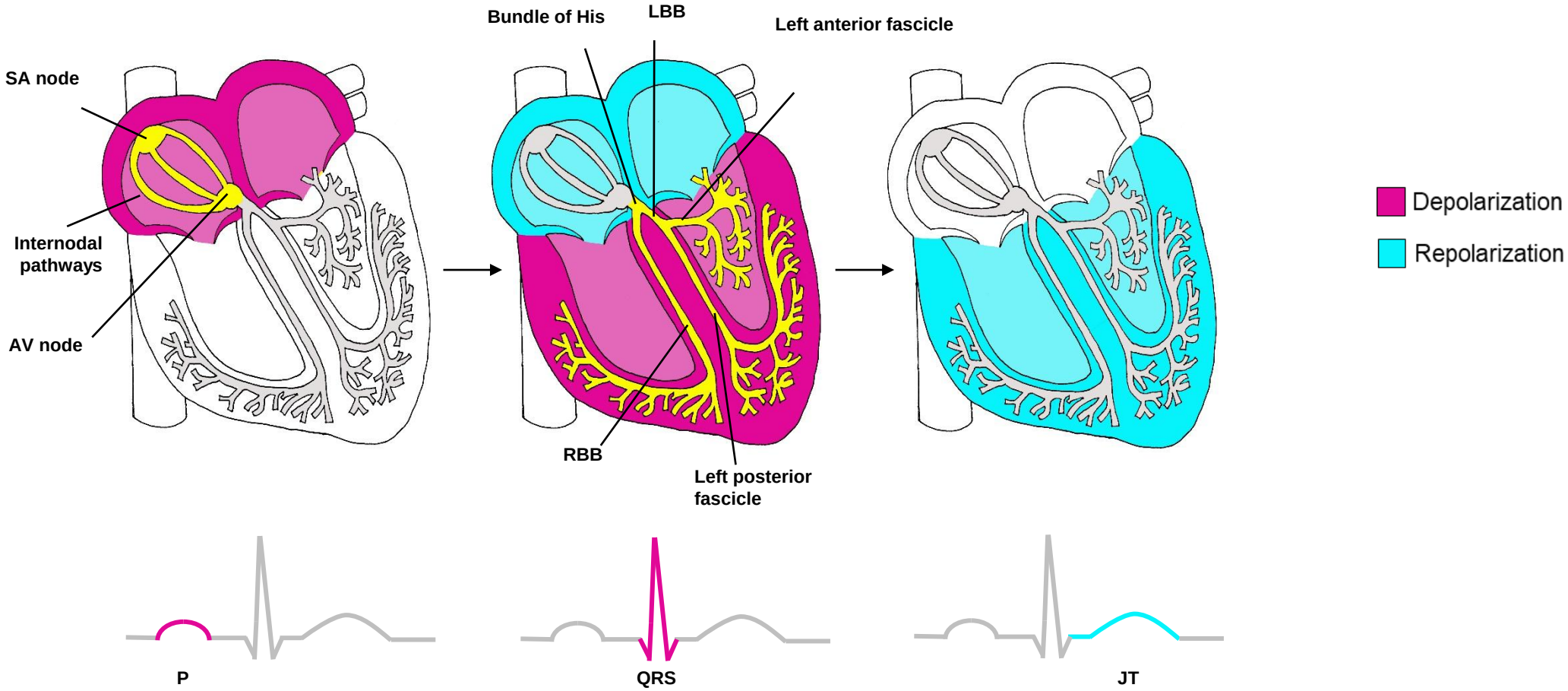
# The QT interval




QRS Complex =
ventricular depolarization

ST segment + T wave =
ventricular repolarization

# Electrophysiology and the ECG




Funk et al., 2021

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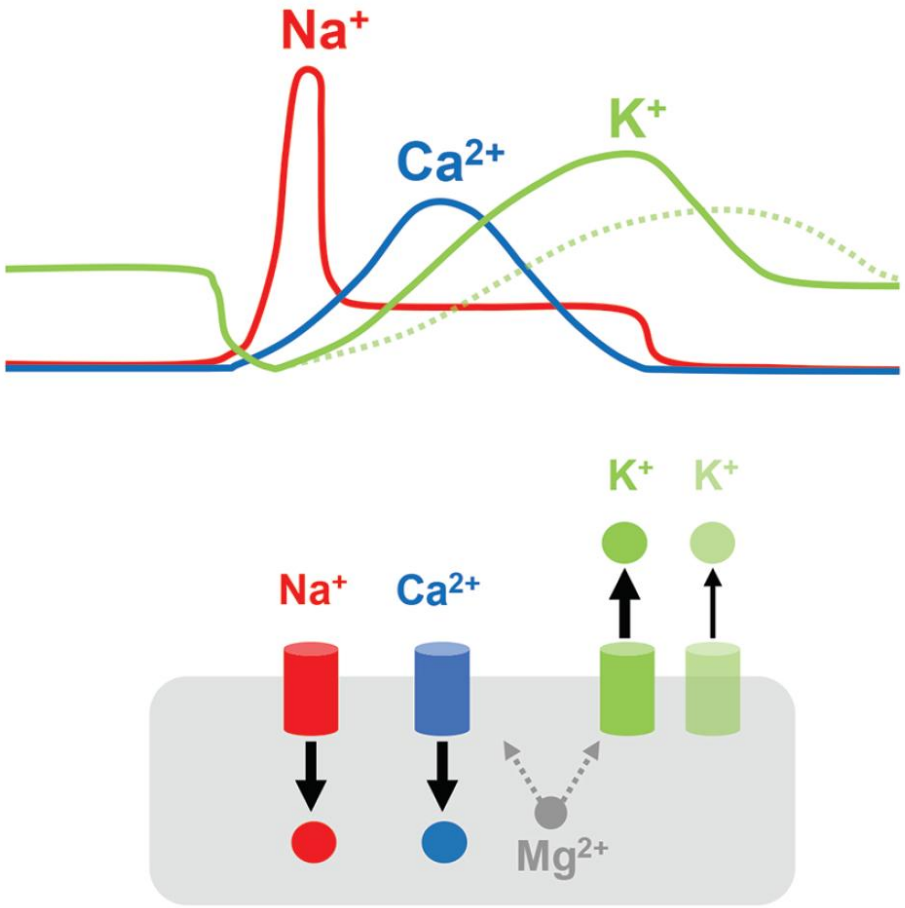
# Physiology of the Cardiac Action Potential




1. Influx of sodium ions leads to rapid depolarization.
2. Efflux of potassium ions and influx of calcium ions leads to a plateau.
3. Efflux of potassium ions overtakes calcium.
4. Membrane returns to resting state.

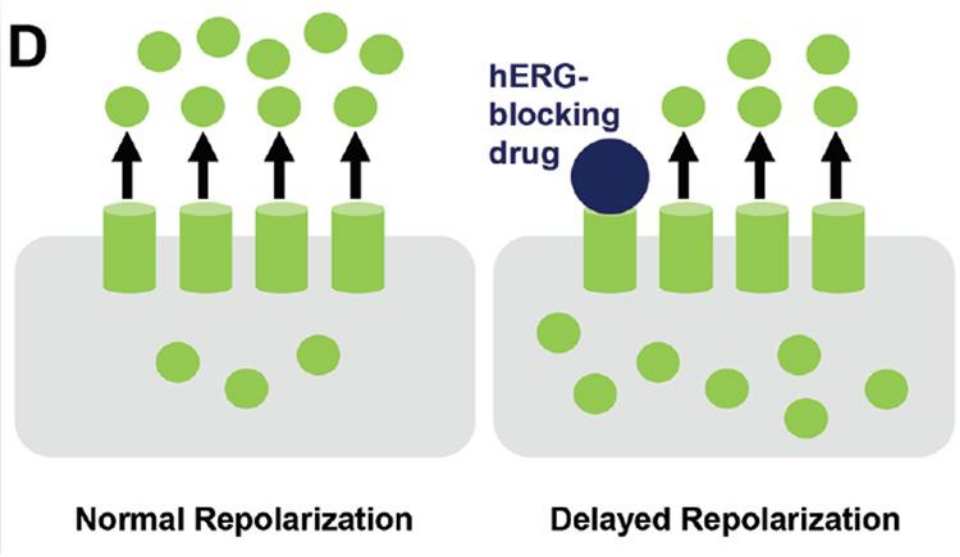
George 2013, Funk et al 2020

# Mechanism Drug-Induced TdP

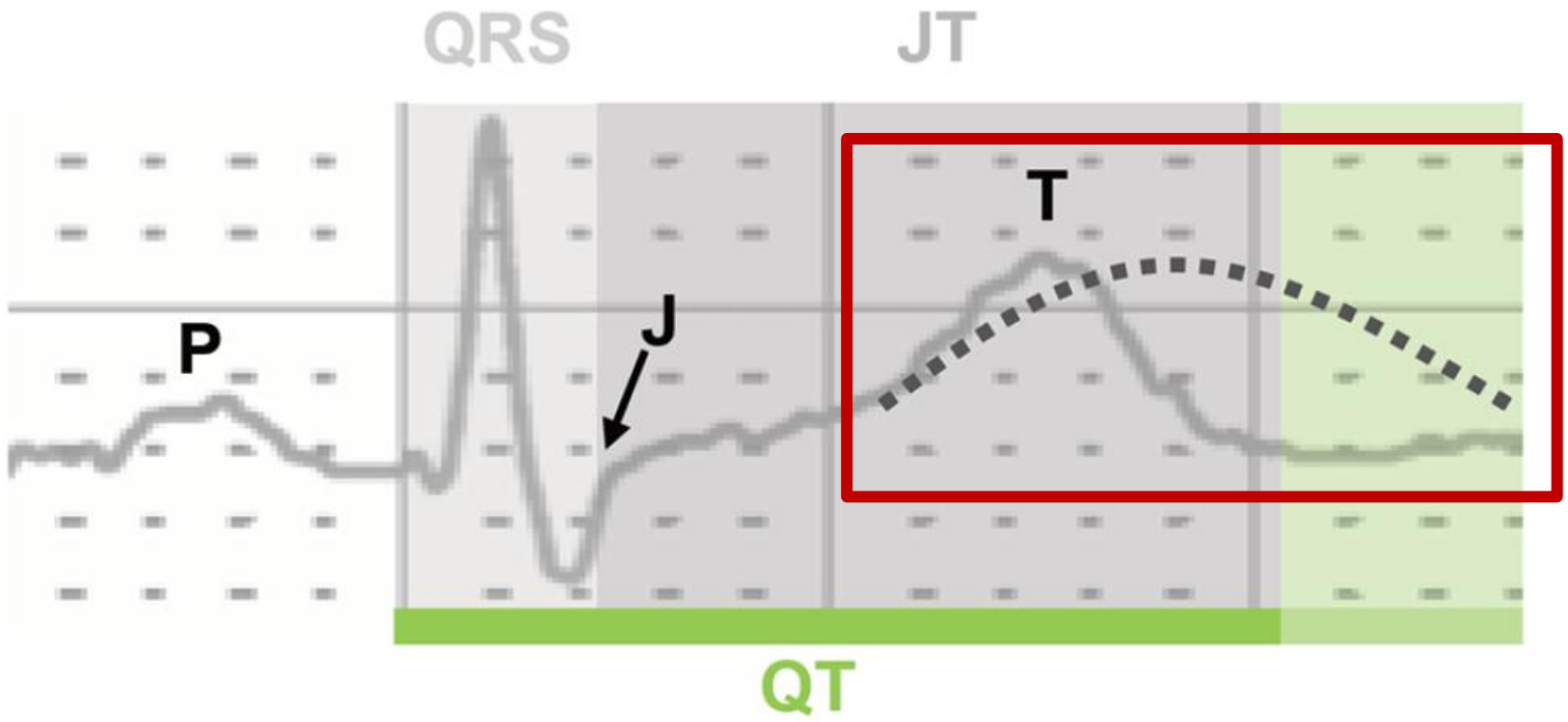
Direct blockade of IKr channel

Disruption of K+ efflux delays repolarization of ventricle

- Widening and distortion of T-wave
- Manifests as prolongation of QT interval on 12-lead ECG



# Electrophysiology and ECG




▪▪▪▪▪▪▪ Prolonged Repolarization

Funk et al 2020

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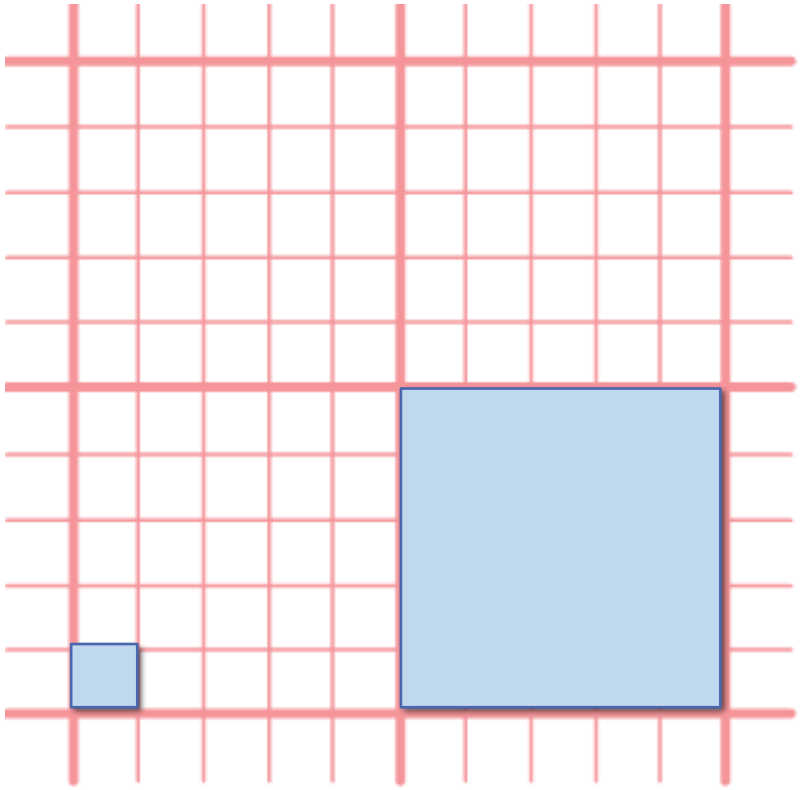
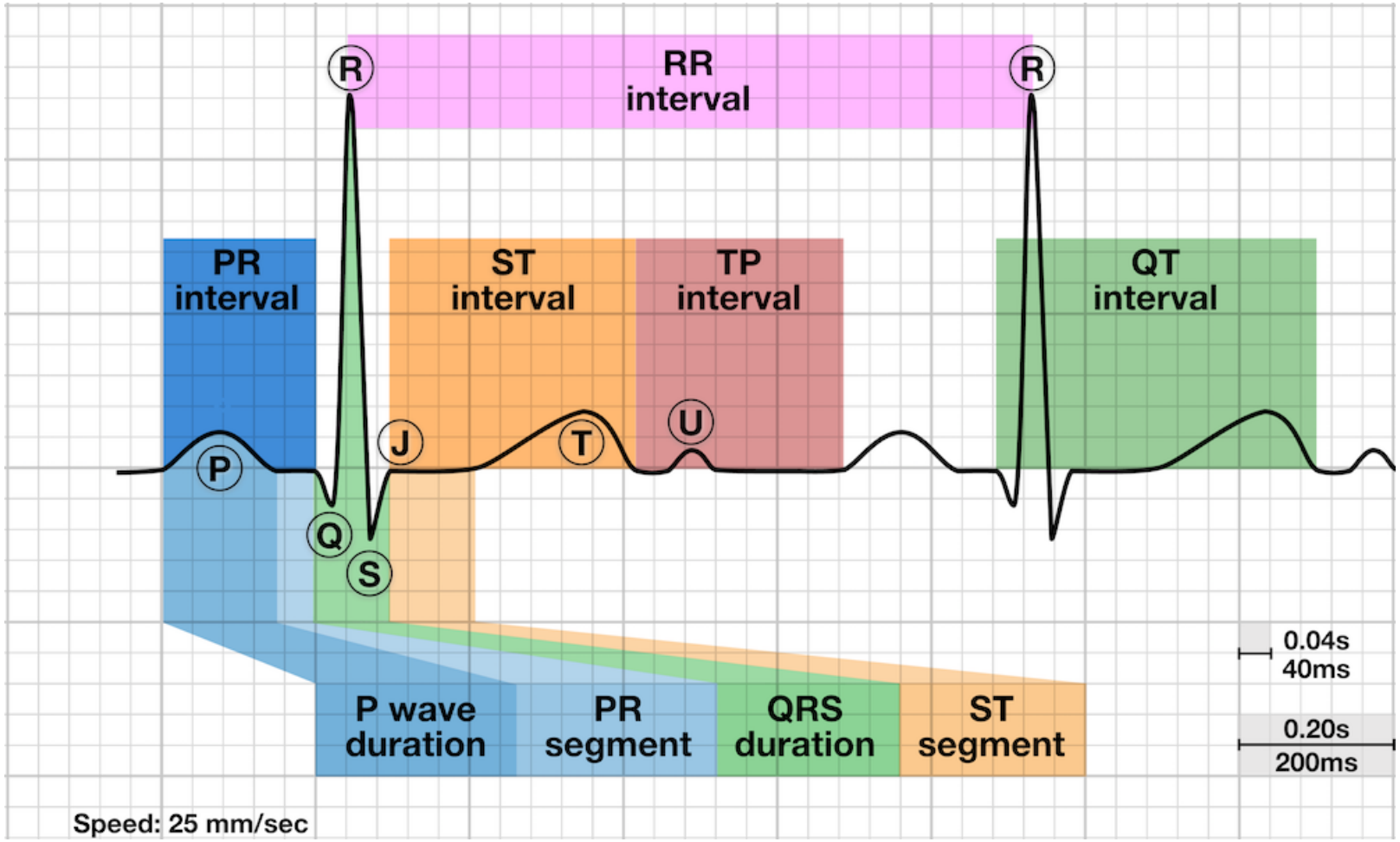
# Basics of ECG Interpretation



small box = 40 msec  large box = 200 msec

# Basics of ECG Interpretation




| Interval | Duration (ms) |
|---|---|
| PR | 120-200 |
| QRS | 80-100 |
| ST | 80 |
| RR | 600-1000 |

# How to measure the QTc

1. Pick an appropriate lead on the ECG (usually II, V2, or V3).
2. Measure the QT interval.
3. Measure the heart rate or RR interval.
4. Calculate the QTc.

Rautaharju 2009, Isbister 2012

# Measure the QT interval

9 boxes + 10 msec
QT = 370 msec

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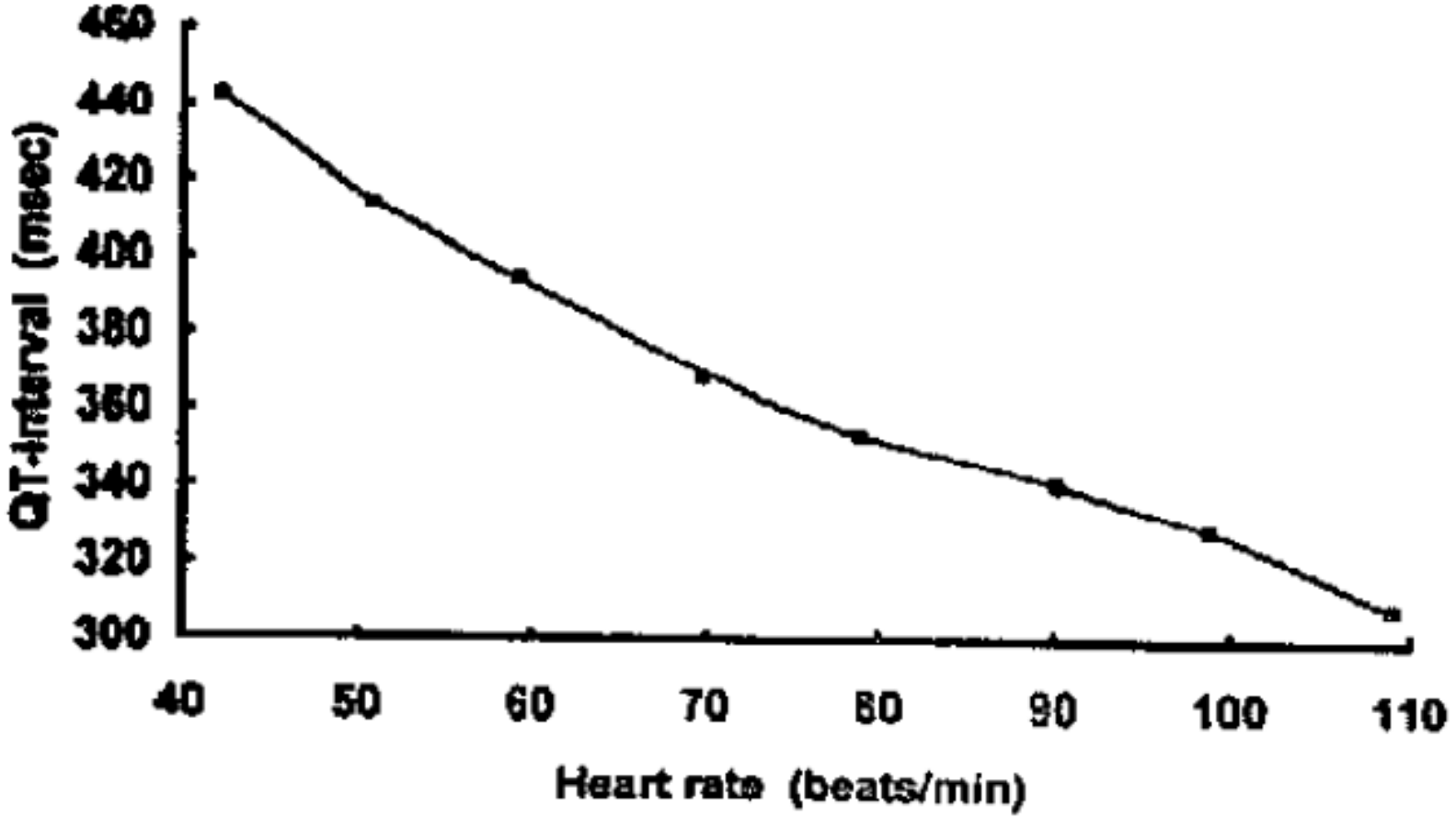
# Measure the RR interval

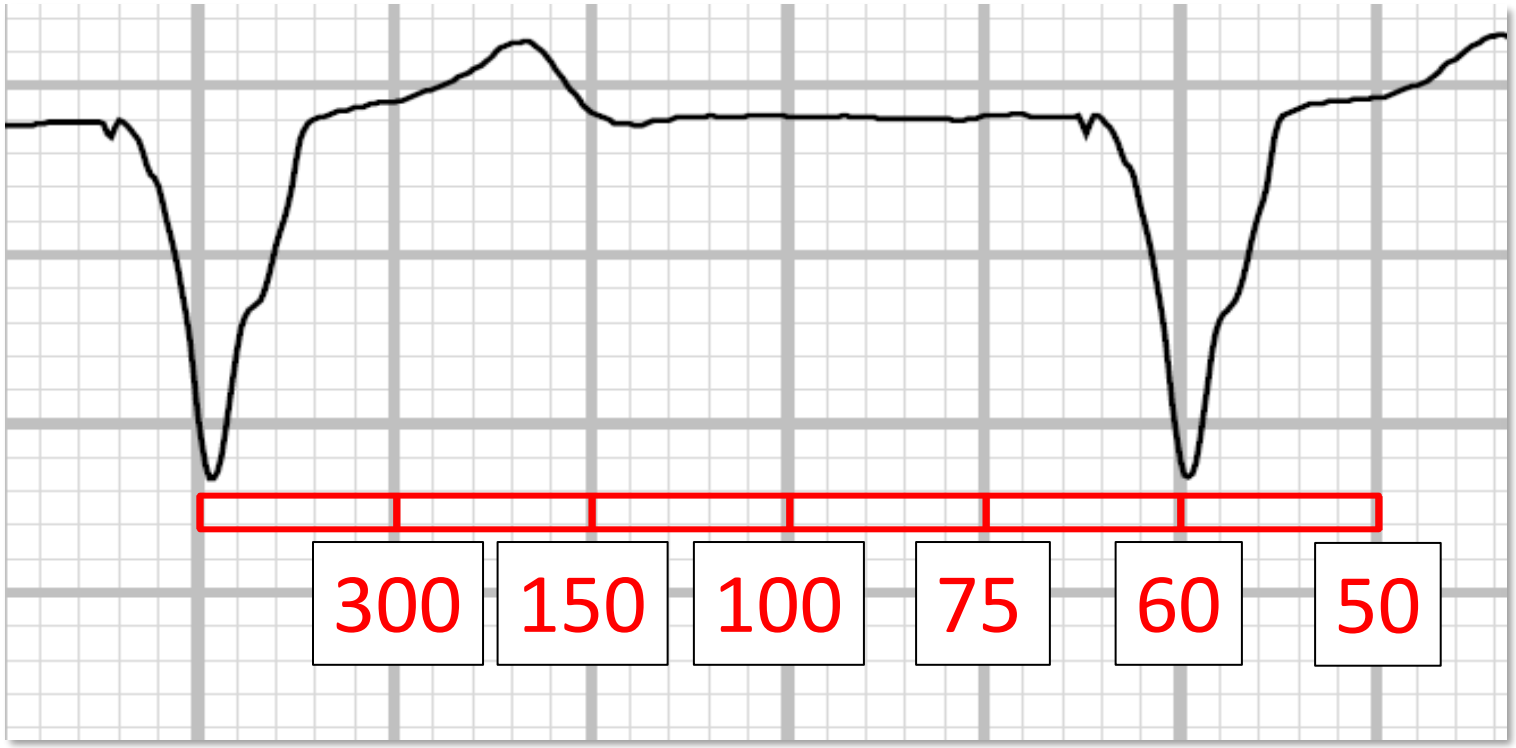
17 boxes + 10 msec
RR = 690 msec
HR = 87 beats/minute

QT = 370 msec

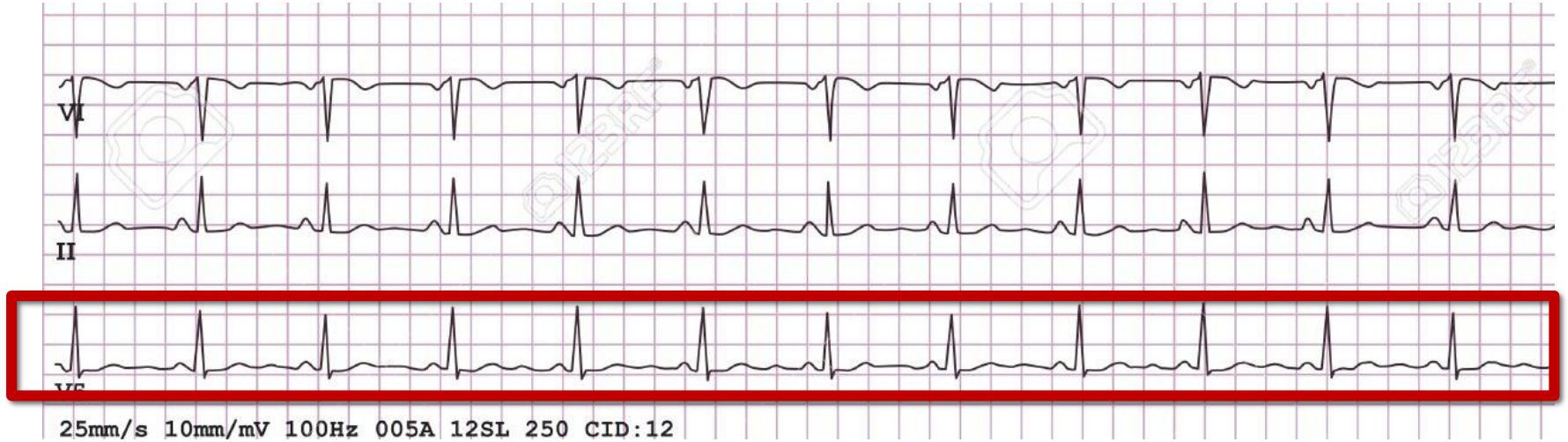
# QT intervals are HR-dependent



# Measuring Heart Rate



# Measuring Heart Rate




**12 Beats x 6 = 72 bpm**

1. Remember: 12 lead ECG = 10 seconds
2. Count the number of beats
3. Multiply number of beats x 6 = Beats per minute

# Correction Formulae

| Method | Formula |
|---|---|
| Bazett | $QTc = QT/\sqrt{RR}$ |
| Fridericia | $QTc = QT/\sqrt[3]{RR}$ |
| Framingham | $QTc = QT + 0.154\,(1000 - RR)$ |
| Hodges | $QTc = QT + 1.75\,(HR - 60)$ |
| Nomogram | plot of QT vs rate |

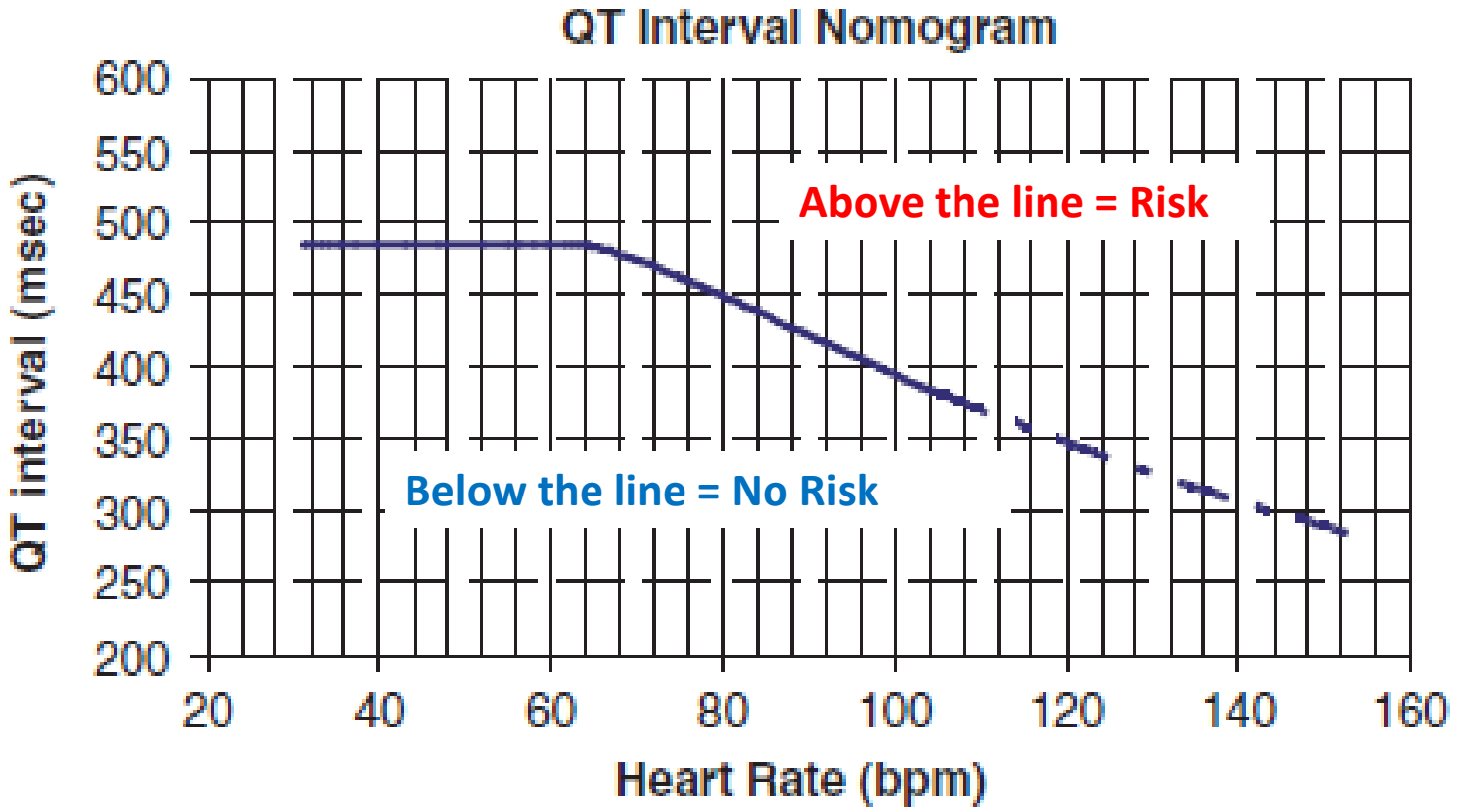
**Hodges:**

QTc = 370 + 1.75 (87-60)
QTc = 370 + 47.25
QTc = 417 msec

**Bazett:**

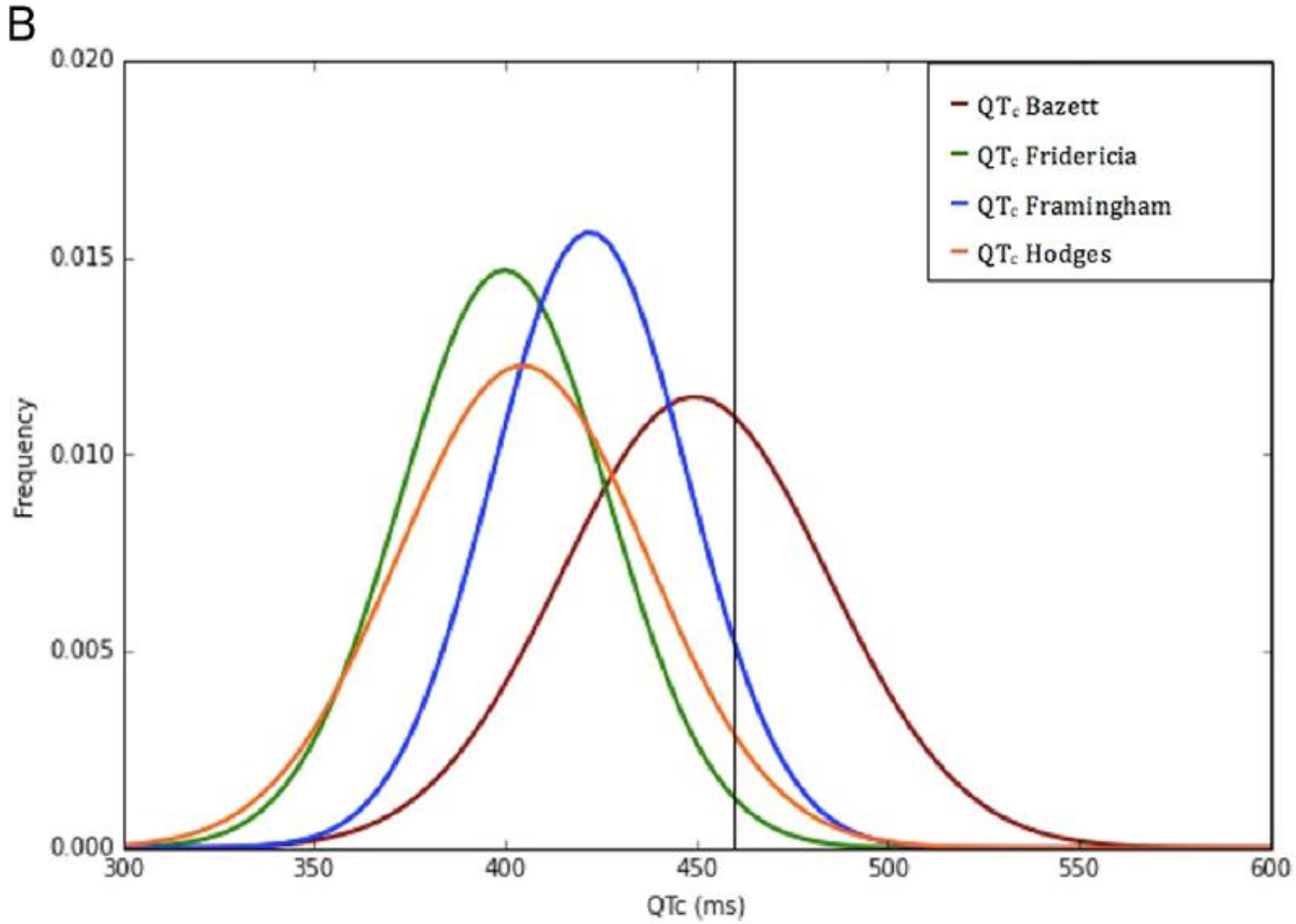
QTc = 0.370/ $\sqrt{0.690}$
QTc = 0.445
QTc = 445 msec

# QTc Nomogram




Chan 2007, Isbister 2012

# QTc Correction Methods




Patel 2016

# QTc Correction Methods

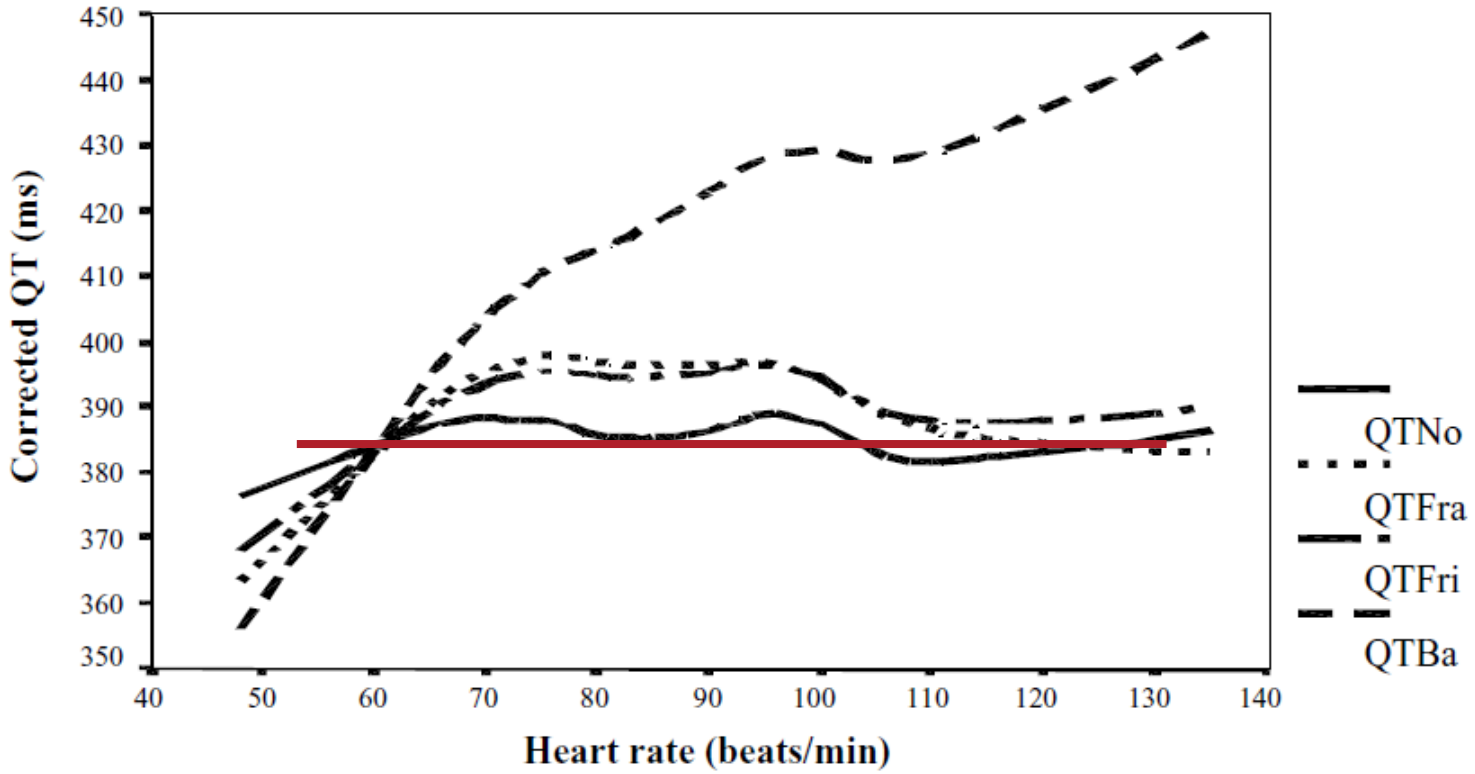



**Figure 2.** Curves of four formulas correcting QT interval at different heart rates.

Dogan 2005

# QTc Normal Ranges

| Rating | Adult Men | Adult Women |
|---|---|---|
| Normal | < 430 msec | < 450 msec |
| Borderline | 431-450 msec | 451-470 msec |
| Prolonged | > 450 msec | > 470 msec |

Moss 2003

# Ventricular Arrhythmias

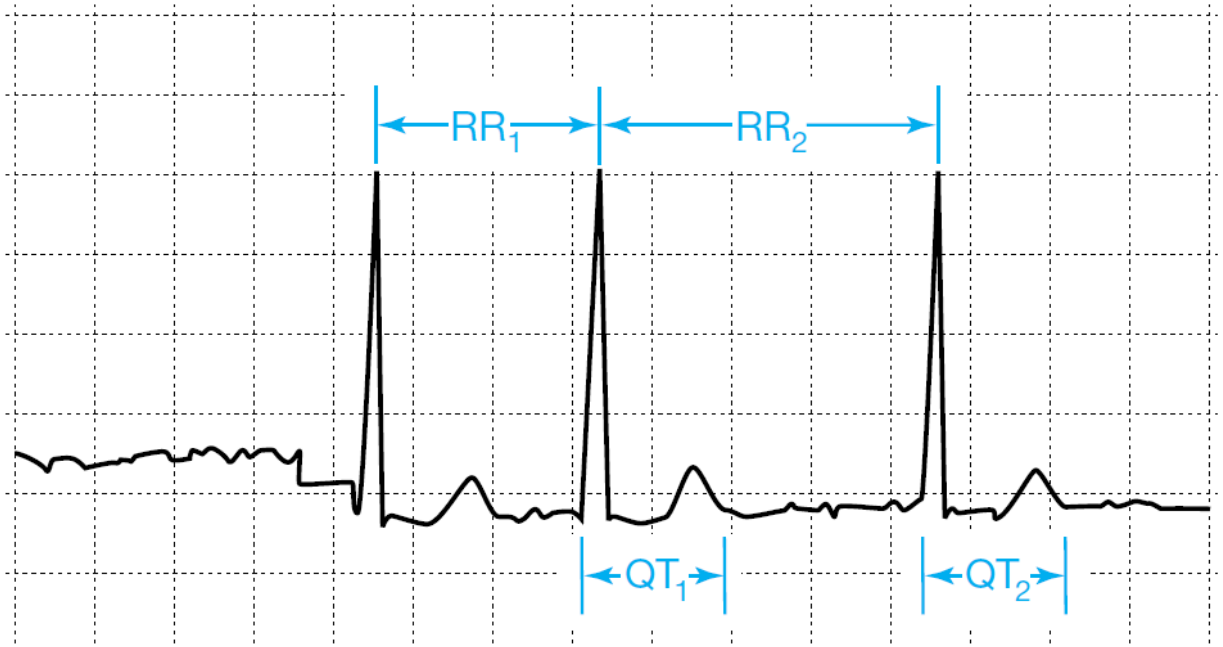
- As a general rule, the risk of ventricular arrhythmias increases by $1.052^{x}$, where x is every 10 msec above a QTc of 400 msec.
- For example:
  - QTc of 450 msec increases the risk of ventricular arrhythmias by $1.052^{5}$, or 1.29.
  - So, an individual with a QTc of 450 msec has a 1.29-fold increased risk of ventricular arrhythmias compared to a person with a QTc of 400 msec.

# Atrial Fibrillation

Difficult to calculate QTc due to variability in RR intervals

Two methods to correct

1. Average several complexes (the more the better)
2. Average the longest and shortest complex.

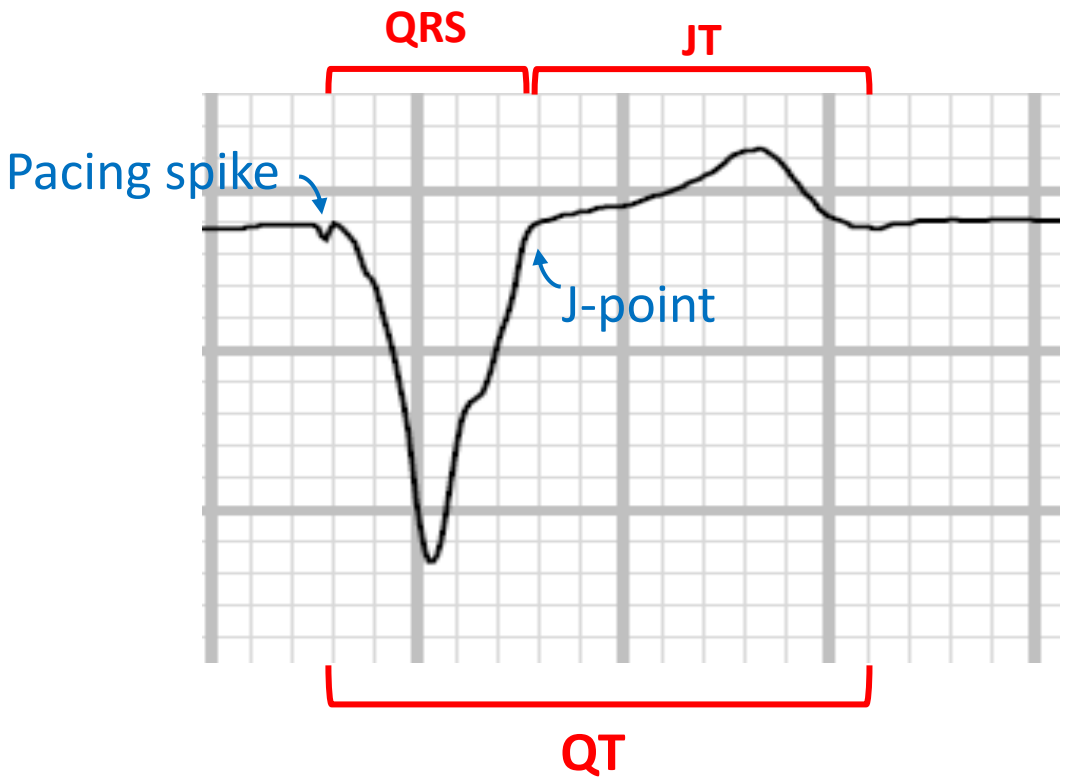



Al-Khatib 2003

# Ventricular Pacing or BBB

Widening of QRS leads to prolongation of QTc without perturbation of repolarization

Several ways to approach this.



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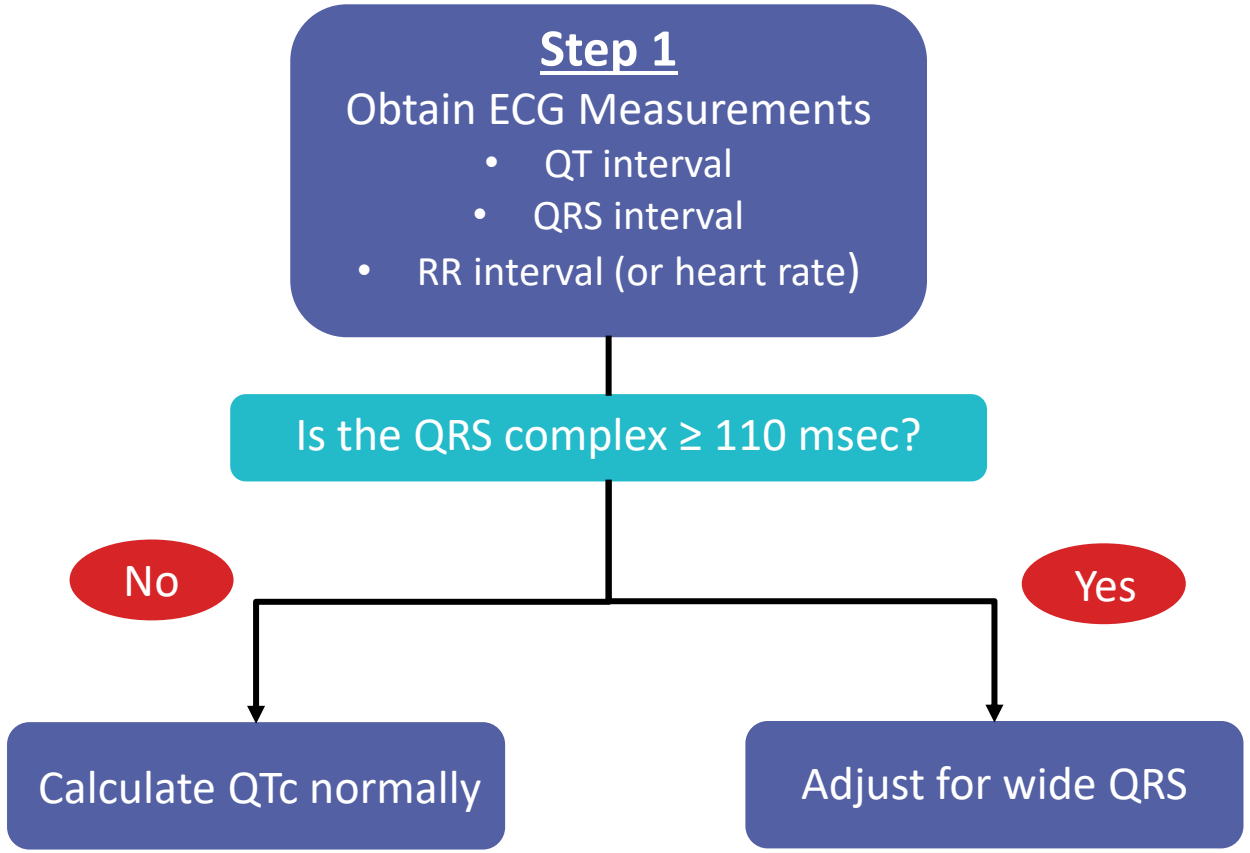
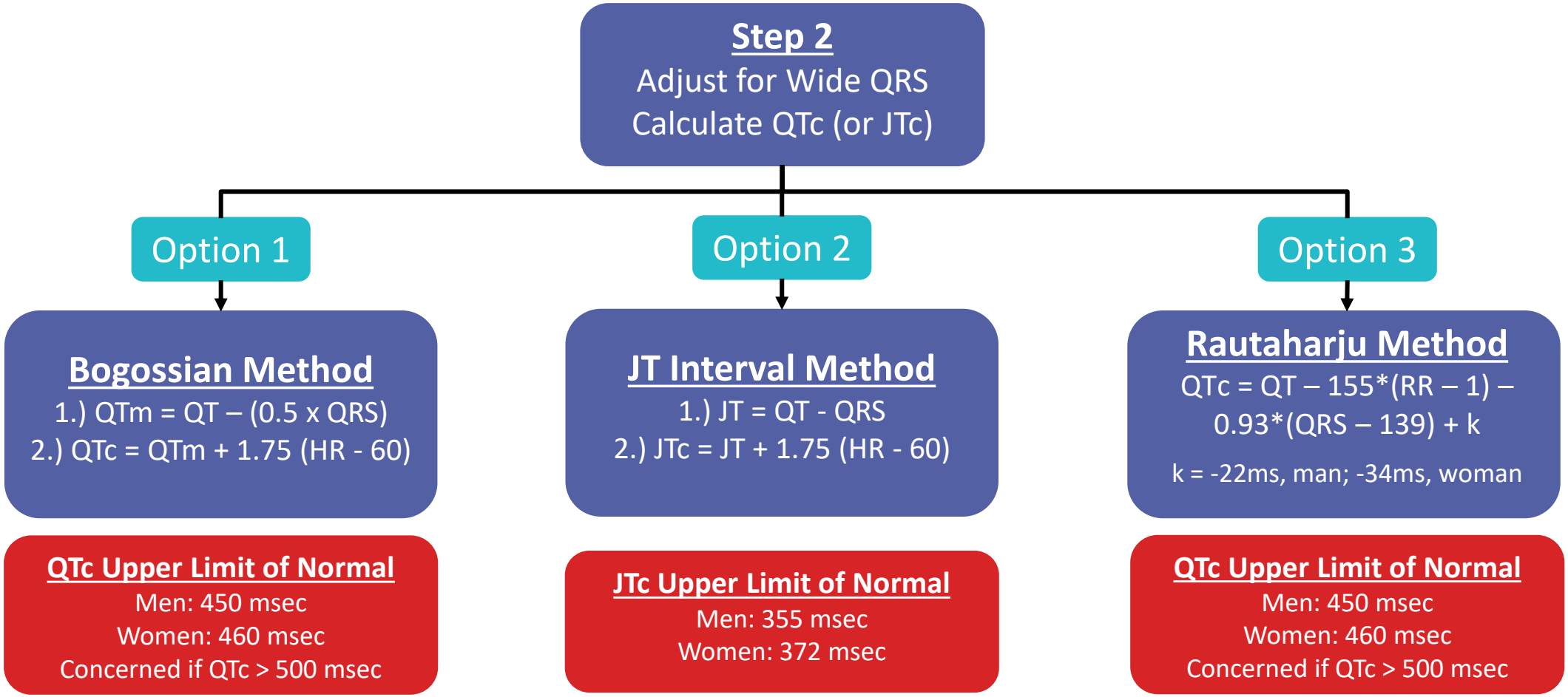
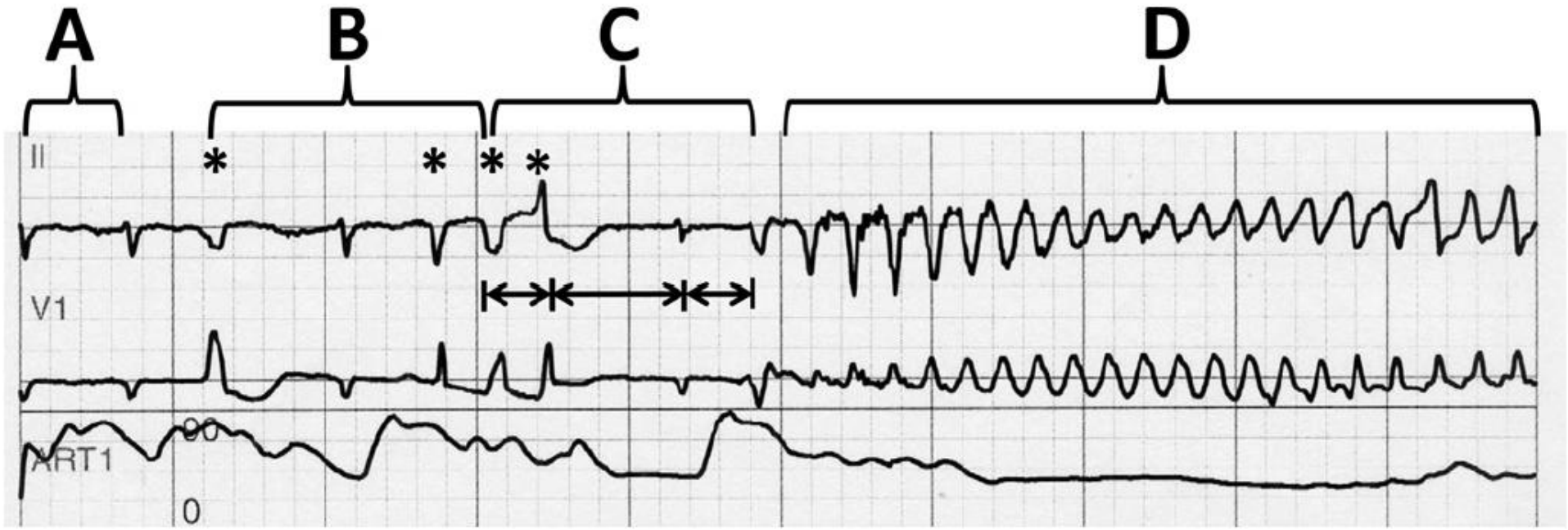


# Ventricular Pacing or BBB



# Why do we worry about QTc prolongation?

- Torsades de Pointes (TdP)
  - "Twisting of the Points"
  - Polymorphic ventricular tachycardia
  - May lead to syncope or dizziness, but also may progress to ventricular fibrillation



# Risk Factors for QTc Prolongation

Female sex

Increased age

Congenital Long QT Syndrome

Structural Cardiovascular Disease

Electrolyte abnormalities

Hepatic dysfunction

Medications that prolong QTc

Metabolic inhibitors

Non-psychiatric medications

- Anti-arrhythmic medications
- Antibiotics (e.g., macrolides, fluoroquinolones)
- Antivirals (HIV medications)
- Anti-emetics
- Acid blockers
- Chemotherapeutic agents

# Clinical Cases

# Case #1

Mr. F. is a 52 y/o man with a history of atrial fibrillation, hypertension, chronic pain, and opioid use disorder (in remission; on methadone), who is referred to you from his primary care physician due to worsening anxiety.

- Though never treated, symptoms of anxiety have been longstanding.
- Medical History
  - Atrial fibrillation (rate-controlled)
  - Hypertension
  - Low back pain (motor vehicle accident)
- Family history
  - Notable for anxiety disorders in the maternal side of his family
  - Mother takes escitalopram and finds it to be quite helpful.

# Case #1

Relevant medications

- Methadone 120mg daily
- Trazodone 100mg QHS
- Gabapentin 600mg TID
- Metoprolol succinate 50mg daily
- Amlodipine 5mg daily
- Hydrochlorothiazide 25mg daily

- Laboratory studies
  - Potassium 4.2
  - Magnesium 2.3
- Most recent ECG
  - 9 months ago
  - HR 93
  - QTc (machine read) = 462 msec

# Question

Based on the available information, what is our next step?

A. Start a medication for the management of generalized anxiety disorder
B. Obtain an ECG
C. It depends

# Question

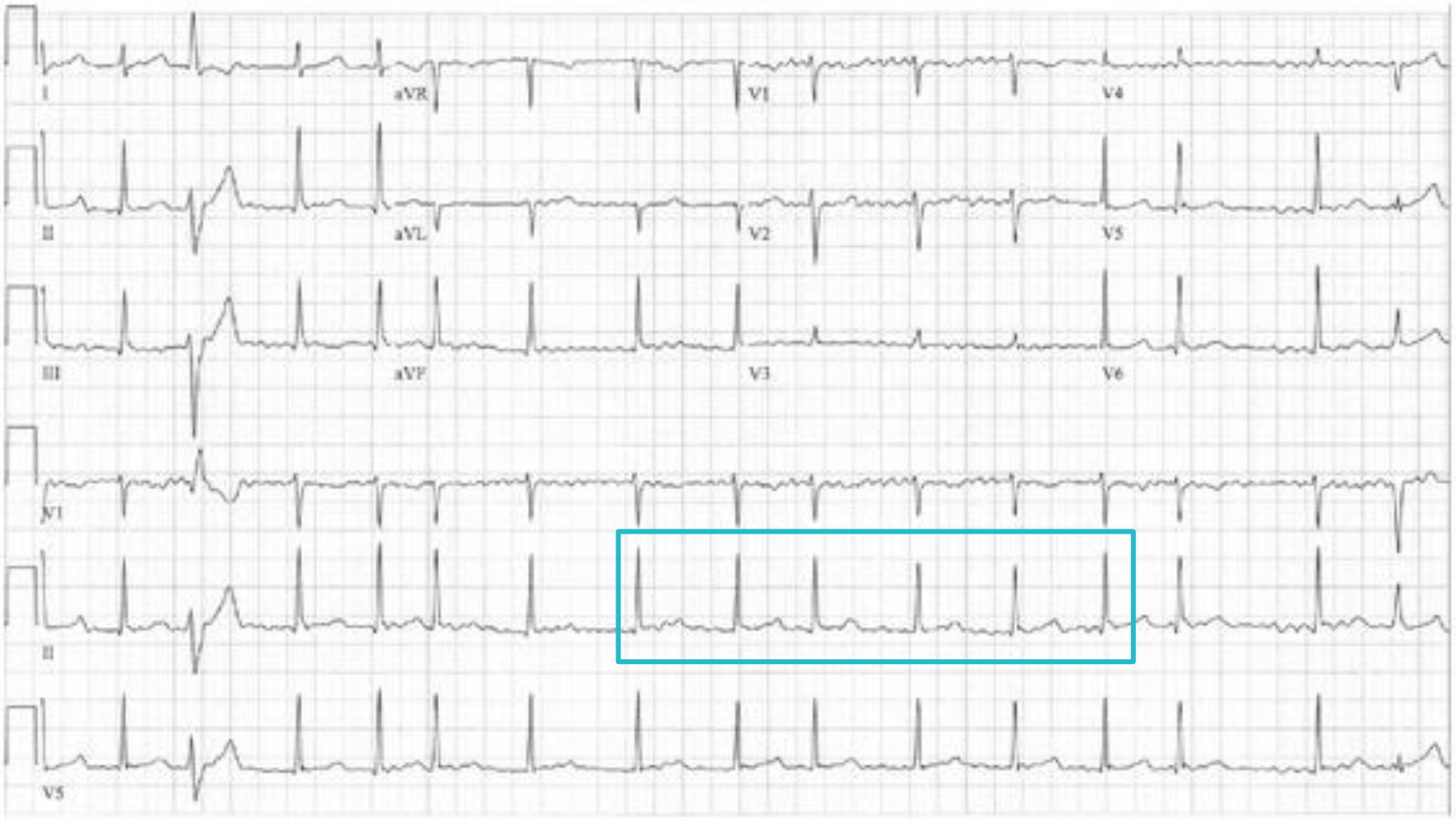
What risk factors does this patient have for QTc prolongation?

A. Age
B. Sex
C. Structural cardiovascular disease
D. Electrolyte disturbances
E. Medications
F. All of the above

# Question

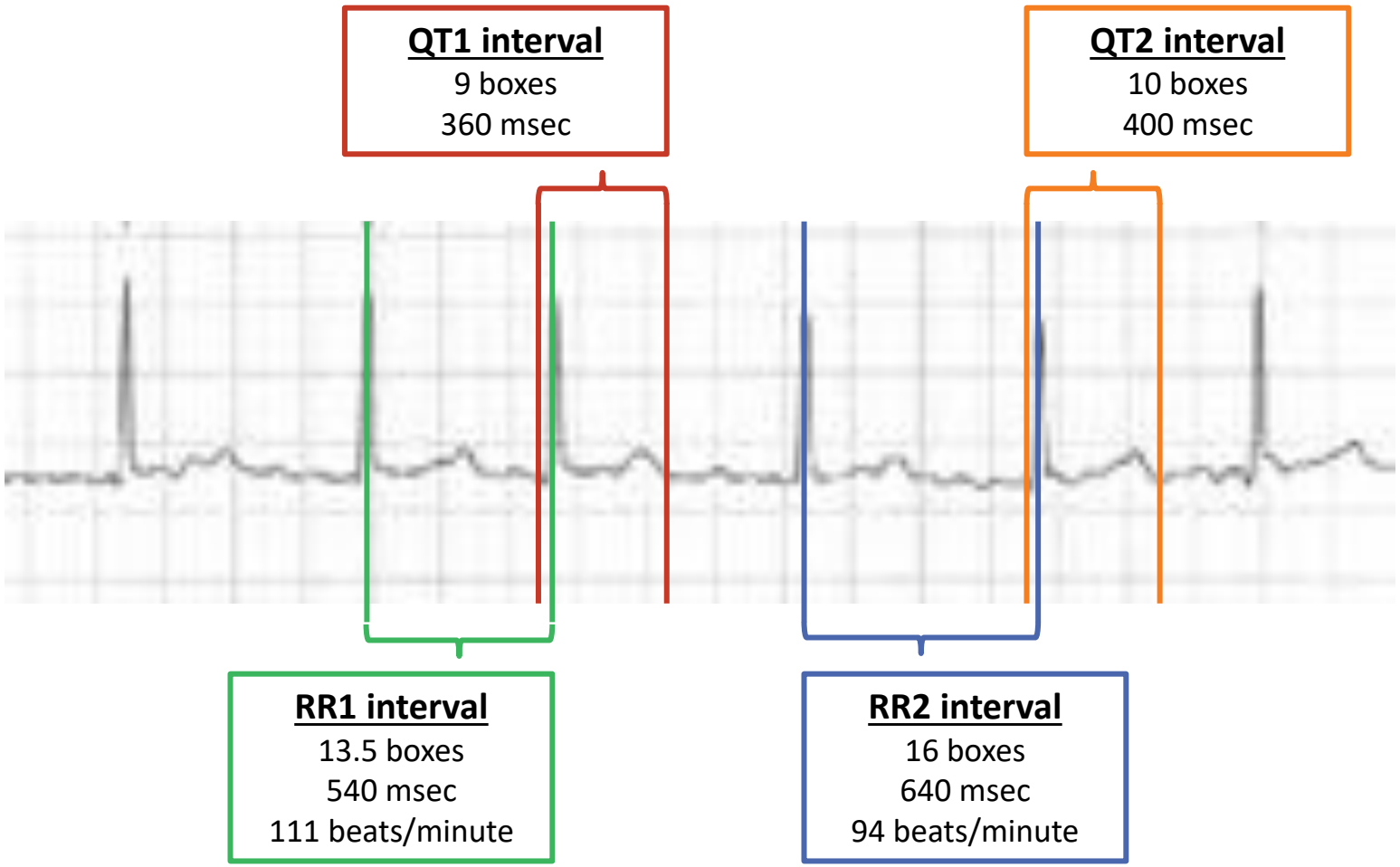
If an ECG were not available, which medication would you choose?

A. Sertraline
B. Nortriptyline
C. Venlafaxine
D. Escitalopram




Knoche 2012

# Step 1: Measure QT and RR intervals




Knoche 2012

# Step 2: Calculate QTc intervals

QTc1 = QT1 + 1.75 (HR – 60)

QTc1 = 360 + 1.75 (111 – 60)

QTc1 = 360 + 1.75 (51)

QTc1 = 360 + 89

QTc1 = 449 msec

QTc2 = QT2 + 1.75 (HR – 60)

QTc2 = 400 + 1.75 (94 – 60)

QTc2 = 400 + 1.75 (34)

QTc2 = 300 + 60

QTc2 = 360 msec

# Step 3: Average the QTc Intervals

QTc (average) = (QTc1 + QTc2) / 2

QTc (average) = (449 + 360) / 2

QTc (average) = 405 msec

# Question

With this information, which medication would you choose?

A. Sertraline
B. Nortriptyline
C. Venlafaxine
D. Escitalopram

# Question

If using escitalopram, how frequently would you monitor the QTc?

A. Never; it is not needed in this situation
B. Every month
C. Every 6 months
D. Yearly
E. When risk factors change

# Follow-up

Mr. F. started escitalopram 10mg daily, which was titrated to 30mg daily over time.

- GAD-7 scores improved from 18 to 5 over the next several months.
- The QTc interval remained stable throughout treatment.

# Case #2

Ms. D. is a 74 y/o woman with a history of heart failure with preserved ejection fraction (s/p pacemaker placement), hypertension, and major depressive disorder, who is admitted due to altered mental status.

- Found to have urinary tract infection → started on levofloxacin
- Course complicated by hypotension, confusion, agitation, and QTc prolongation.
- Psychiatry is consulted for the management of agitation.

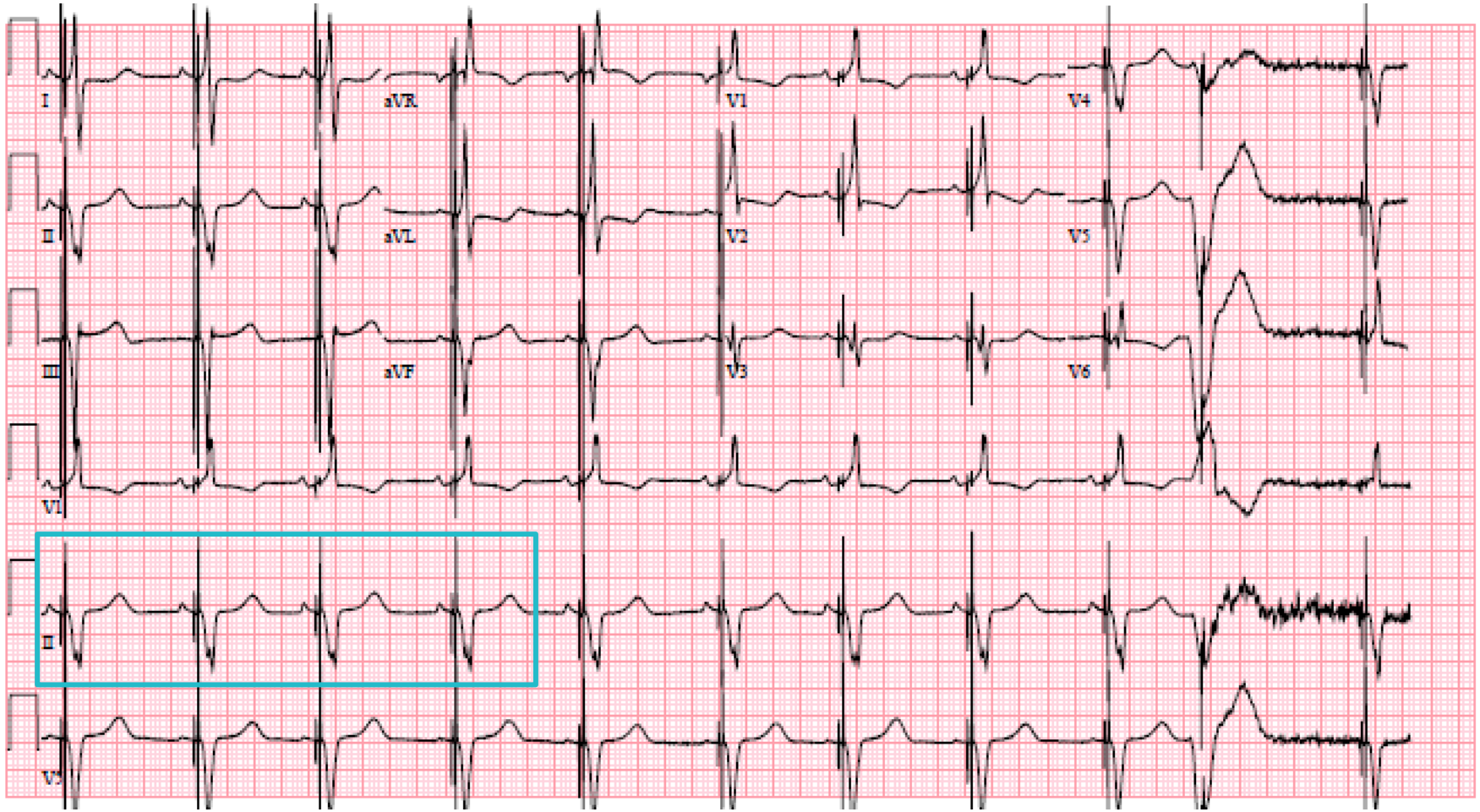
# Case #2

Relevant medications

- Fluoxetine 20mg daily
- Trazodone 50mg QHS
- Torsemide 40mg daily
- Lisinopril 5mg daily
- Levofloxacin 250mg daily

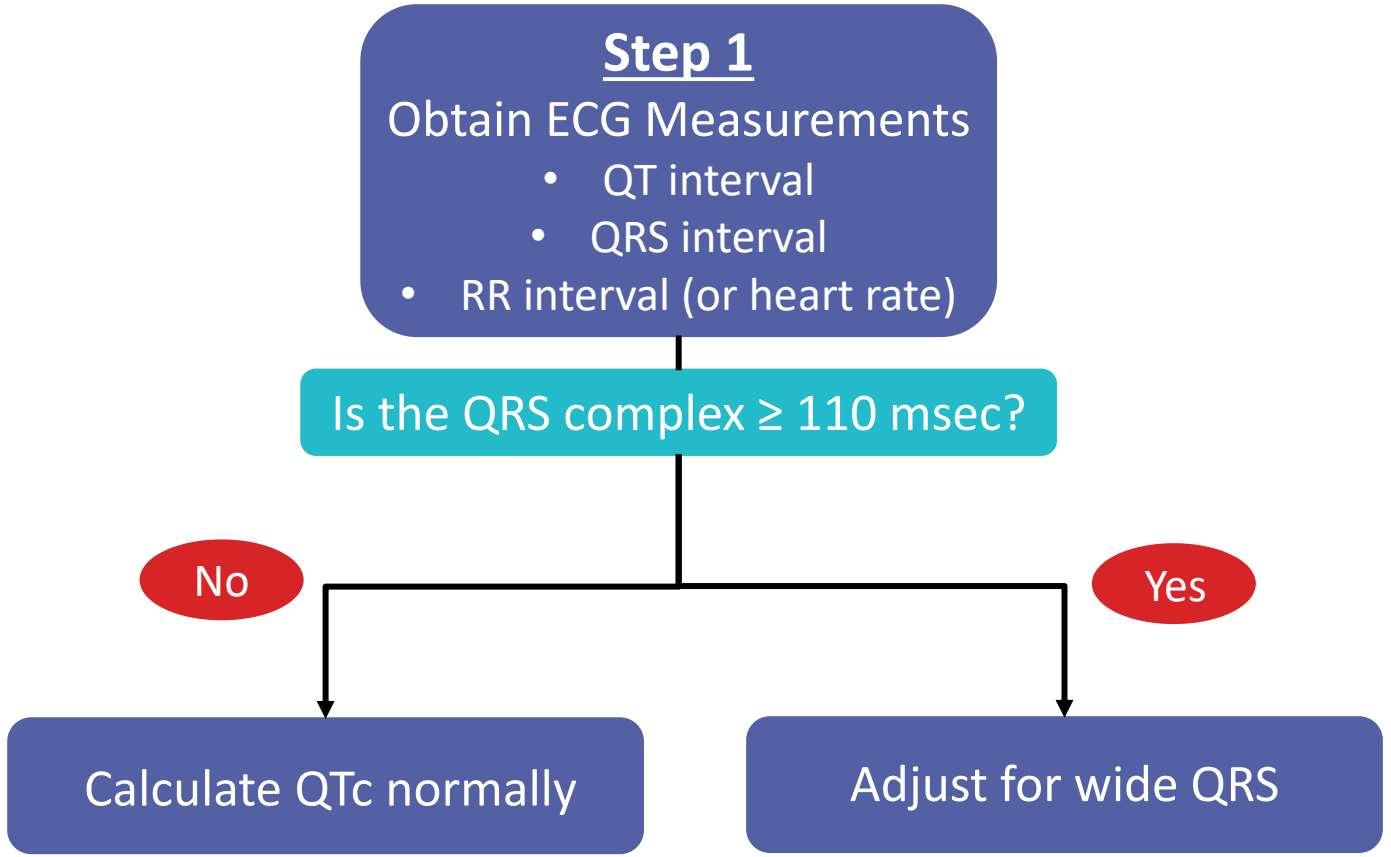
- Laboratory studies
  - WBC 13.8
  - Hemoglobin/hematocrit: 13.2 / 38.3
  - Potassium 3.2
  - Magnesium 1.7
- Vital signs
  - Temperature 101.4
  - HR 62
  - Blood pressure 92/66

# ECG Tracing

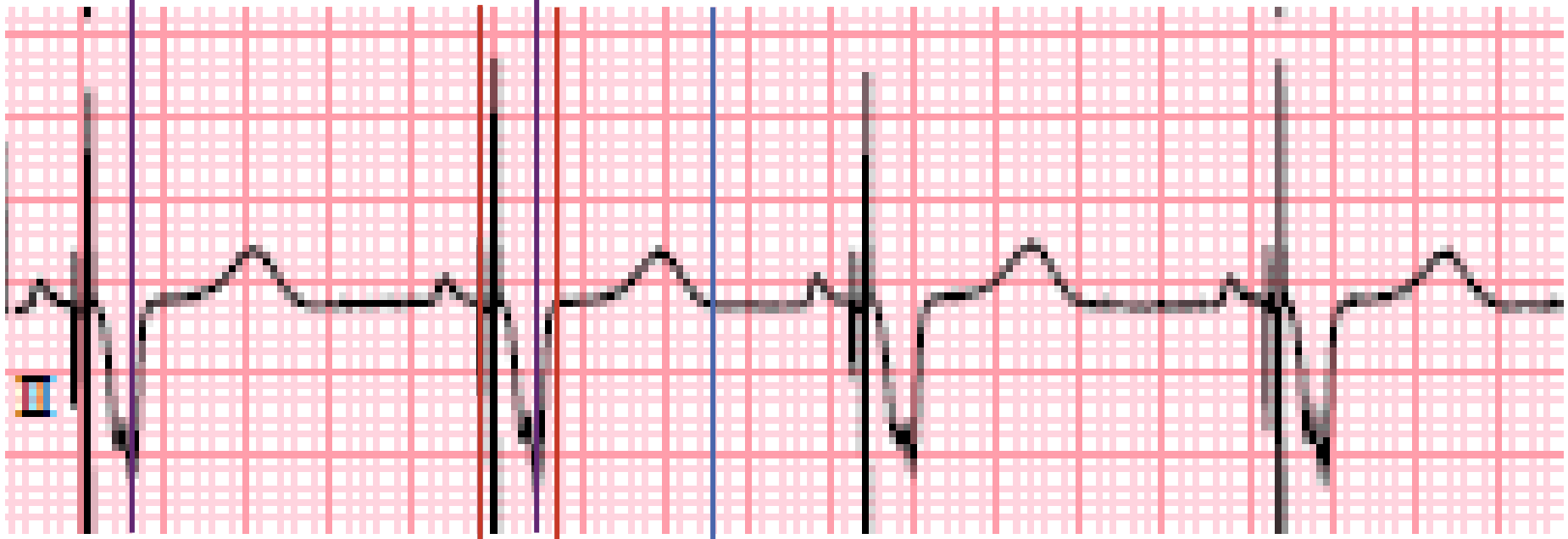



| | |
|---|---|
| Vent. Rate | 63 bpm |
| PR interval | 114 msec |
| QRS duration | 176 msec |
| QT/QTc | 556/569 msec |

# Approach to Measuring QTc



# Step 1: Obtain ECG measurements




**RR interval**
24 boxes + 10 msec
970 msec
62 beats/minute

**QT interval**
14 boxes
560 msec

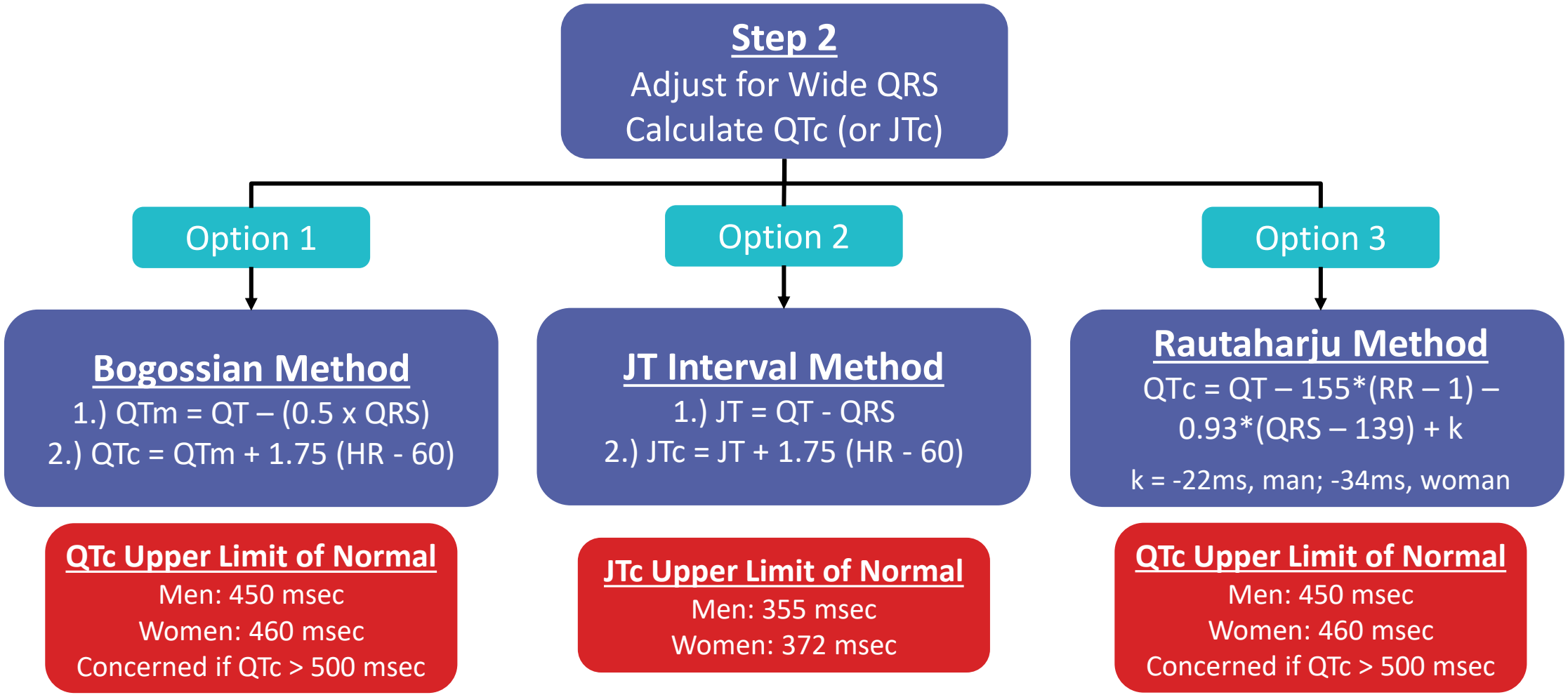
**QRS interval**
4.5 boxes
180 msec

# Question

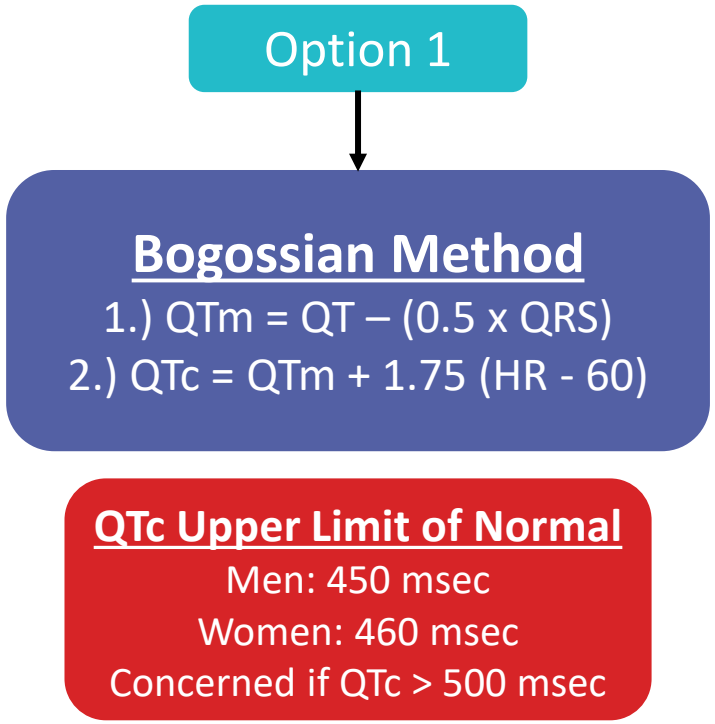
Based on the available information, what is our next step?

A. Calculate the QTc normally
B. Adjust for a wide QRS interval

# Step 2: Choose a Method



# Option 1: Bogossian Method




1. QTm = QT – (0.5 x QRS)
   QTm = 560 – (0.5 x 180)
   QTm = 560 – 90
   QTm = 470 msec

2. QTc = QTm + 1.75 (HR – 60)
   QTc = 470 + 1.75 (62 – 60)
   QTc = 470 + (1.75) (2)
   QTc = 473.5 msec

# Option 2: JT Interval Method

Option 2

**JT Interval Method**

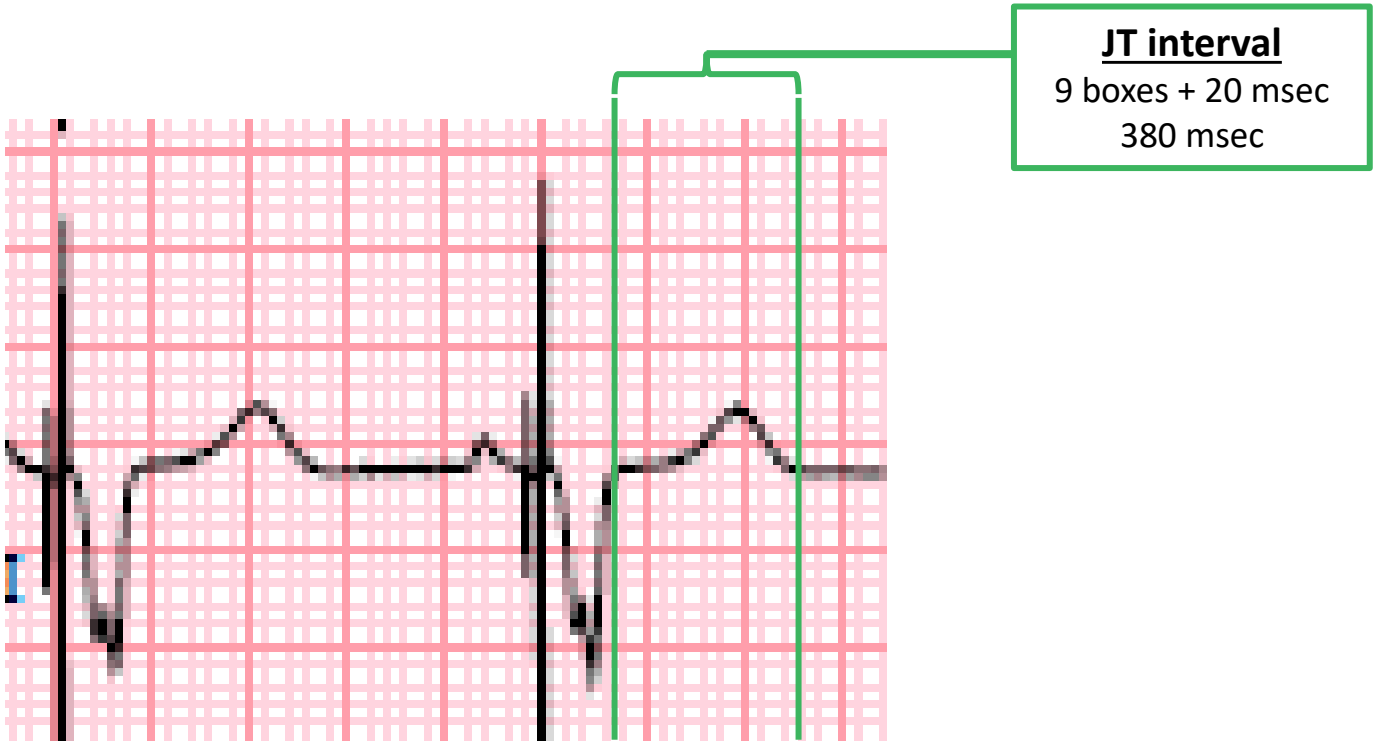
1.) JT = QT - QRS

2.) JTc = JT + 1.75 (HR - 60)

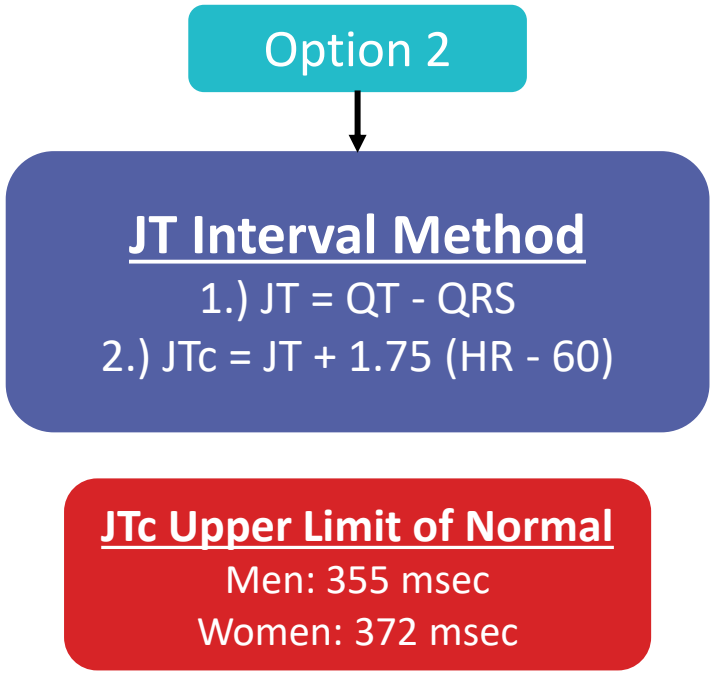
**JTc Upper Limit of Normal**

Men: 355 msec

Women: 372 msec



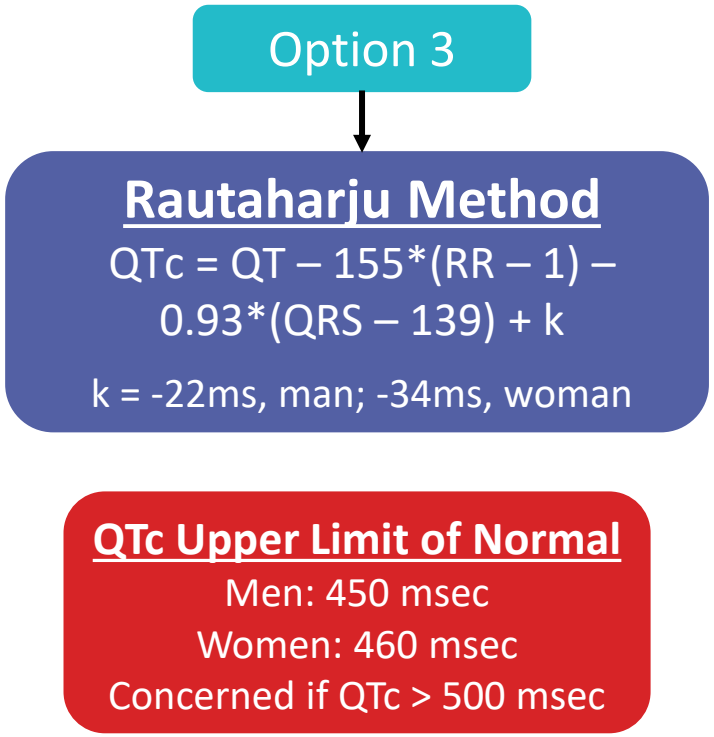
# Option 2: JT Interval Method




1. JT = QT – QRS
   QTm = 560 – 180
   QTm = 380 msec

2. JTc = JT + 1.75 (HR – 60)
   QTc = 380 + 1.75 (62 – 60)
   QTc = 380 + (1.75) (2)
   QTc = 383.5 msec

# Option 3: Rautaharju Method




1. QTc = QT – 155 (RR – 1) – 0.93 (QRS – 139) + k
   QTc = 560 – 155 (0.970 – 1) – 0.93 (180 – 139) – 34
   QTc = 560 – 155 (-0.03) – 0.93 (41) – 34
   QTc = 560 – (-4.65) – (38.13) – 34
   QTc = 492 msec

# Question

What risk factors does this patient have for QTc prolongation?

A. Age
B. Sex
C. Structural cardiovascular disease
D. Electrolyte disturbances
E. Medications
F. All of the above

# Question

What medication would you consider using for the management of agitation?

A. Haloperidol IV
B. Chlorpromazine IV
C. Dexmedetomidine IV
D. Olanzapine IM
E. Valproic acid IV

# Question

How frequently would you monitor the QTc?

A. Never
B. Once per week
C. When risk factors change
D. Daily
E. Continuously

# Follow-up

Ms. D's antibiotic was adjusted, and electrolytes were repleted.

Follow-up ECG demonstrated improvement in QTc (460 msec).

With treatment of UTI, Ms. D. improved and was discharged home.

# Thank you!

- Questions?
  - E-mail: ccelano@mgh.harvard.edu

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