Toxicologic Manifestations on EKG

Chris Root

#Goals

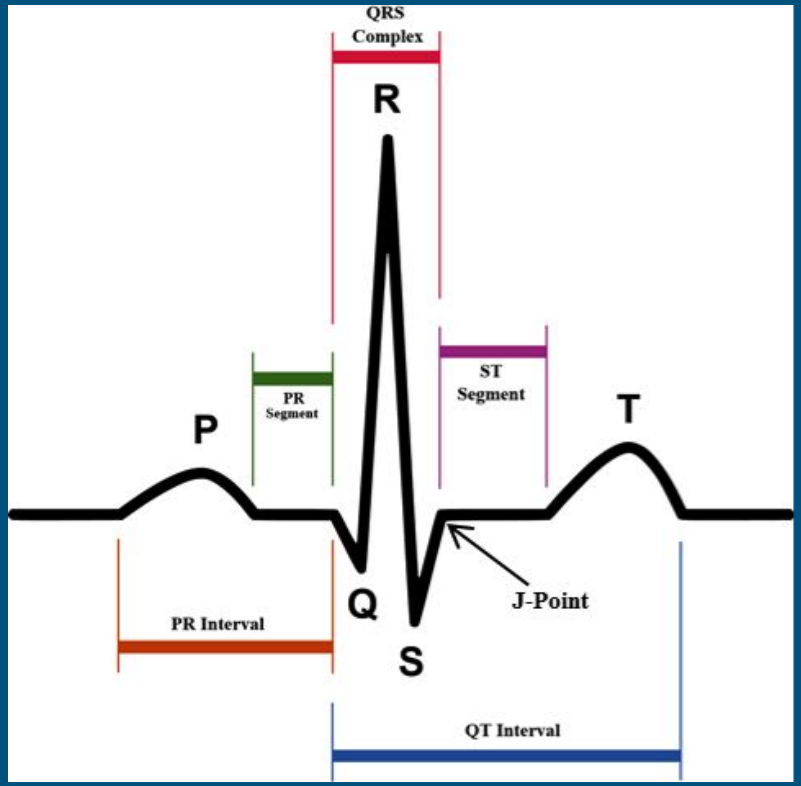
-Brush up on the basics of EKG.

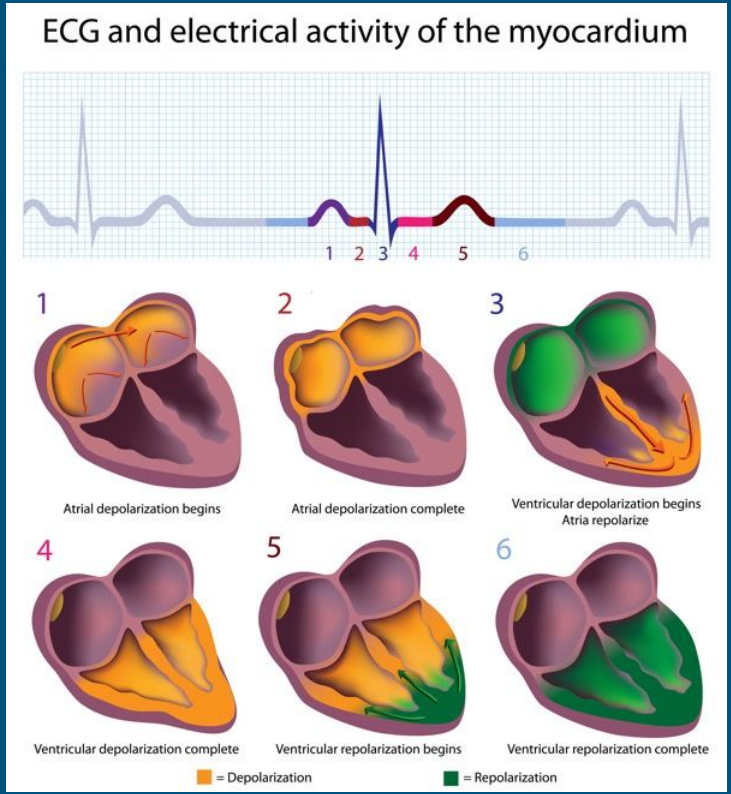
-Understand how select agents act on the heart with potentially disastrous results.

-Understand why we care so much about all those little intervals.

-Practice applying our EKG prowess to a few select cases.

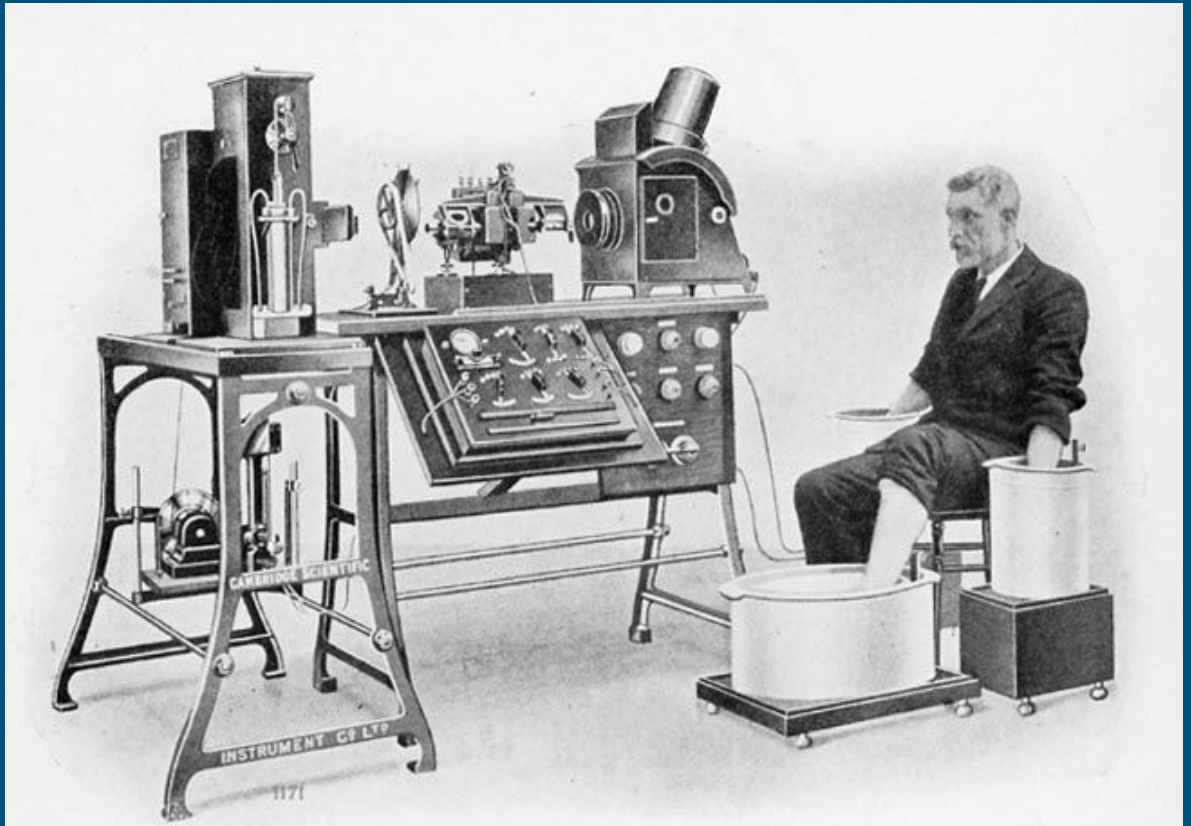
EKG Basics


QRS
Complex
R
PR
Segment
ST
Segment
P
T
PR Interval
Q
J-Point
S
QT Interval


ECG and electrical activity of the myocardium
1 2 3 4 5 6
1
2
3
Atrial depolarization begins
Atrial depolarization complete
Ventricular depolarization begins
Atria repolarize
4
5
6
Ventricular depolarization complete
Ventricular repolarization begins
Ventricular repolarization complete
= Depolarization
= Repolarization

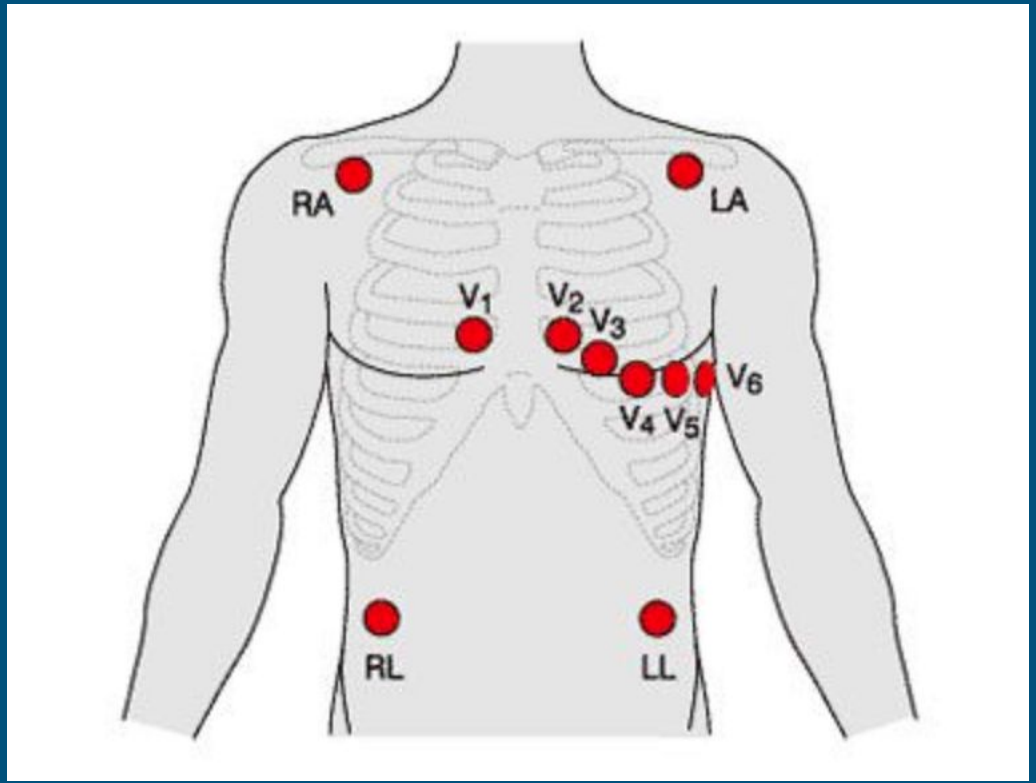
Hipster EKG

Einthoven doing EKGs before they were cool

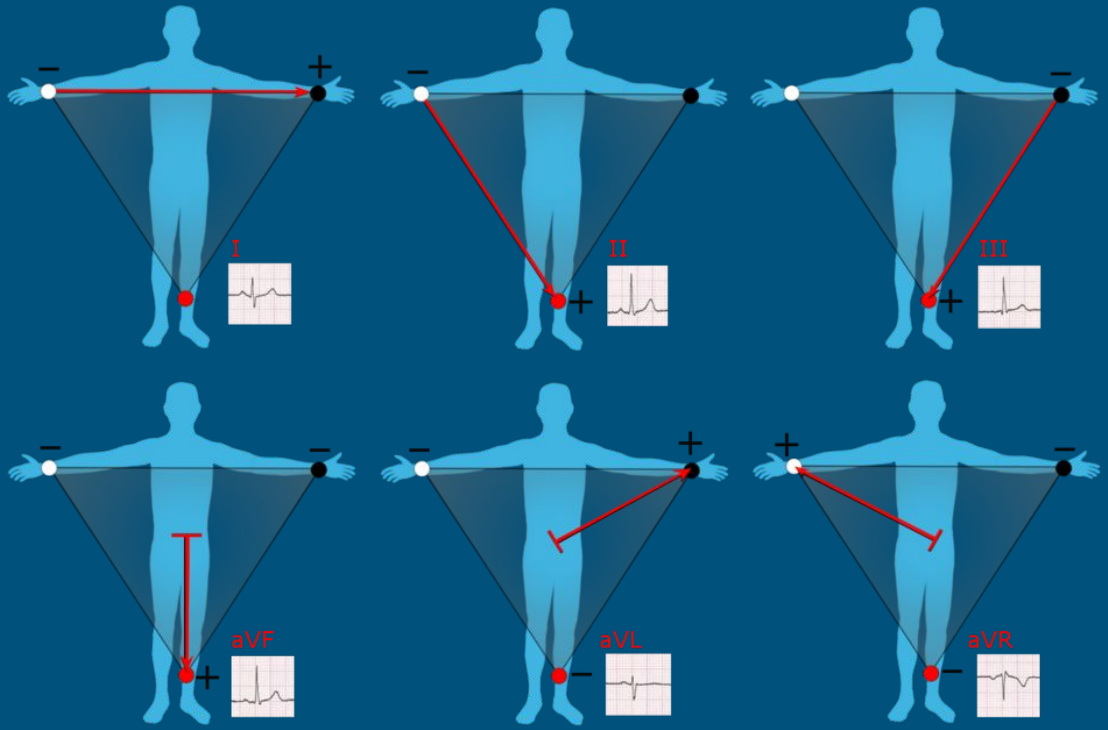


PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

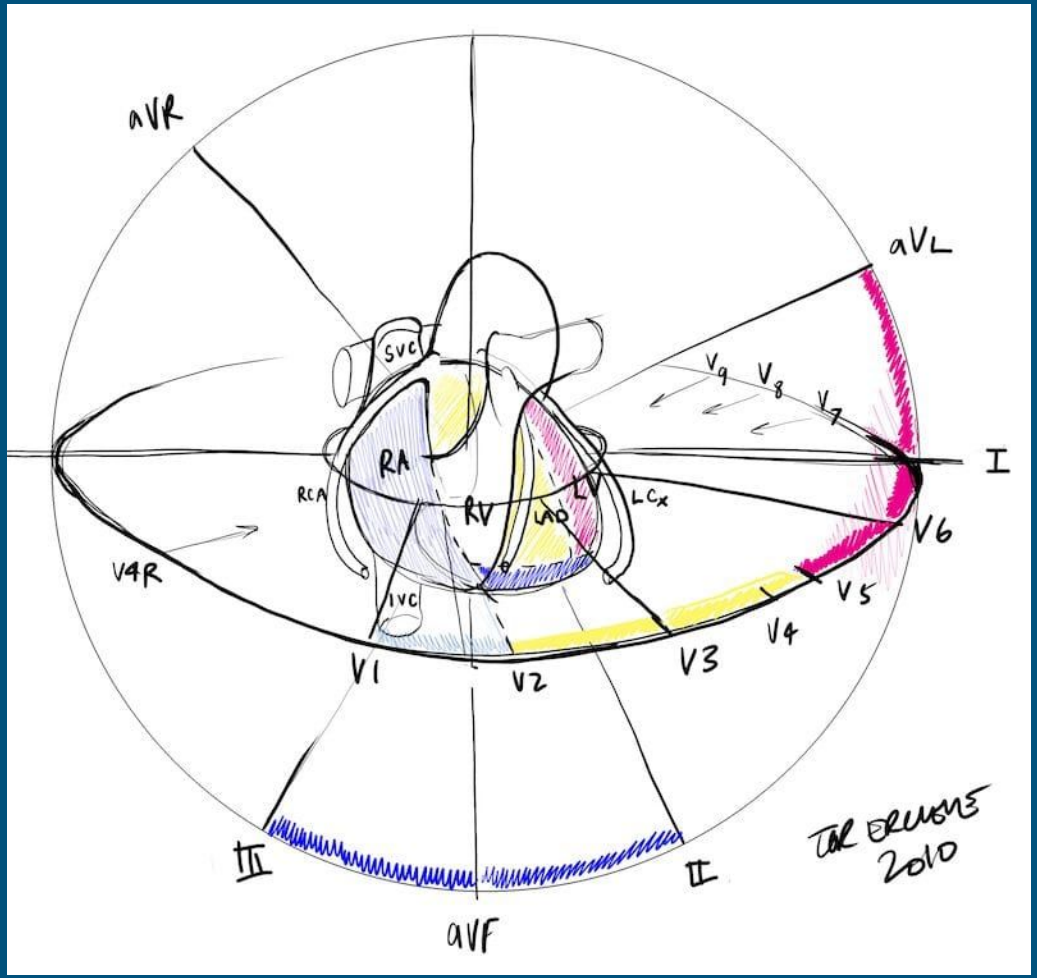
How many electrodes does it take to obtain a 12 lead-EKG?



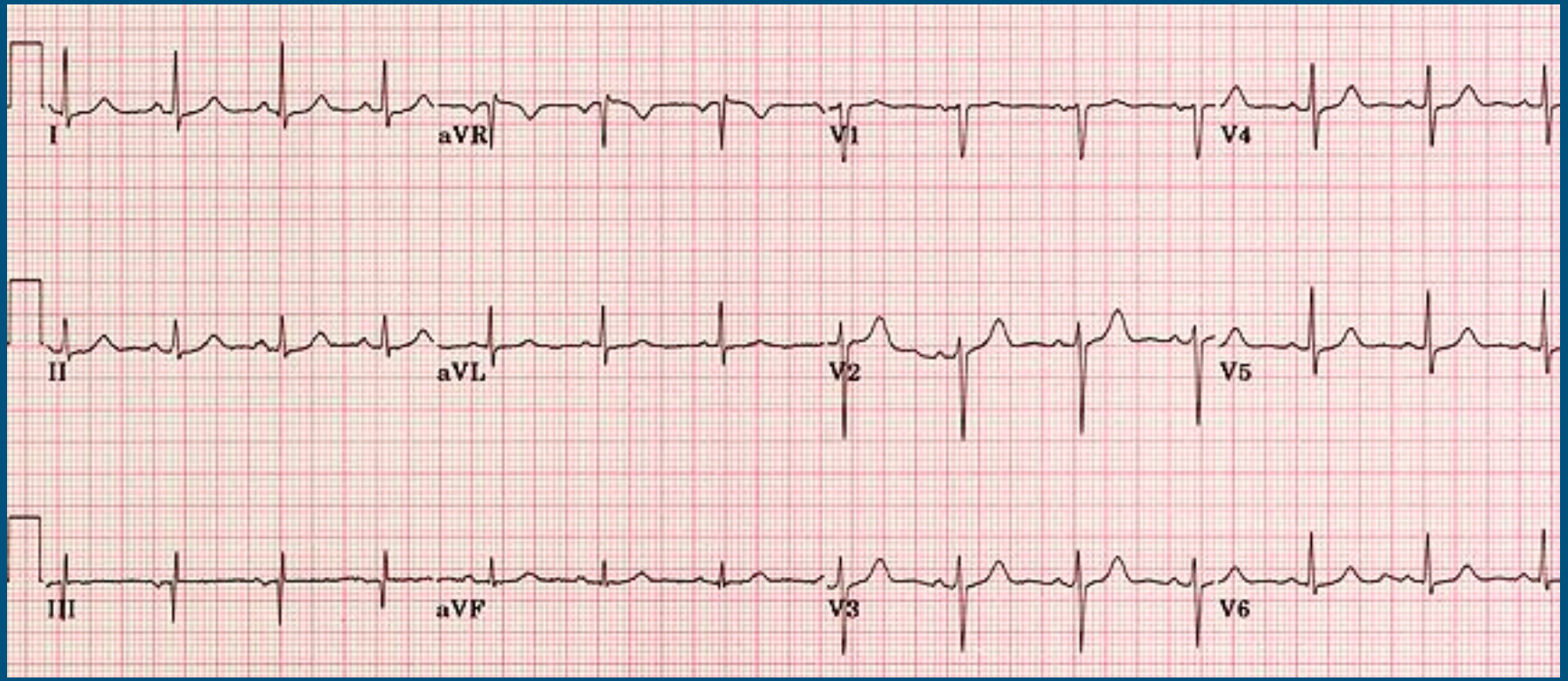
How does 10 add up to 12?



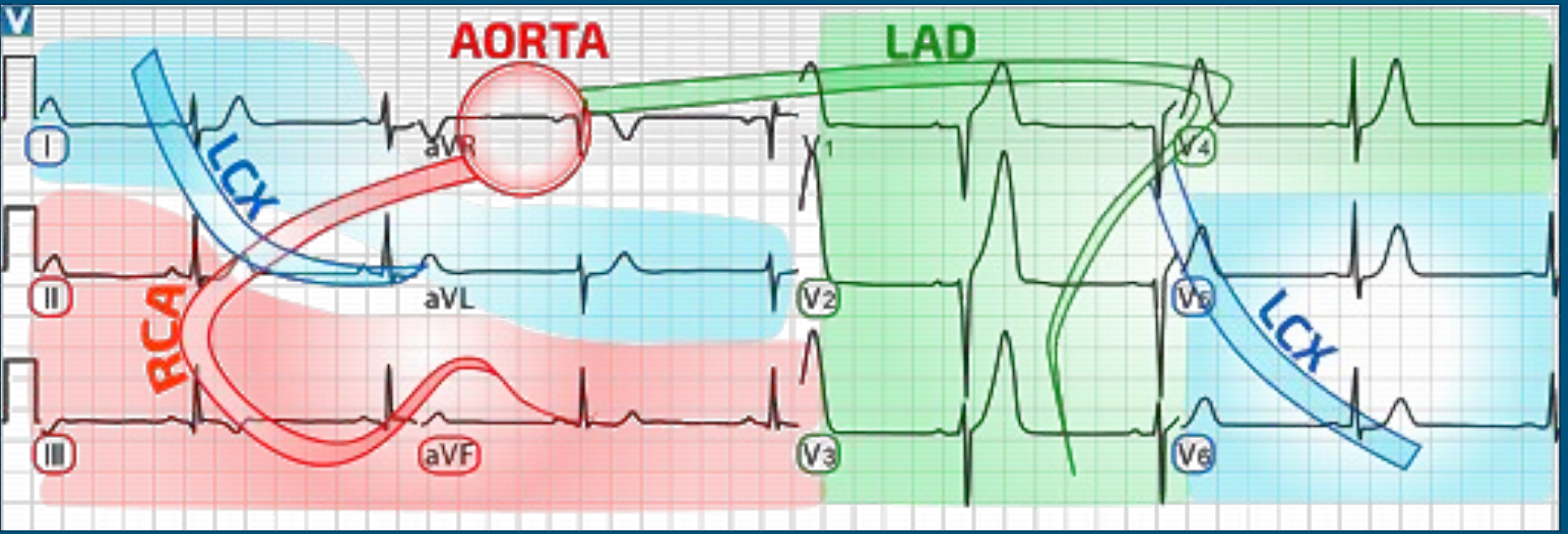
Heart Shish Kabob



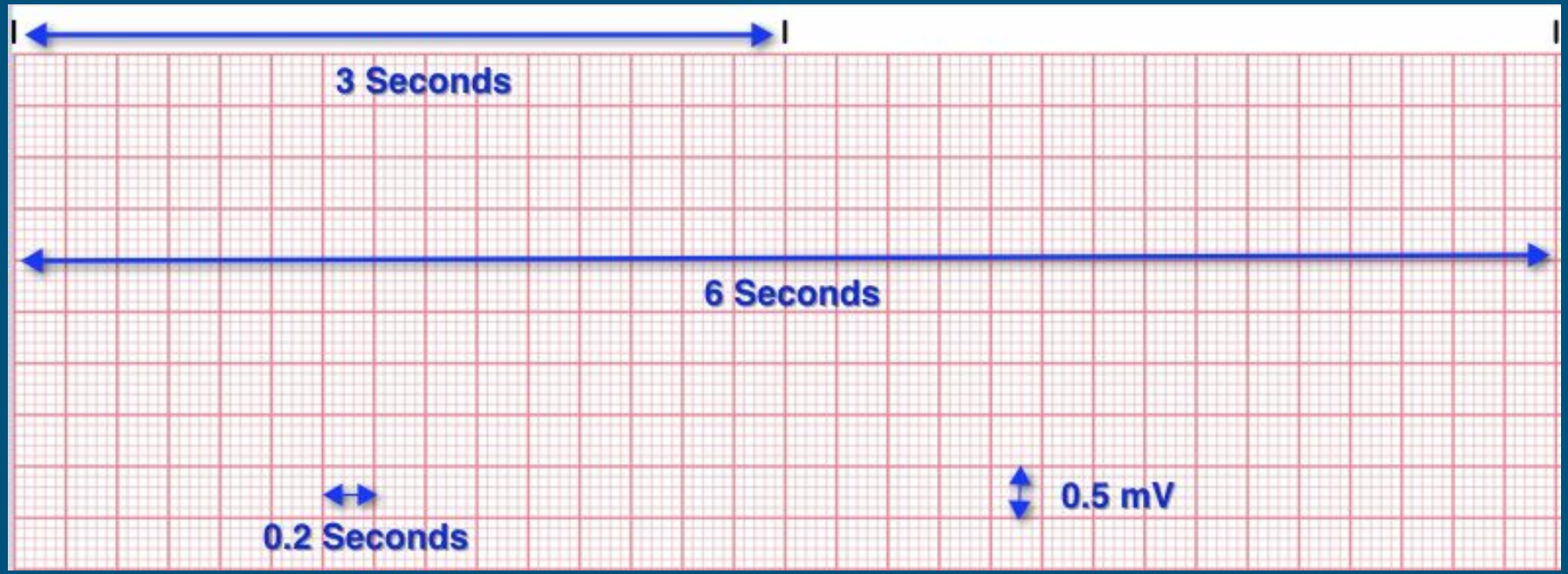
Put it all together and you get:



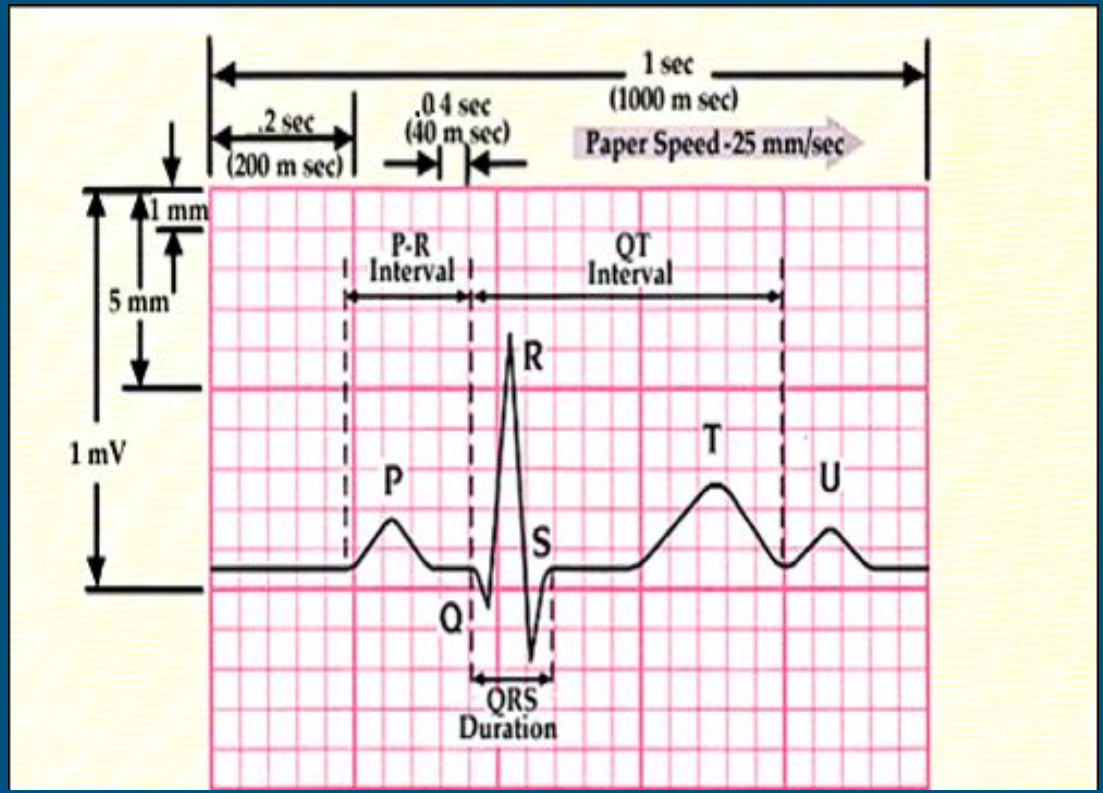
The squiggles are a map of the heart



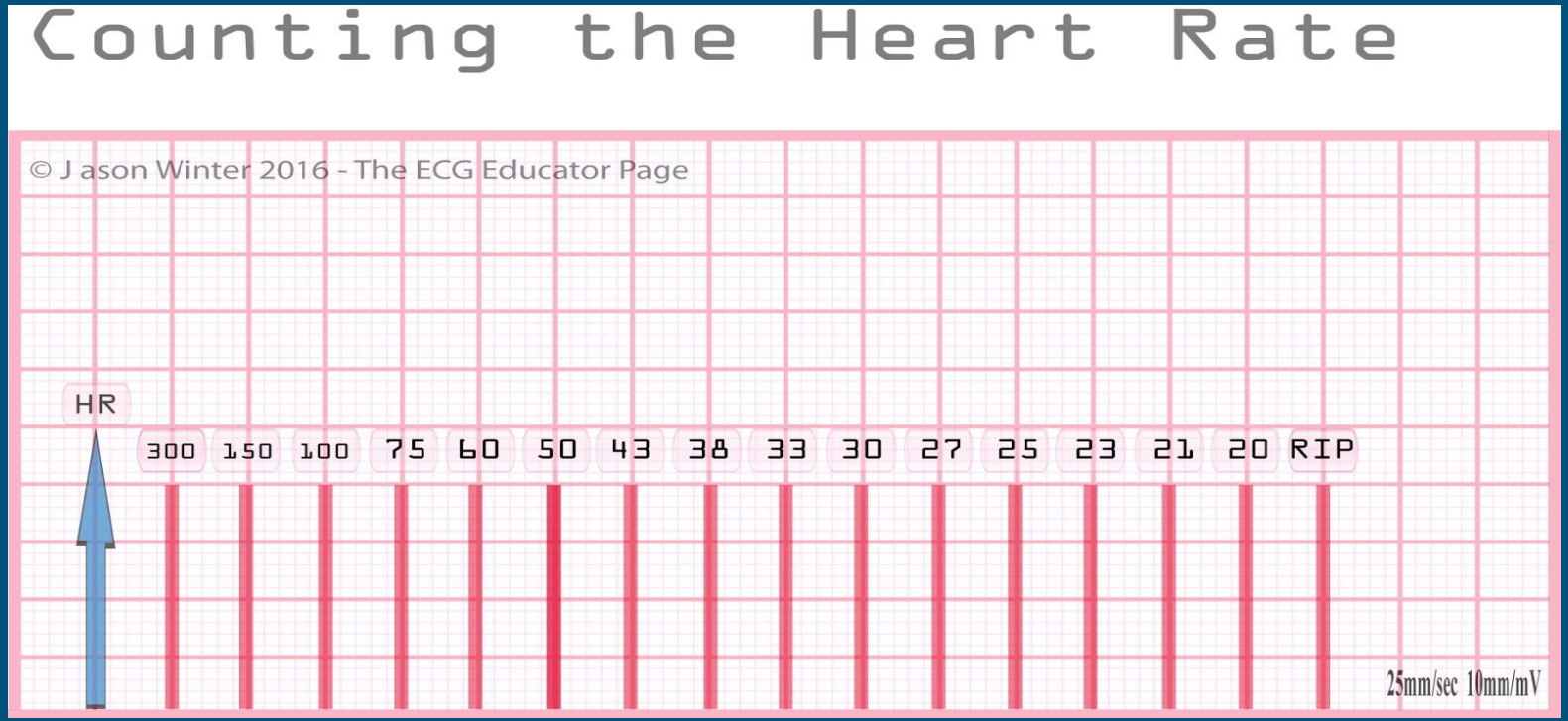
EKG Paper: a very inefficient way to tell time



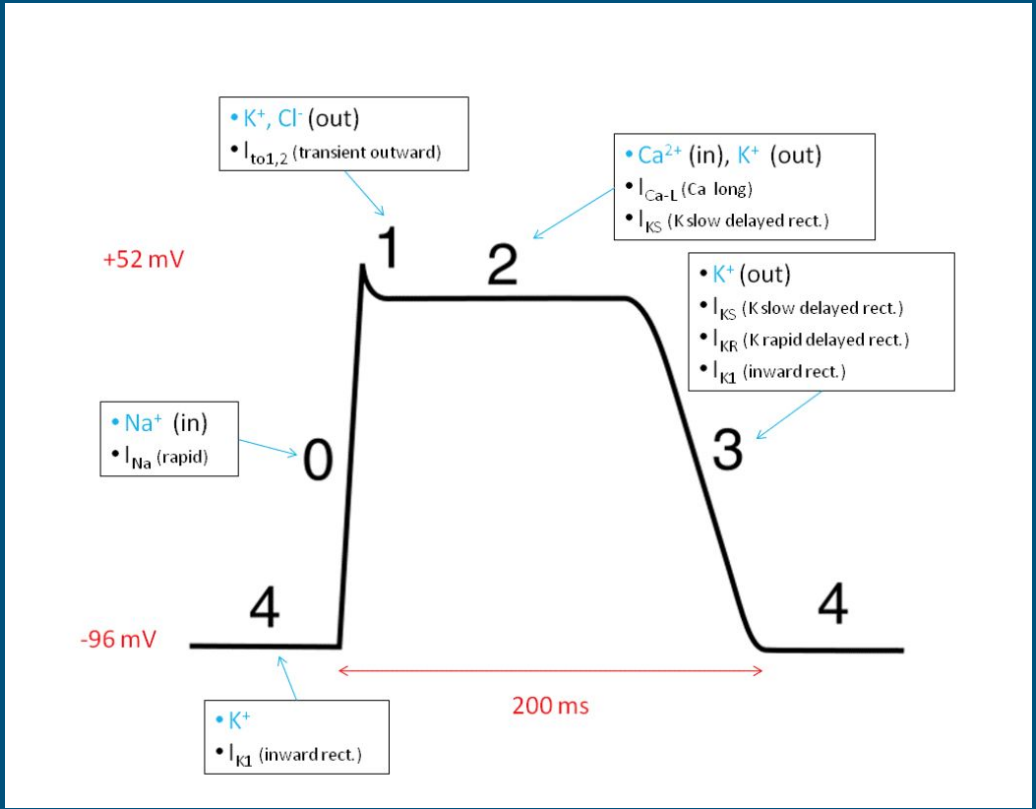
Let’s talk boxes



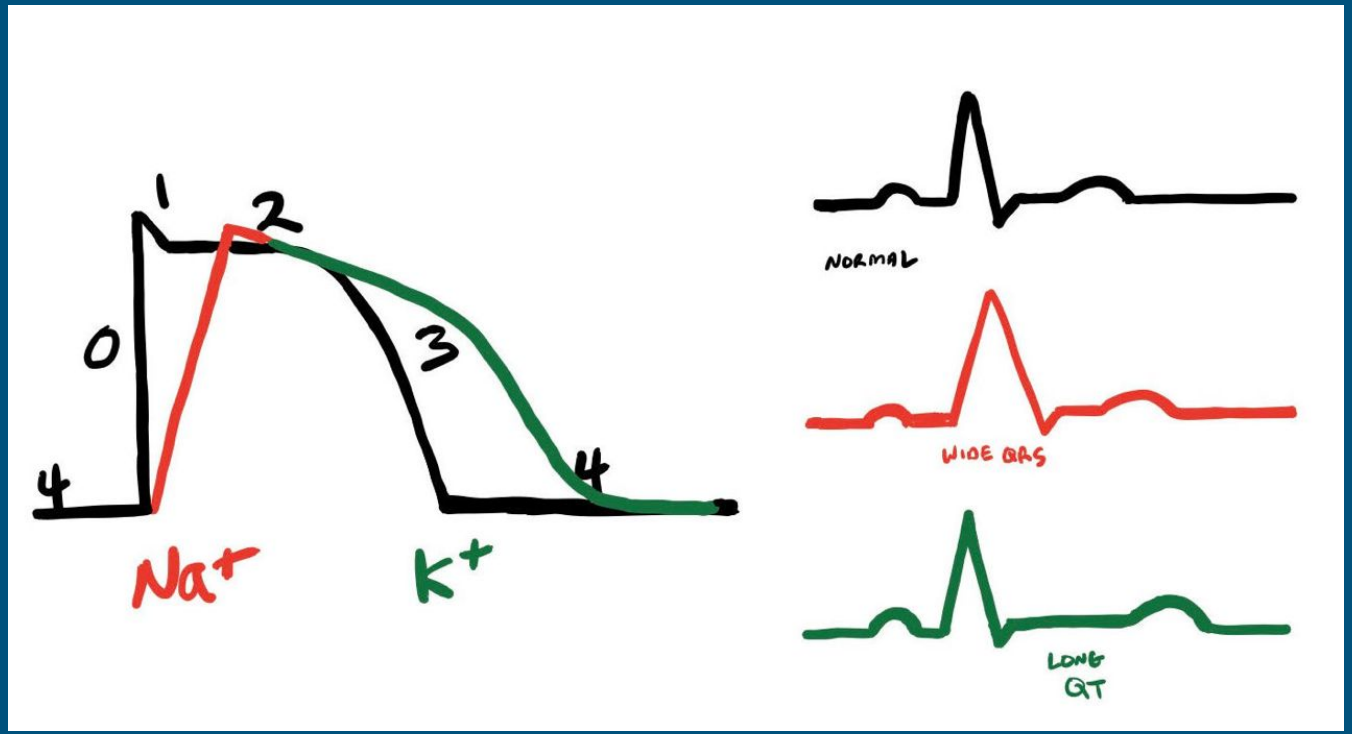
Rate by boxes



Unfortunate Obligatory physiology flashback



What do we look for as toxicologists?



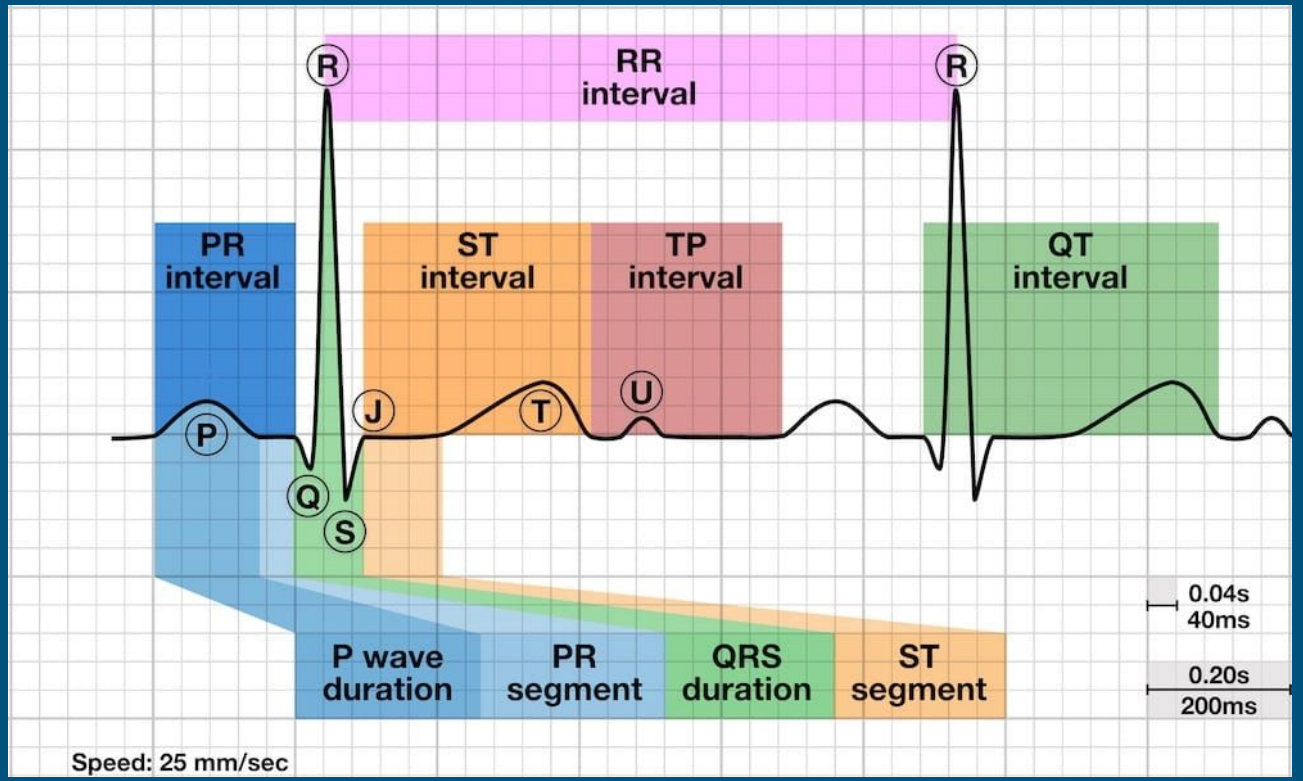
http://www.tamingthesru.com/blog/diagnostics/ekg-toxicology

Interval Training

PR: .12-.2 ms

QRS: .8-.12ms

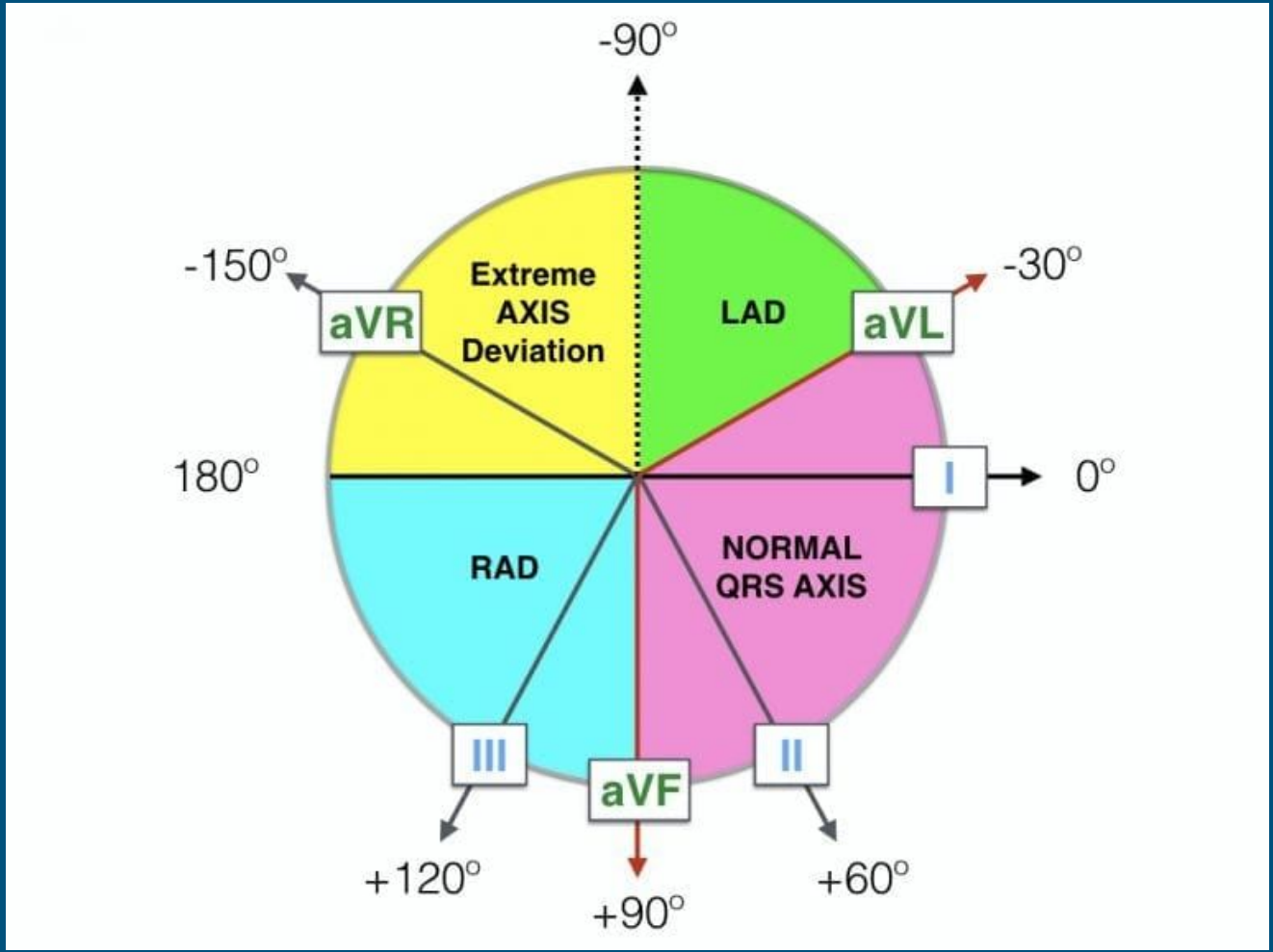
QTc: <440ms M, <460ms F, > 500ms is really bad



https://litfl.com/qt-interval-ecg-library/

Axis

The thing that tells you its V-Tach



Reading an EKG

Fast or Slow?

Regular or irregular?

P waves before every QRS, QRS after every P wave?

QRS narrow or wide?

ST segments, axis, Intervals?

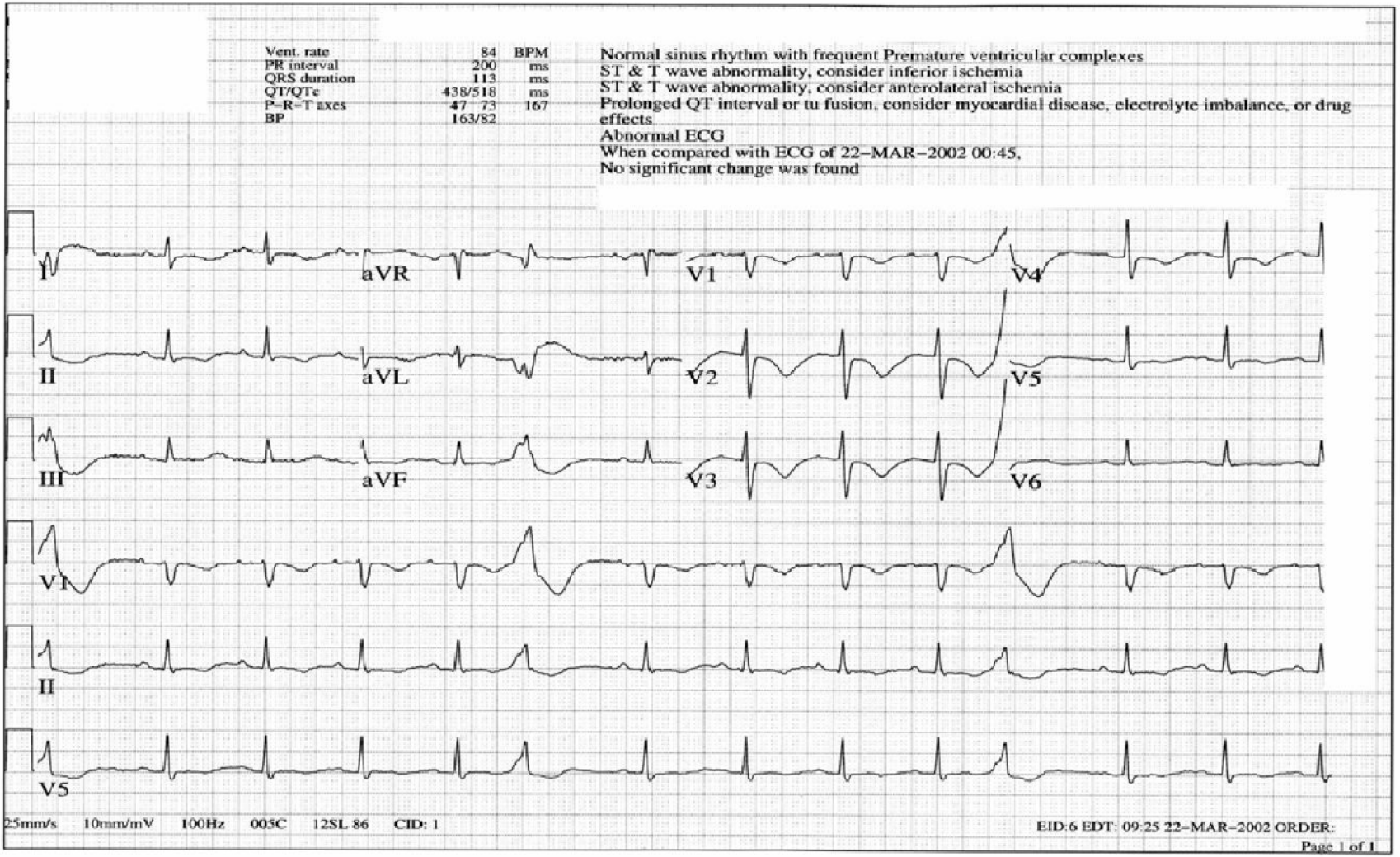
Review

Rate	EKG Change	Consider
Normal	PR prolonged	Early CCB or BB
Normal	QT prolonged	QT prolonging drugs (antipsychotics, antidepressants, antimicrobials)
Bradycardic	PR prolonged	CCB (high glucose), BB (low glucose), Digoxin
Bradycardic	QT prolonged	Methadone
Bradycardic	Enhanced automaticity (PVCs)	Digoxin
Bradycardic	ST changes, AV block, QT prolongation, Brugada pattern	Lithium
Tachycardic	Wide QRS, Dominant R in aVR	Class I antiarrythmics, TCA, cocaine, other antidepressants
Tachycardic	Narrow QRS	Sympathomimetics, anticholinergics

http://www.tamingthesru.com/blog/diagnostics/ekg-toxicology

An EKG by itself is just one clue

But with context it can be the key that cracks the whole case:


Vent. rate 84 BPM
PR interval 200 ms
QRS duration 113 ms
QT/QTc 438/518 ms
P-R-T axes 47 73 167
BP 163/82
Normal sinus rhythm with frequent Premature ventricular complexes
ST & T wave abnormality, consider inferior ischemia
ST & T wave abnormality, consider anterolateral ischemia
Prolonged QT interval or tu fusion, consider myocardial disease, electrolyte imbalance, or drug effects
Abnormal ECG
When compared with ECG of 22-MAR-2002 00:45,
No significant change was found
I
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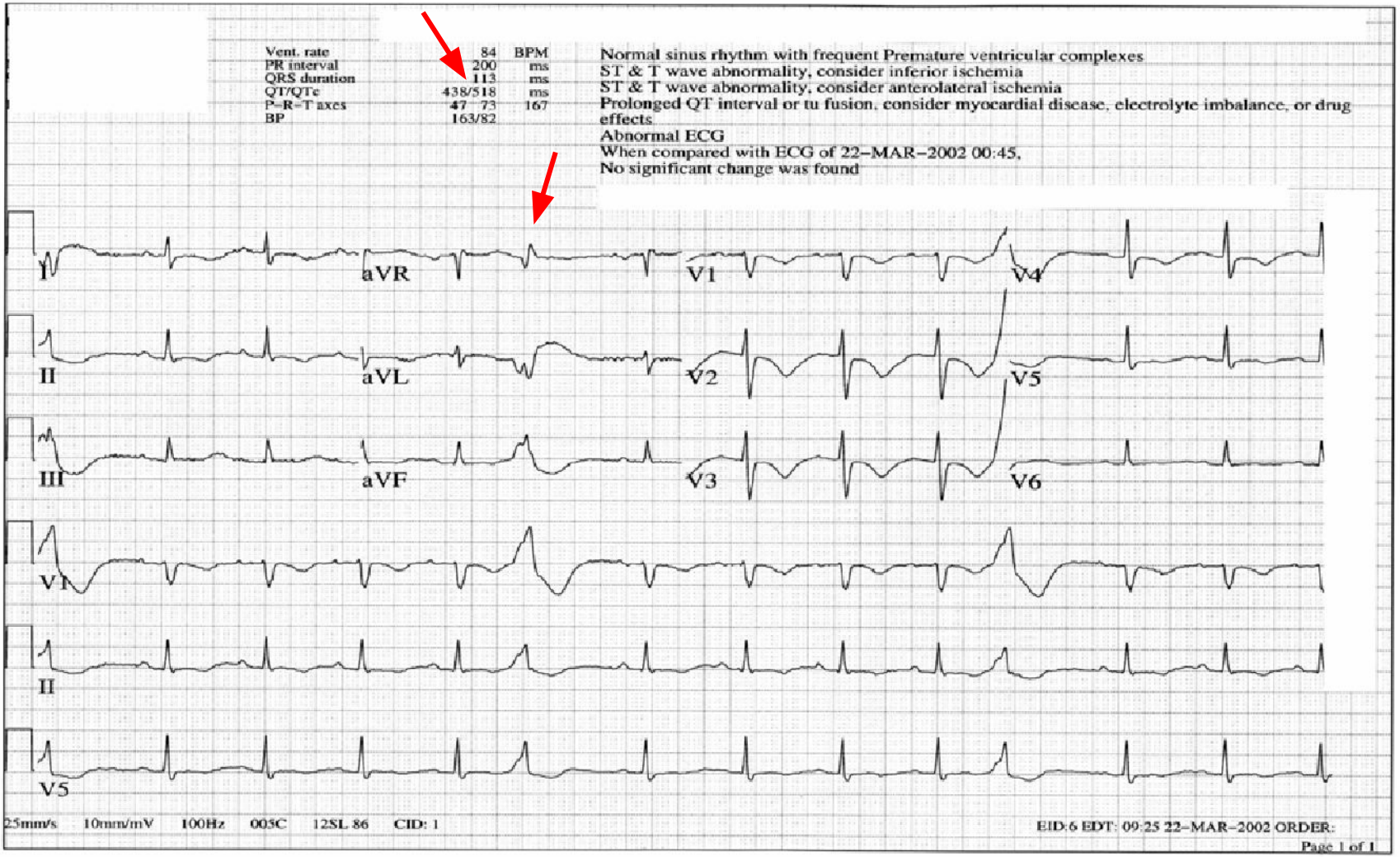
25mm/s 10mm/mV 100Hz 005C 12SL 86 CID: 1
EID:6 EDT: 09:25 22-MAR-2002 ORDER:
Page 1 of 1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25mm/s 10mm/mV 100Hz 005C 12SL 86 CID: 1
EID:6 EDT: 09:25 22-MAR-2002 ORDER:
Page 1 of 1

Bupivacaine

Long-acting, local, amide-based anesthetic.

Interferes with voltage gated sodium channels.

Marked QT prolongation and prominent R wave in aVR due to Na+ Channel blockade

Tx: Lipid Emulsion

Local Reg Anesth. 2010; 3: 11–19.
Published online 2010 Feb 26. doi: 10.2147/lra.s8814
PMCID: PMC3417942
PMID: 22915863

A review of local anesthetic cardiotoxicity and treatment with lipid emulsion

Emma Bourne,[1] Christine Wright,[1] and Colin Royse[2]

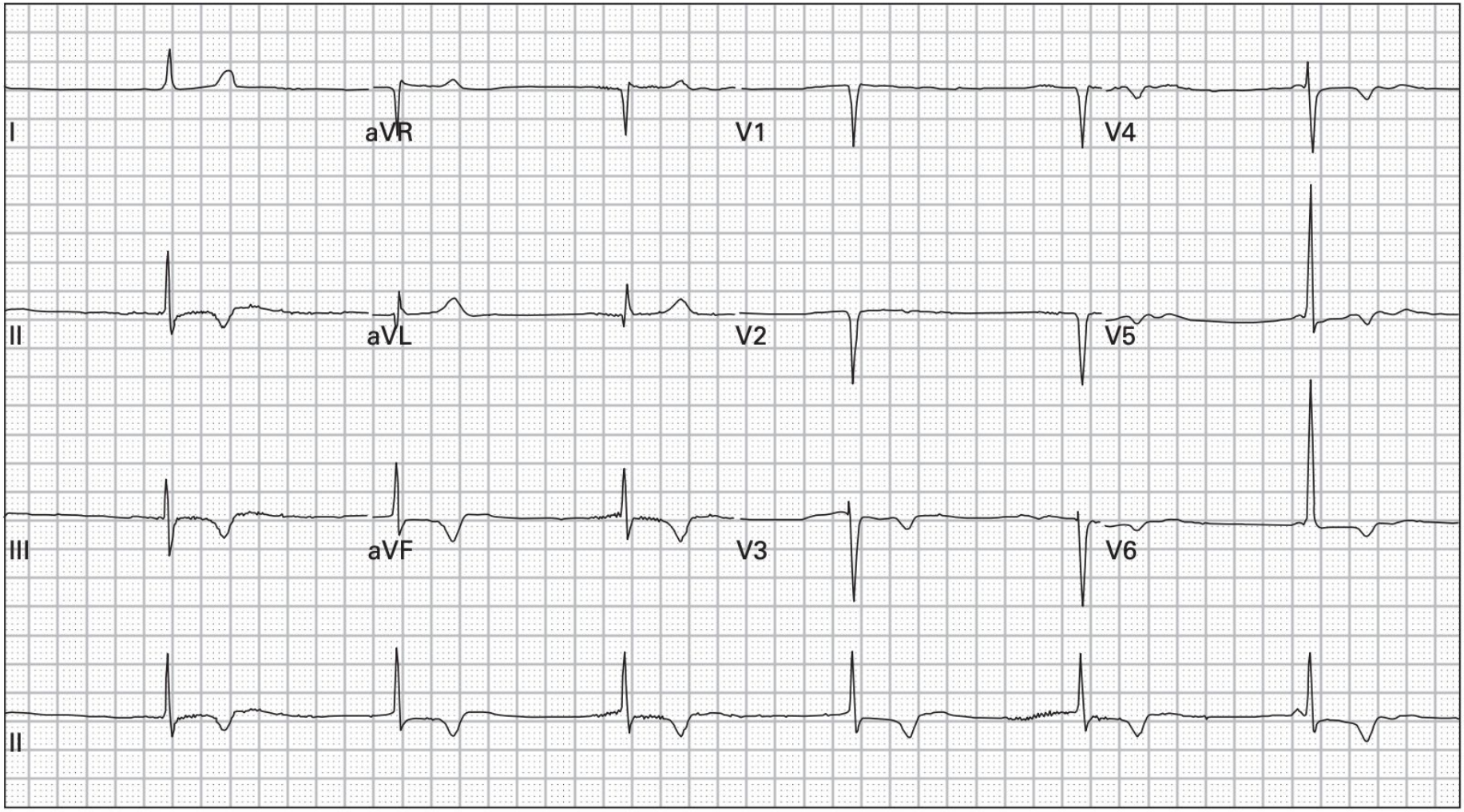
Case Reports > Can J Clin Pharmacol. Fall 2005;12(3):e240-5. Epub 2005 Oct 24.

Cardiovascular collapse from low dose bupivacaine

Marc E Levsky [1], Michael A Miller

Affiliations + expand

PMID: 16278496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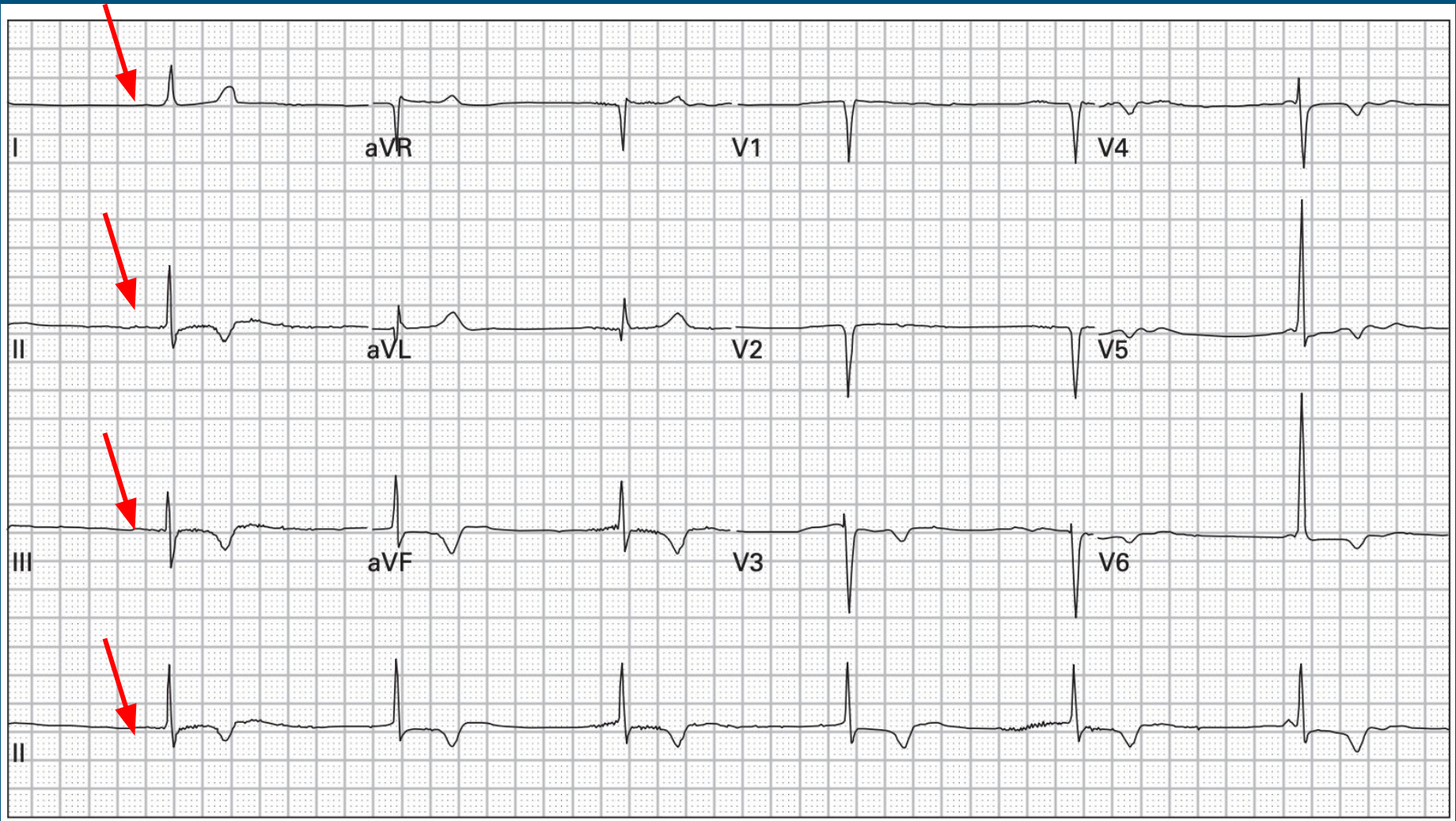
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Metoprolol

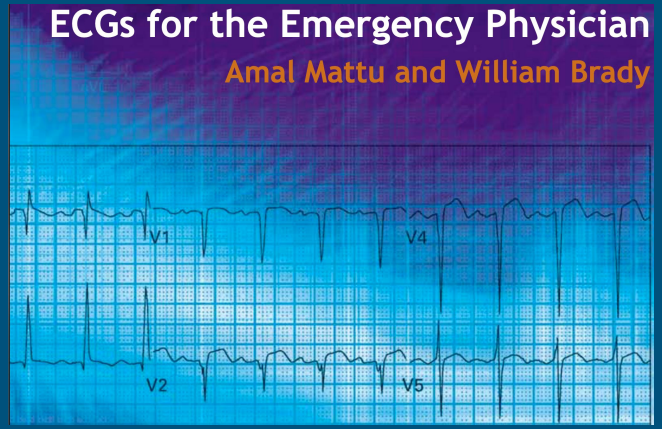
Beta-antagonist

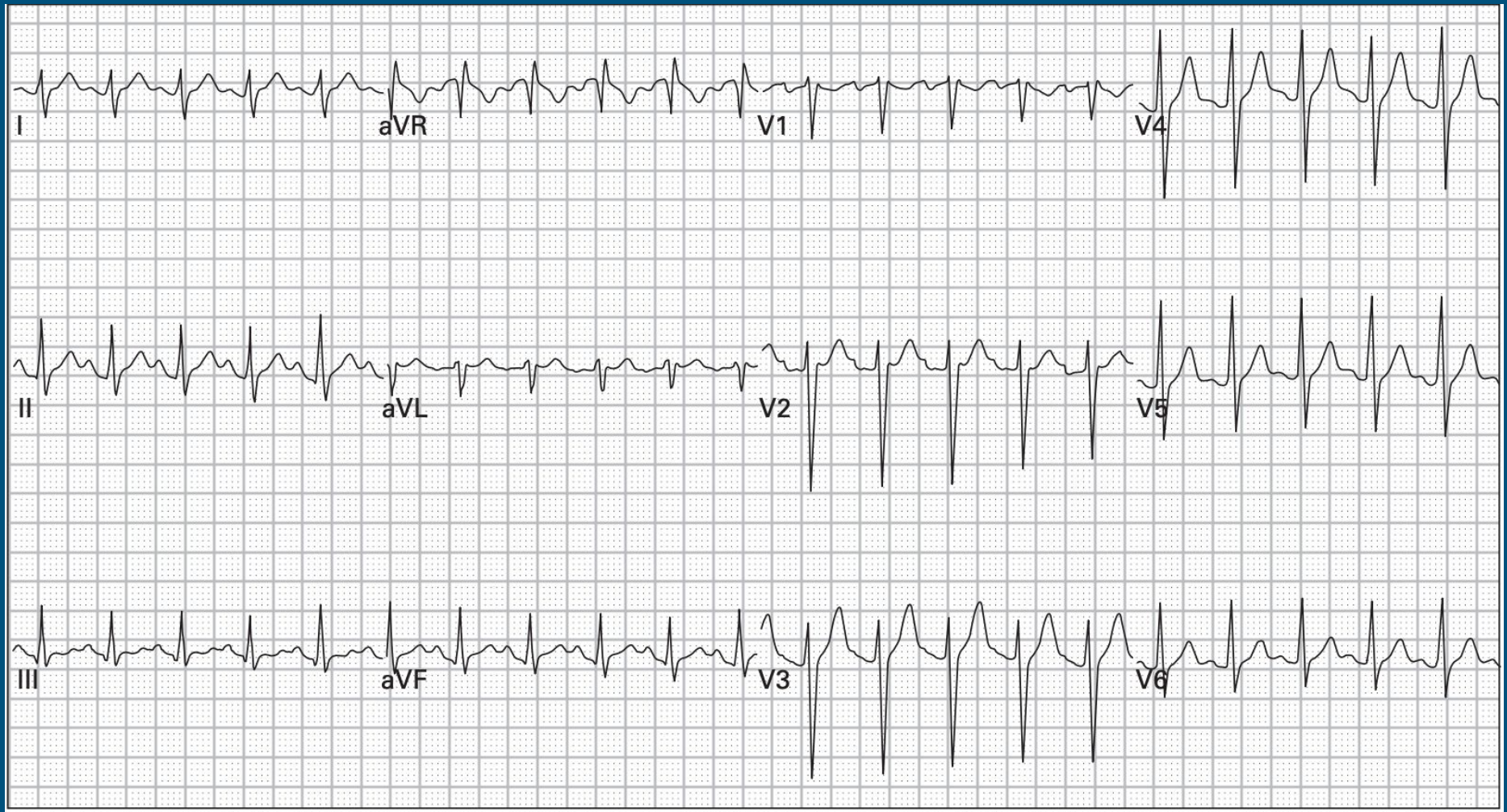
Blocks Beta receptors, decreased cAMP production leads to blunted response to catecholamines

Prolonged PR, bradycardia, Heart Block

Tx: Glucagon?,

High Dose insulin Euglycemic Therapy (HIET)?

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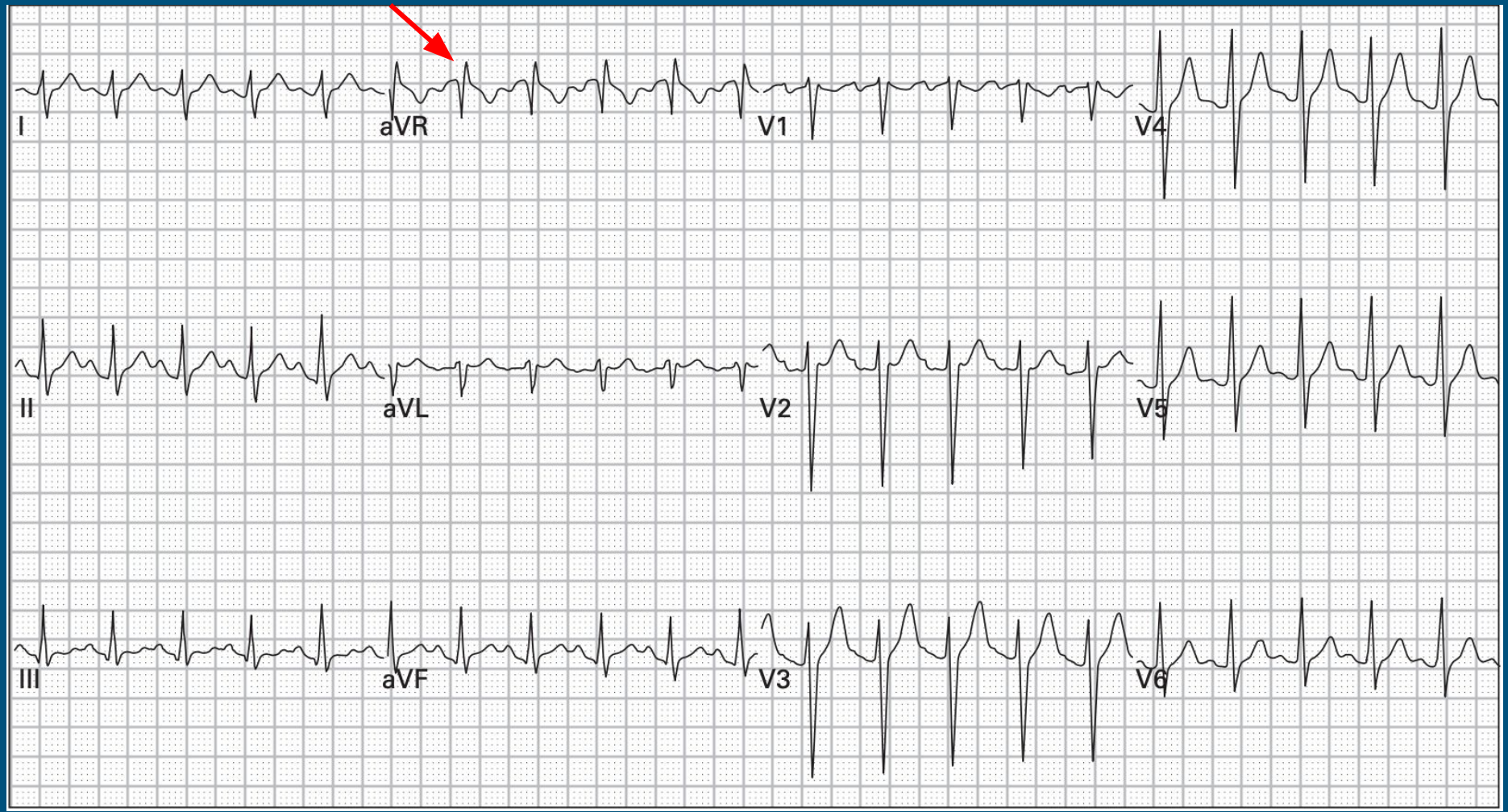
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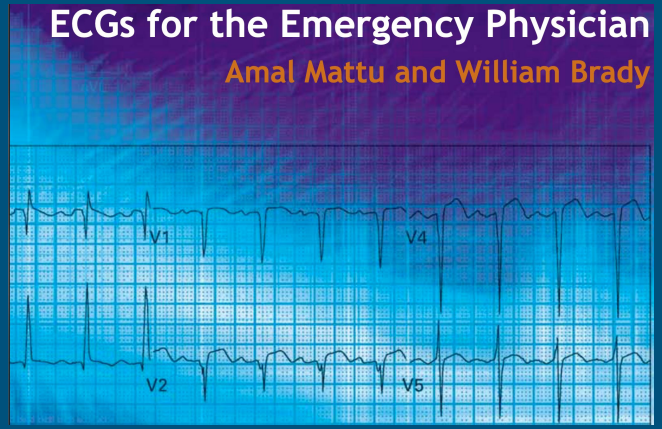
Amitriptyline

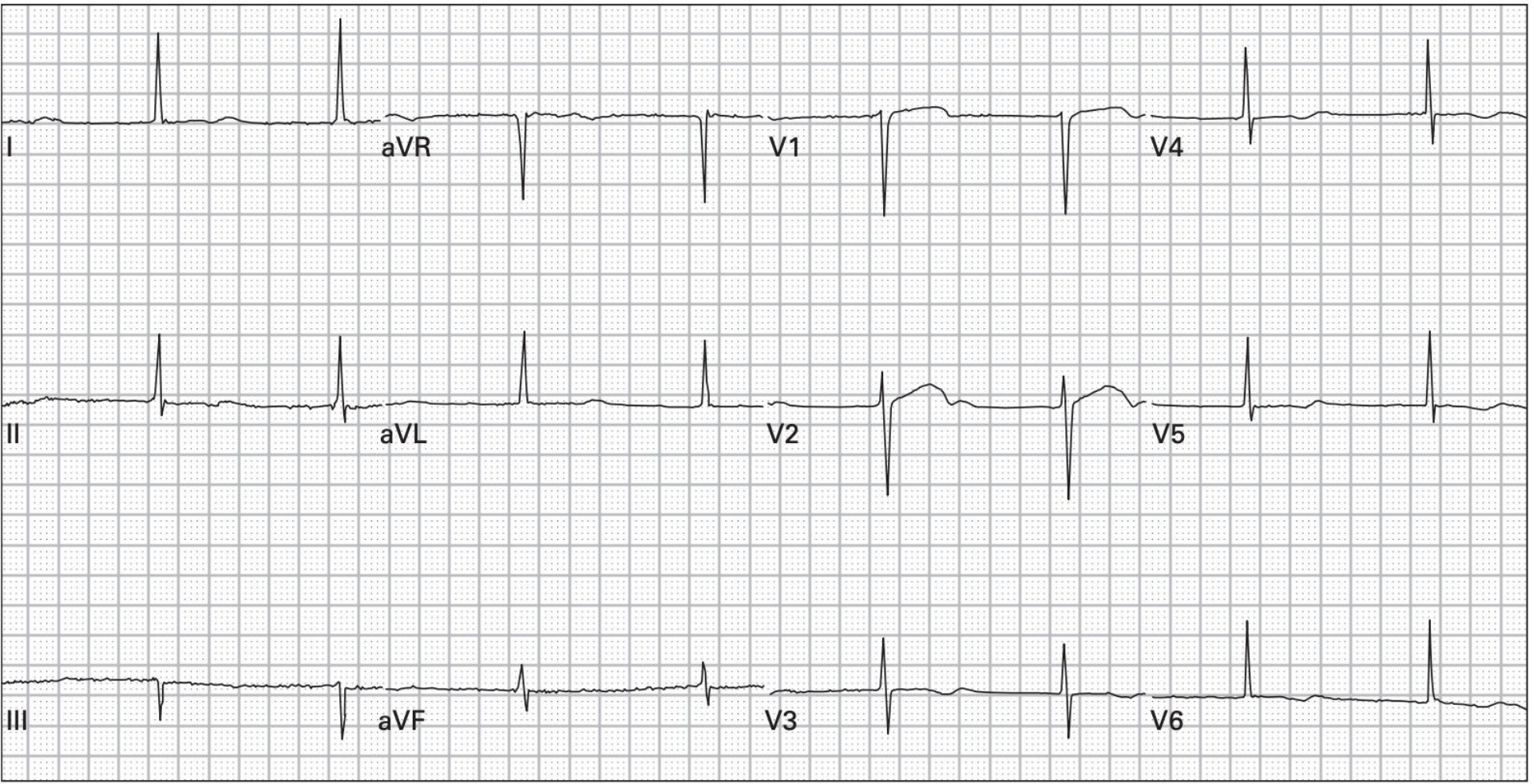
Tricyclic antidepressant

Interferes with Na+ channels

Tachycardia, Rightward Axis, Prominent R in aVR, slight QRS prolongation

Tx: IV Bicarbonate

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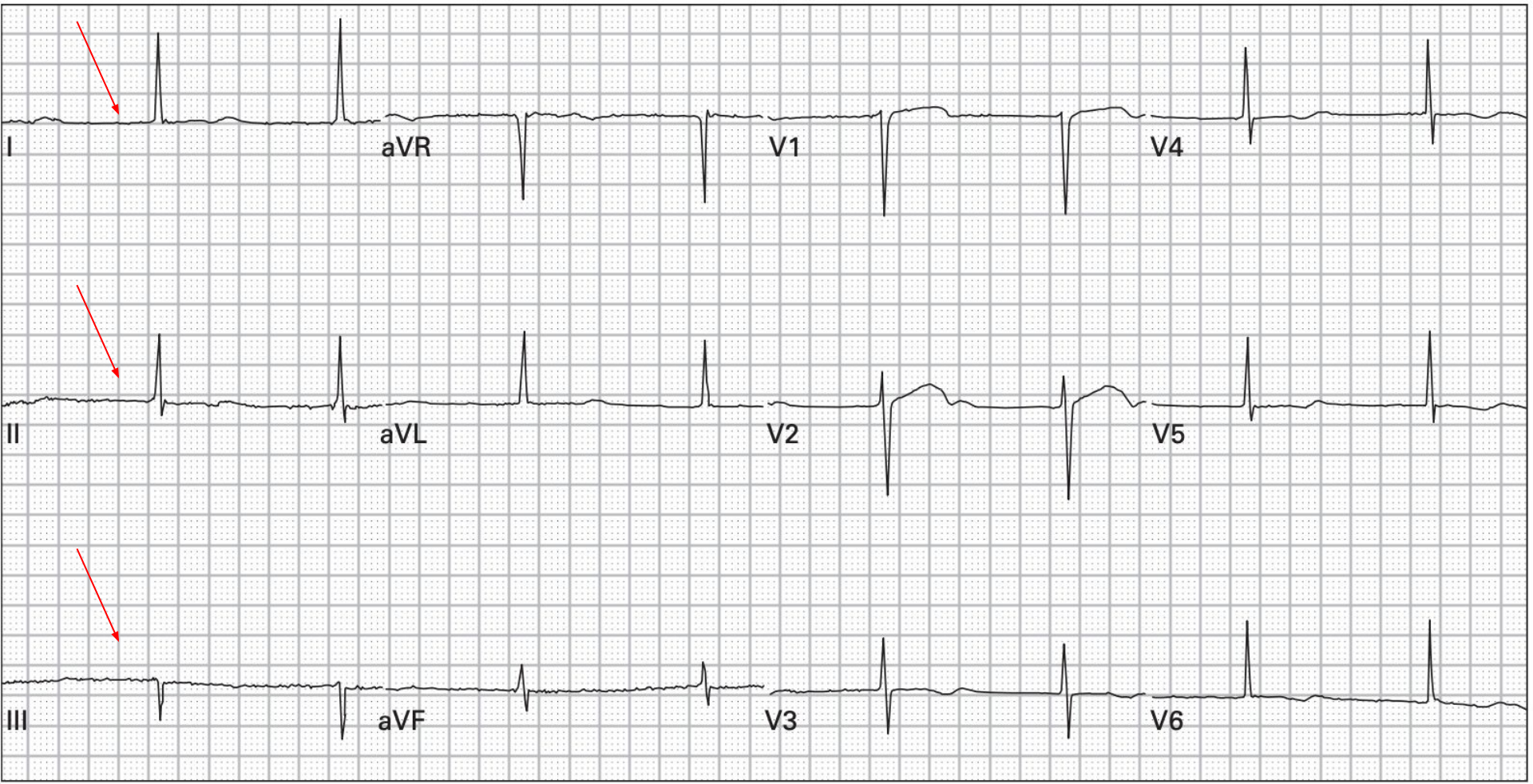
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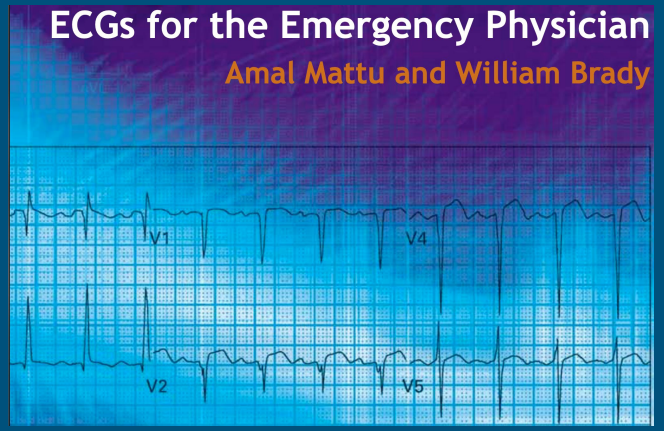
Calcium Channel Blocker + Beta Blocker

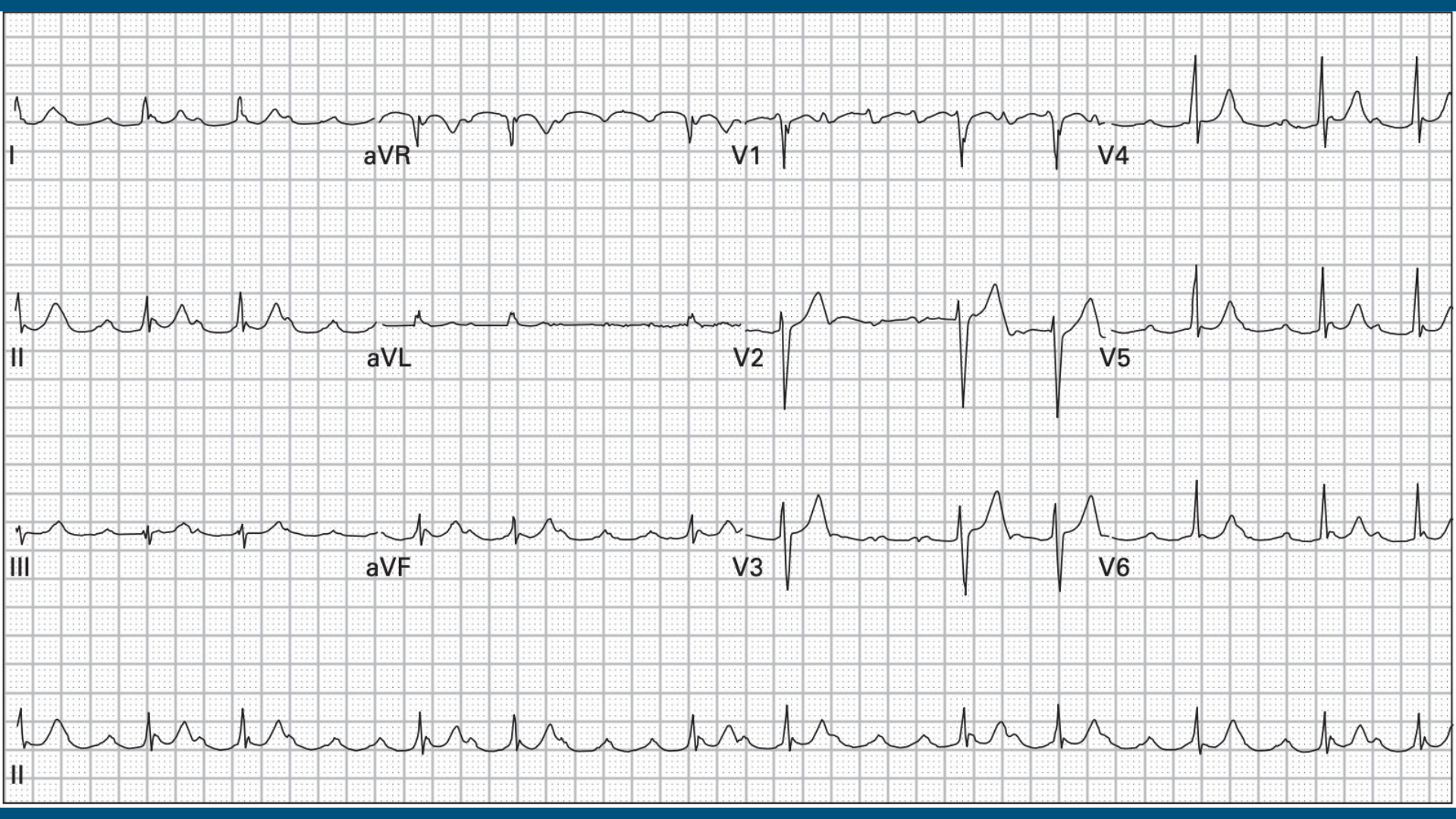
Calcium Channel Blocker

Non-dihydroperidine CCBs inhibit L-type Ca2+ channels in the heart

Prolonged, PR, Bradycardia, heart block

Tx: HIET

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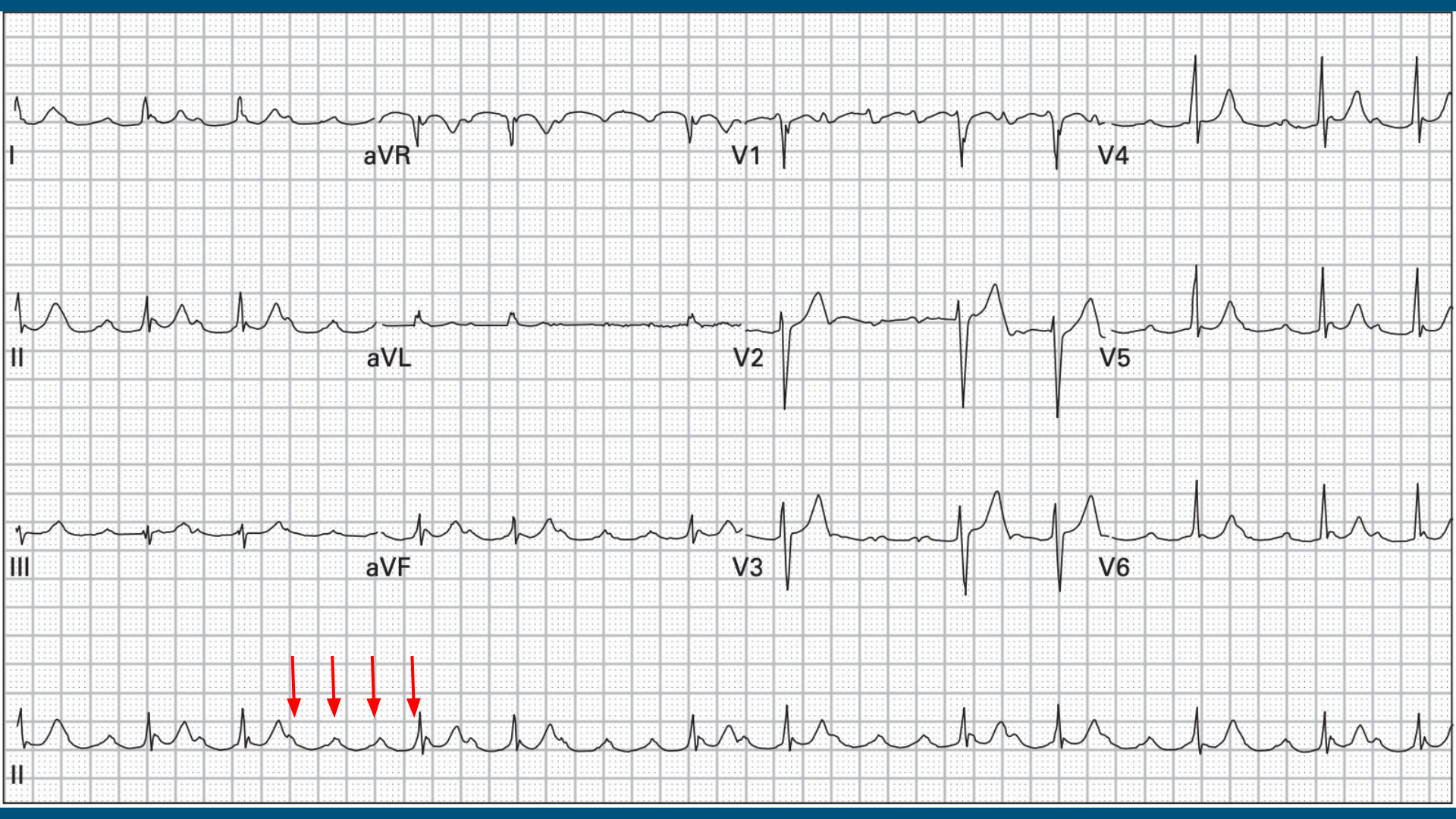
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Digitalis

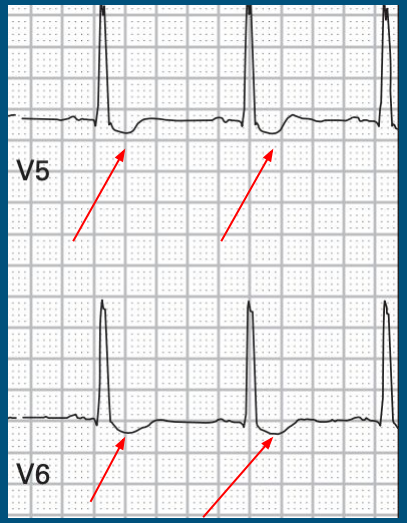
Cardiac Glycoside

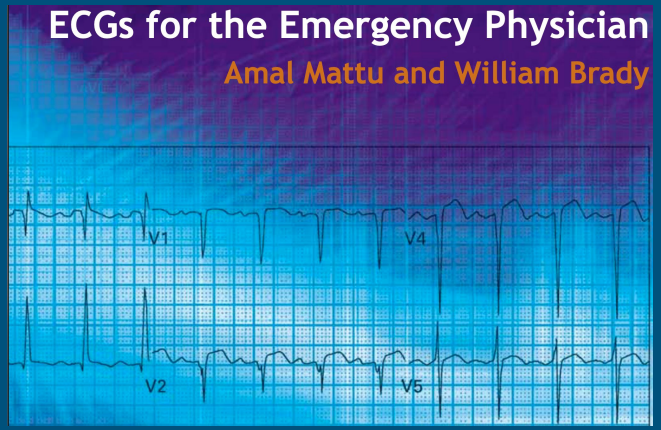
Reversibly inhibits Na-K-ATPase, increasing intracellular Na+, leading to increased intracellular Ca2+ and increased inotropy. I

In toxicity, Increased automaticity, decreased AV conduction.

Tx: Dig Immune Fab

"Hockey Stick"
Digoxin Effect



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III
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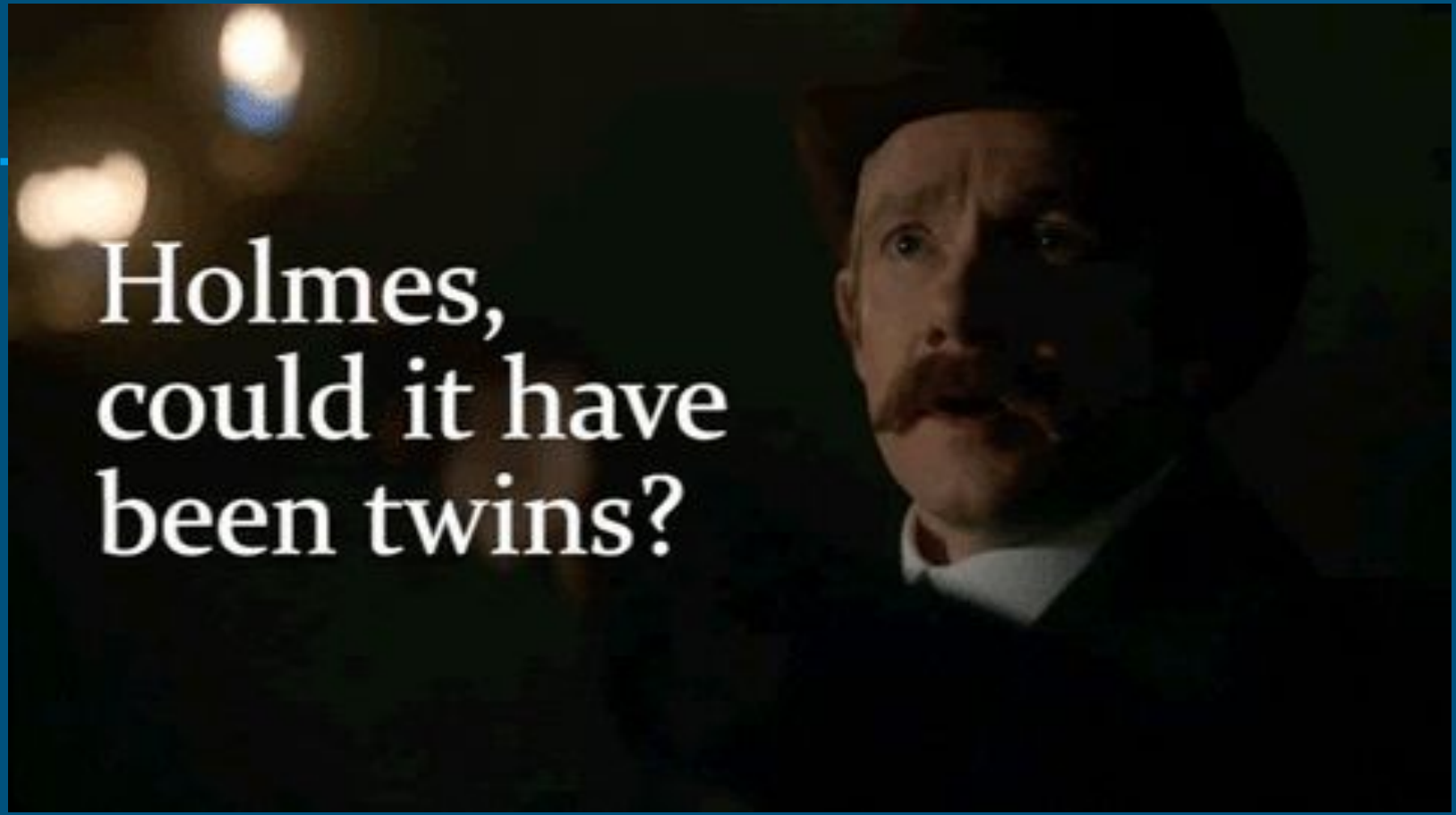

Holmes,
could it have
been twins?

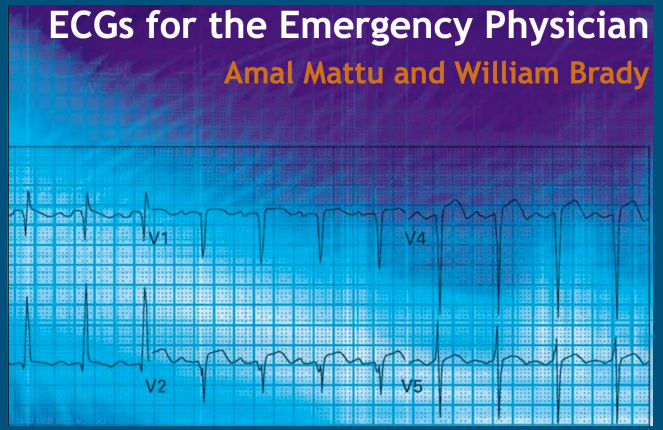
Digitalis Again! This is bidirectional VT

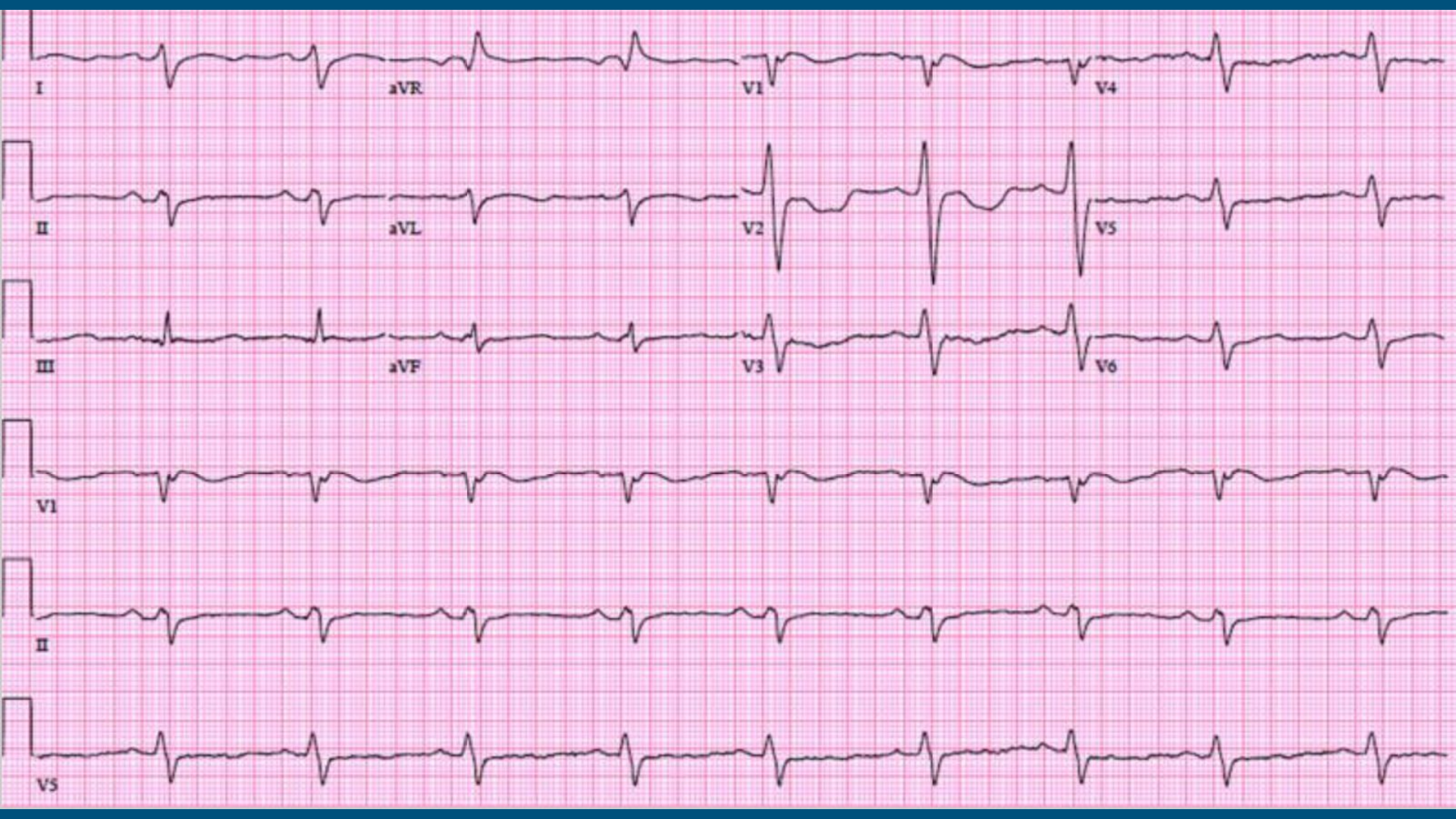
Cardiac Glycoside

Reversibly inhibits Na-K-ATPase, increasing intracellular Na+, leading to increased intracellular Ca2+ and increased inotropy.

In toxicity, Increased automaticity, decreased AV conduction.

Tx: Dig Immune Fab

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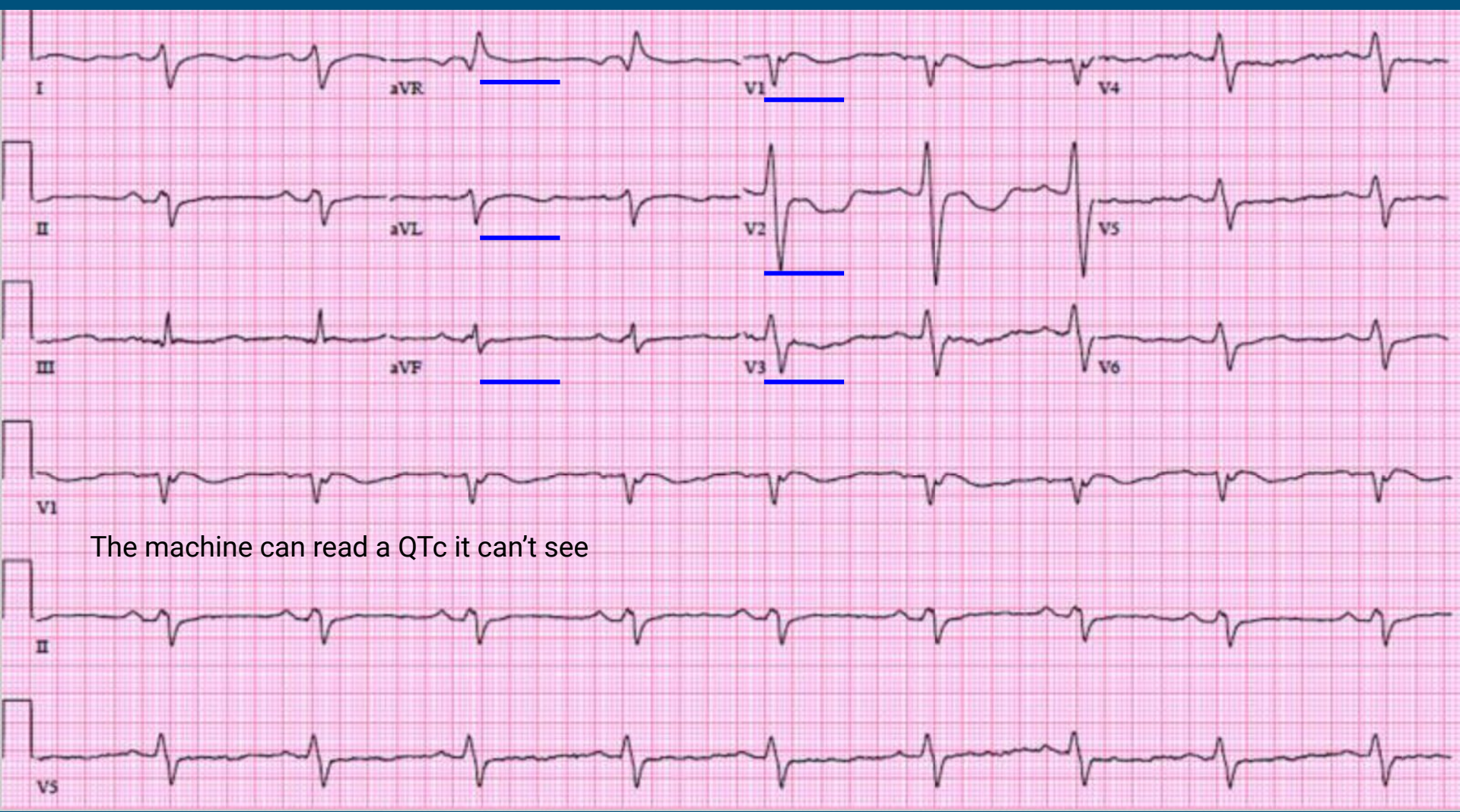


The machine can read a QTc it can’t see

Loperamide

Mu opiate receptor agonist

Decreases intestinal peristalsis

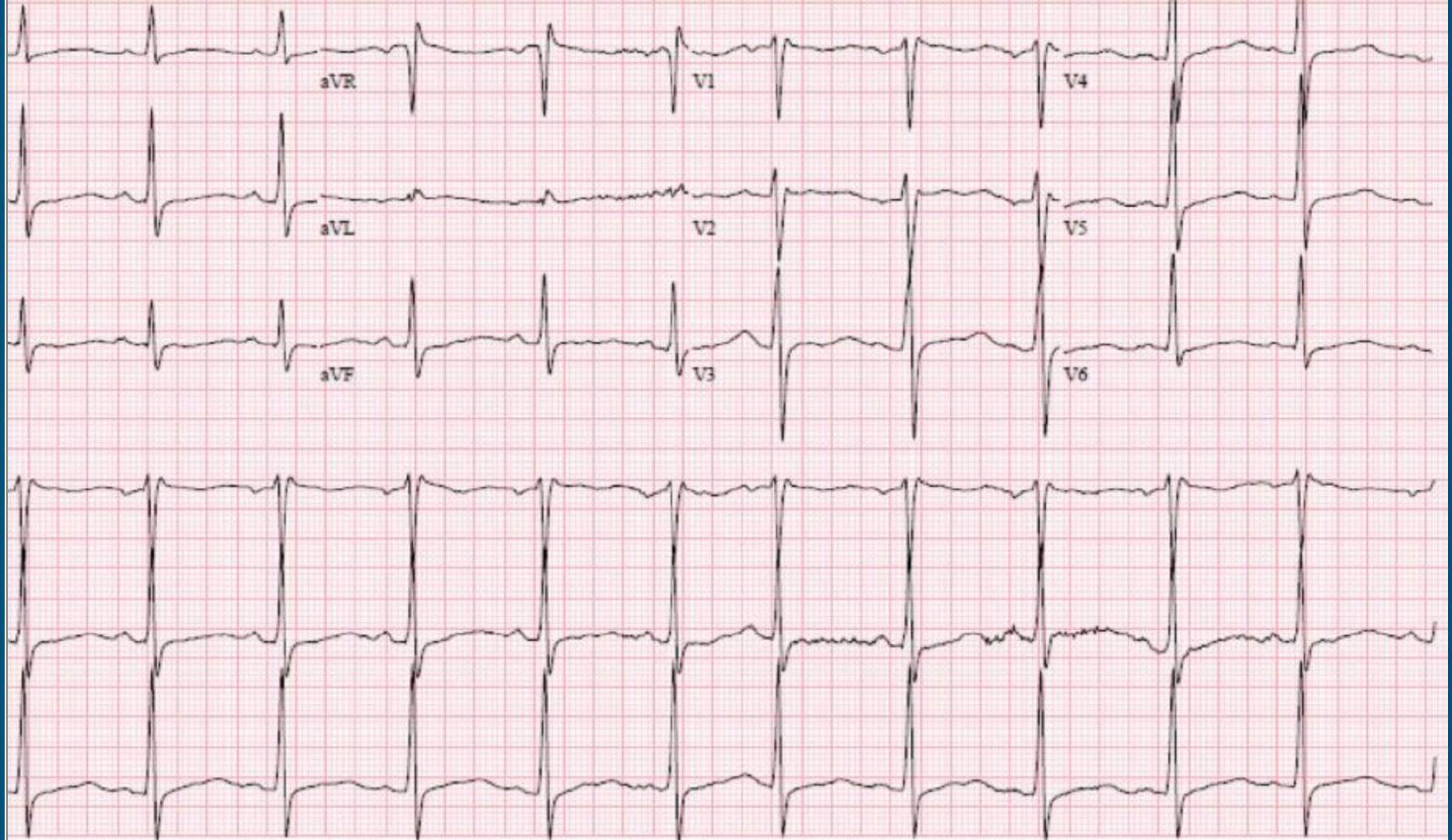
Also has activity on sodium and potassium channels

Tx: ?

HeartRhythm Case Rep. 2016 May; 2(3): 232–236.
Published online 2016 Mar 7. doi: 10.1016/j.hrcr.2016.01.002
PMCID: PMC5419750
PMID: 28491676

High-dose loperamide abuse–associated ventricular arrhythmias

Charles W. O'Connell, MD,[*†*] Amir A. Schricker, MD, MS,[‡] Aaron B. Schneir, MD,[*] Imir G. Metushi, PhD,[§] Ulrika Birgersdotter-Green, MD,[‡] and Alicia B. Minns, MD[*†]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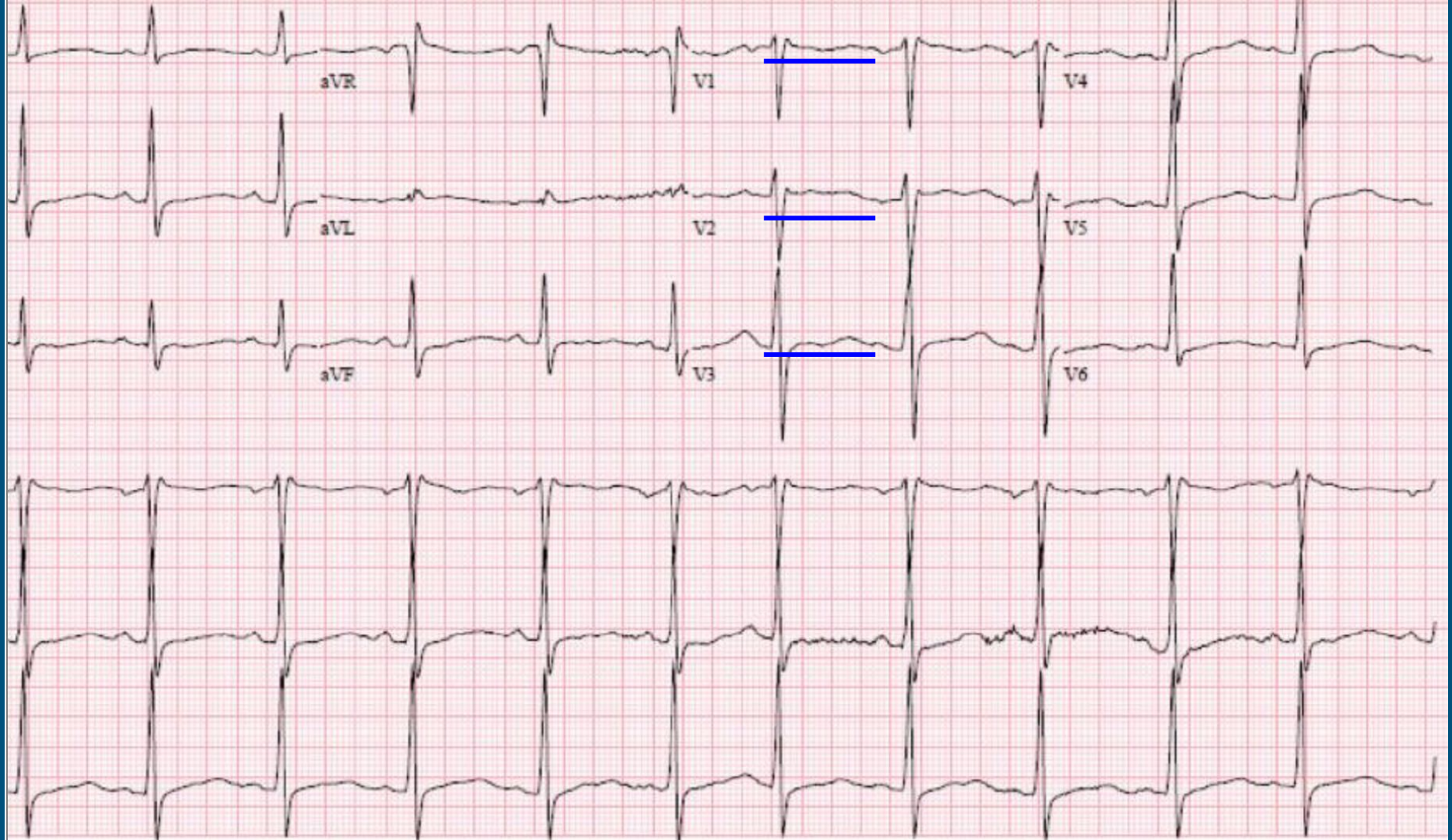
aVR
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Hydroxychloroquine

Aminoquinolone

Blocks sodium and potassium Efflux

QT prolongation, QRS prolongation

Tx: High dose Epi and high dose diazepam

J Med Toxicol. 2020 Jul; 16(3): 314–320.
Published online 2020 Jun 8. doi: 10.1007/s13181-020-00790-8
PMCID: PMC7278768
PMID: 32514696

Intentional Hydroxychloroquine Overdose Treated with High-Dose Diazepam: an Increasing Concern in the COVID-19 Pandemic

Peter R. Chai,[1,2,3,4] E. G. Ferro,[5] J. M. Kirshenbaum,[5] B. D. Hayes,[6,7] S. E. Culbreth,[1,8] E. W. Boyer,[1,3] and T. B. Erickson[1,9]

Everything Prolongs the QT

Antipsychotics: Chlorpromazine, Haloperidol, Droperidol, Quetiapine, Olanzapine, Amisulpride, Thioridazine

Type IA antiarrhythmics: Quinidine, Procainamide, Disopyramide,

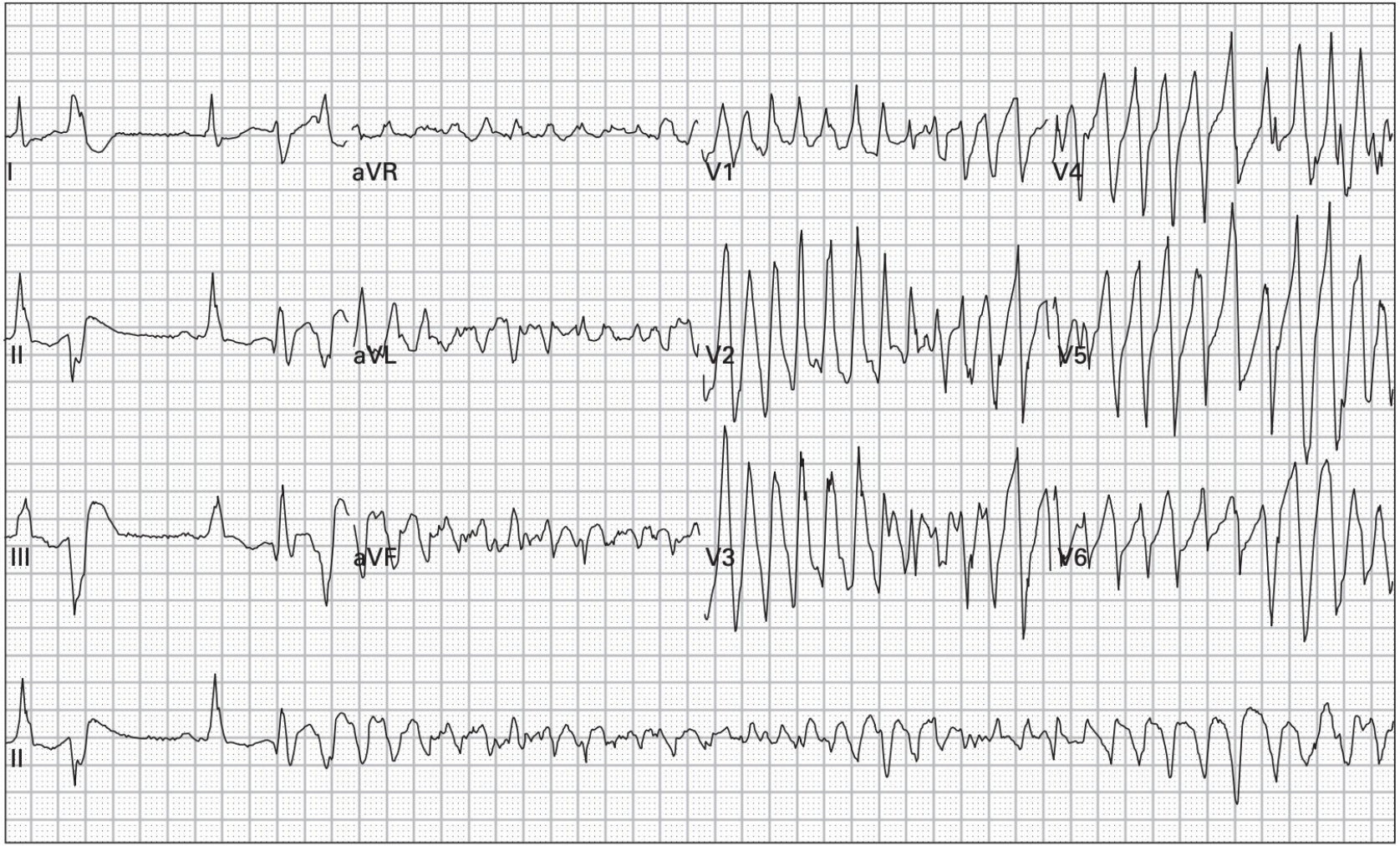
Type IC antiarrhythmics: Flecainide, Encainide

Class III antiarrhythmics: Sotalol, Amiodarone, Tricyclic antidepressants, Amitriptyline,]Doxepin, Imipramine, Nortriptyline, Desipramine

Other antidepressants: Mianserin, Citalopram, Escitalopram, Venlafaxine, Bupropion, Moclobemide, Antihistamines, Diphenhydramine, Astemizole, Loratidine, Terfanadine,

Other Drugs: Chloroquine, Hydroxychloroquine, Quinine,

Macrolides: Erythromycin; Clarithromycin


I
aVR
V1
V4
II
aVL
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V5
III
aVF
V3
V6
II

Resources for those who wish to nerd out further

Life In The Fast Lane: https://litfl.com/ecg-library

Dr. Smith's ECG Blog: http://hqmeded-ecg.blogspot.com/

Amal Mattu's Weekly ECG Workout: https://ecgweekly.com/

Taming the SRU ECG in Toxicology: http://www.tamingthesru.com/blog/diagnostics/ekg-toxicology