

Introduction to Clinical Physiology

**Zoltán Papp
UD Faculty of Medicine
Department of Cardiology
Division of Clinical Physiology**

Clinical Physiology

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**Lectures of Clinical Physiology are
available on the internet:**

<https://aok.unideb.hu/en/clinfiz>

Clinical Physiology

Lectures

Semester II: 14 lectures

Circulation (9 lectures)

Respiratory system (2 lectures)

Nutrition (1 lecture)

Nervous system (2 lectures)

(9th week: self control)

(14th week: self control)

Clinical Physiology

Seminars

Seminars are compulsory!

Semester II (week 1-14):

**Electrocardiography
(10th week: self control)**

**Respiratory functions
Echocardiography
Cardiac catheterisation**

Clinical Physiology

Exam at the end of semester II

“A” exam: written

“B” exam: written

“C” exam: oral

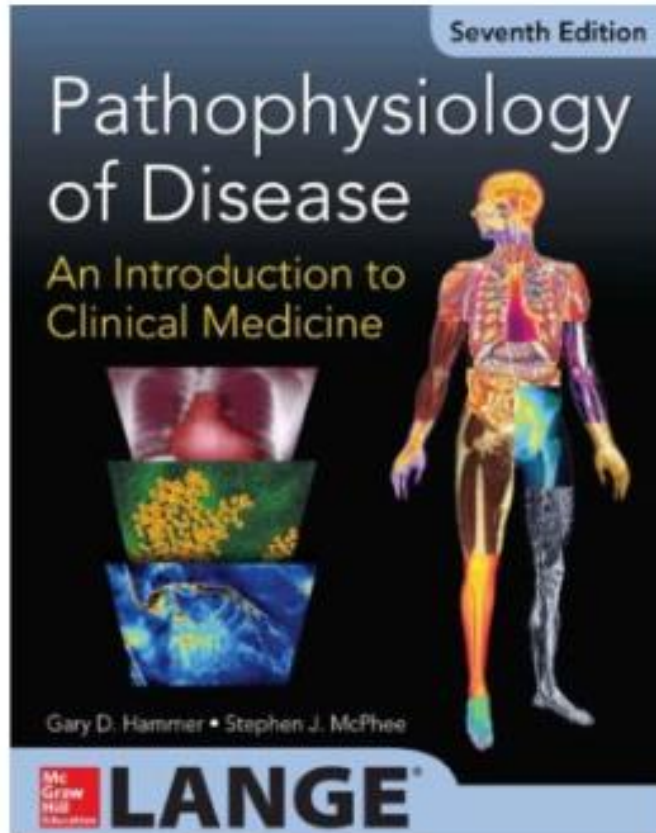
Clinical Physiology

Exam results in 2024:

	final:	2nd self-control:
English program gen. med.:	2,57	fail: 20,3 %
Hungarian program gen. Med.:	3,00	fail: 12,1 %

Clinical Physiology

Recommended textbooks



**PATHOPHYSIOLOGY
OF
DISEASE
7TH EDITION
(FREE PDF DOWNLOAD)**



Clinical Physiology

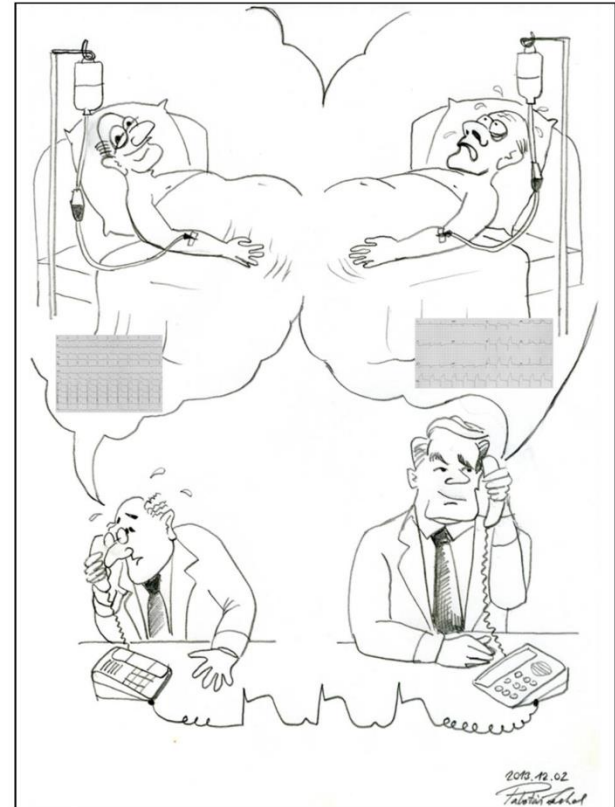
ECG BASICS



Recommended text for the seminars:

Written by:
László Balogh M.D.

University of Debrecen Clinical Center
Institute of Cardiology and Cardiac Surgery



<https://aok.unideb.hu/en/educational-materials-clinical-physiology-medical-program>

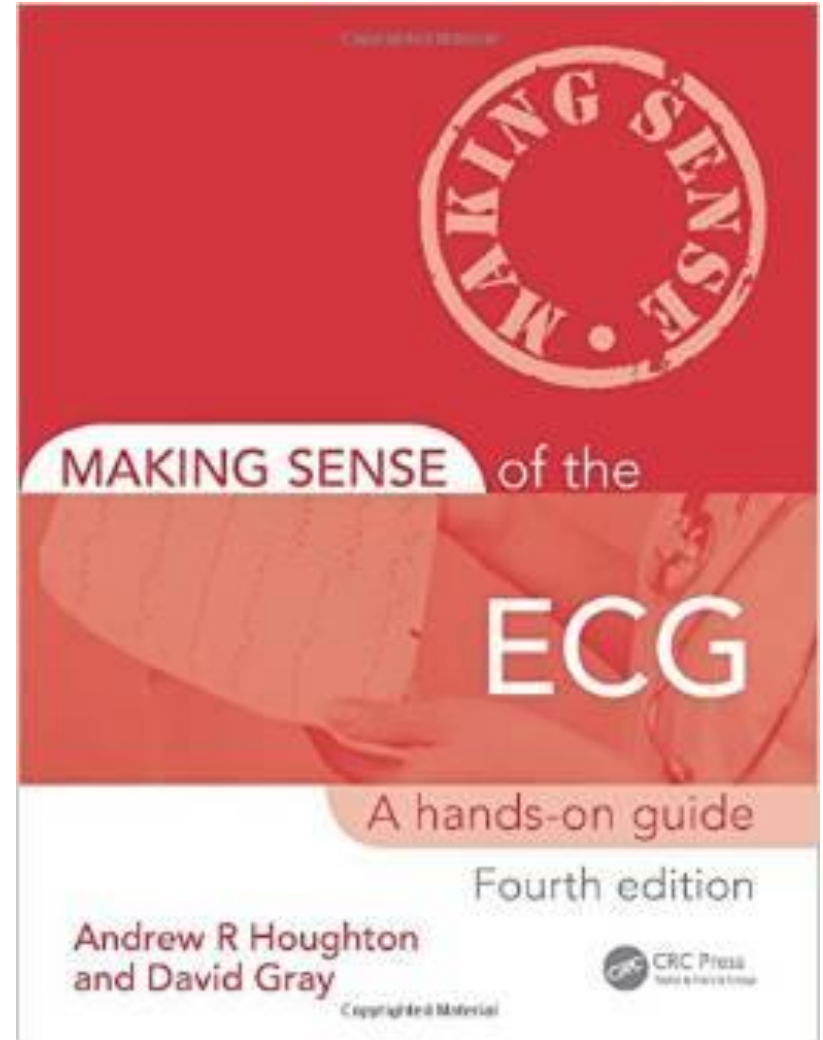
Making Sense of the ECG (4th edition, 2014)

Date of publication: 2014

Publisher: CRC Press

ISBN-13: 978-1444181821

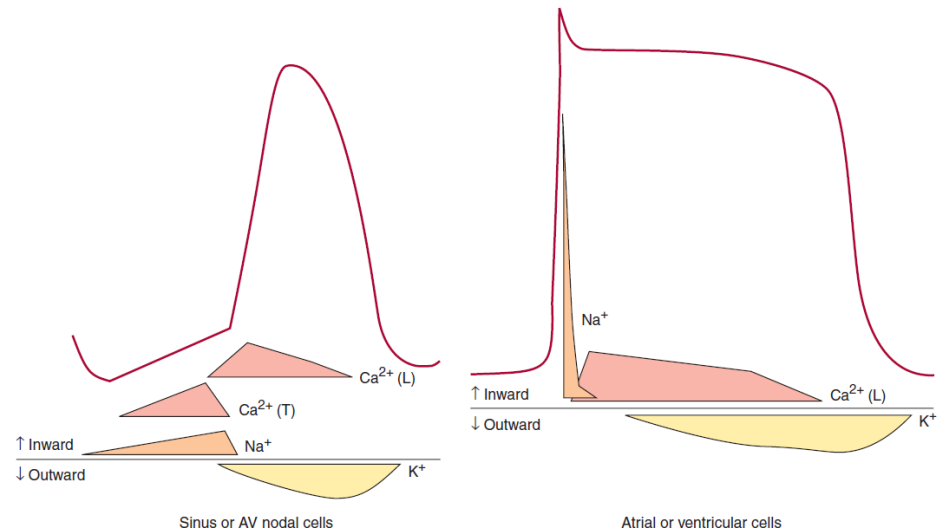
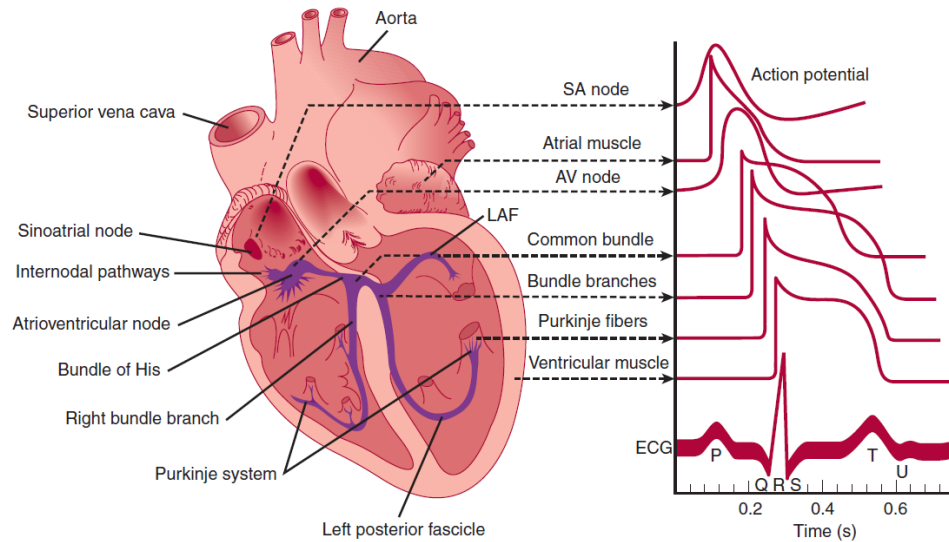
ISBN-10: 1444181823



Cellular and molecular factors of pathologic cardiac excitability

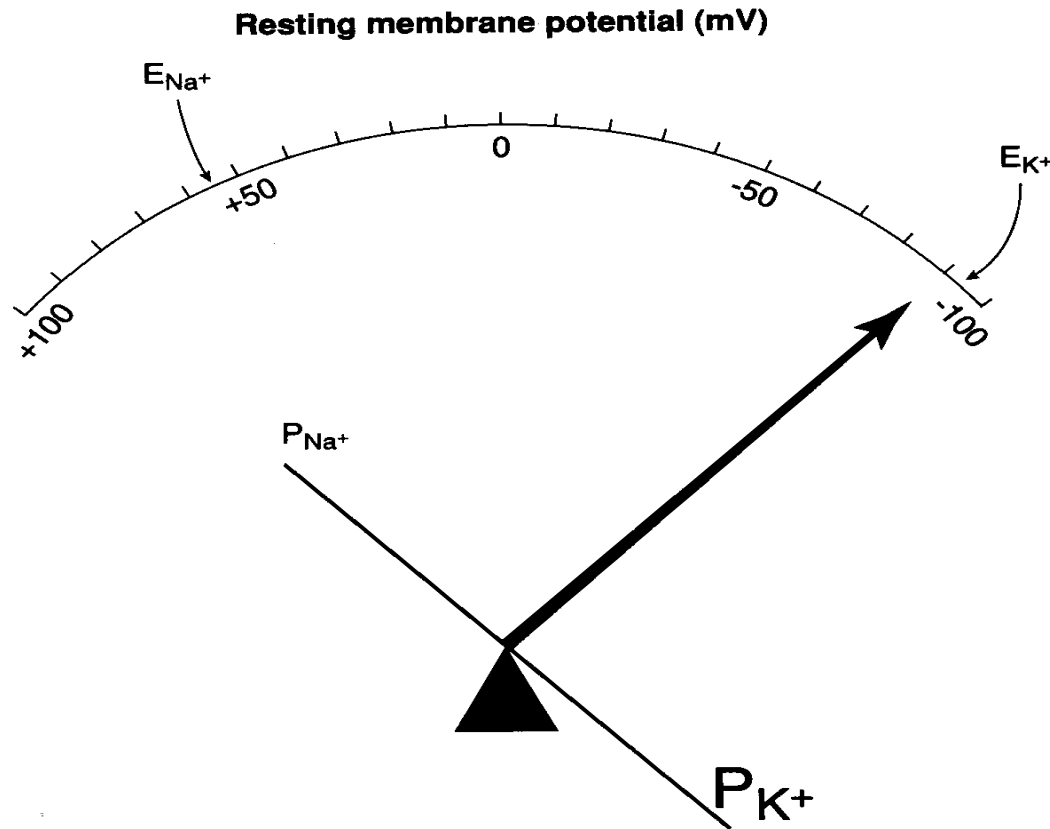
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Physiological background



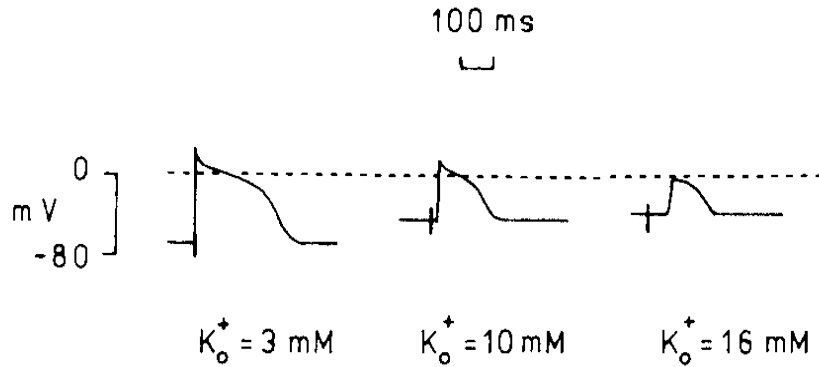
K⁺ balance and membrane potential

$$E_m = -\frac{RT}{ZF} \ln \frac{P_K[K^+]_i + P_{Na}[Na^+]_i + P_{Cl}[Cl^-]_e}{P_K[K^+]_e + P_{Na}[Na^+]_e + P_{Cl}[Cl^-]_i}$$

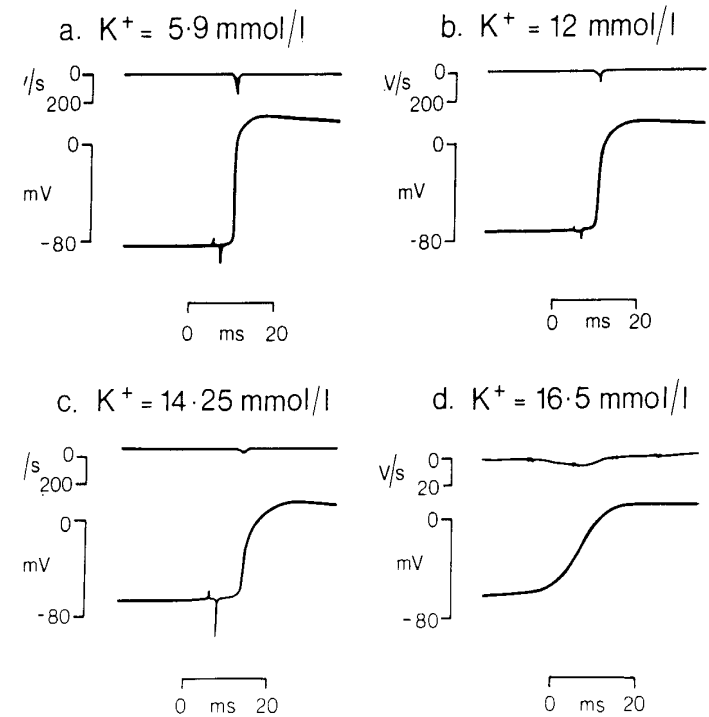


Hyperkalaemia and cardiac excitability

Depolarization



Na⁺ channel blockade



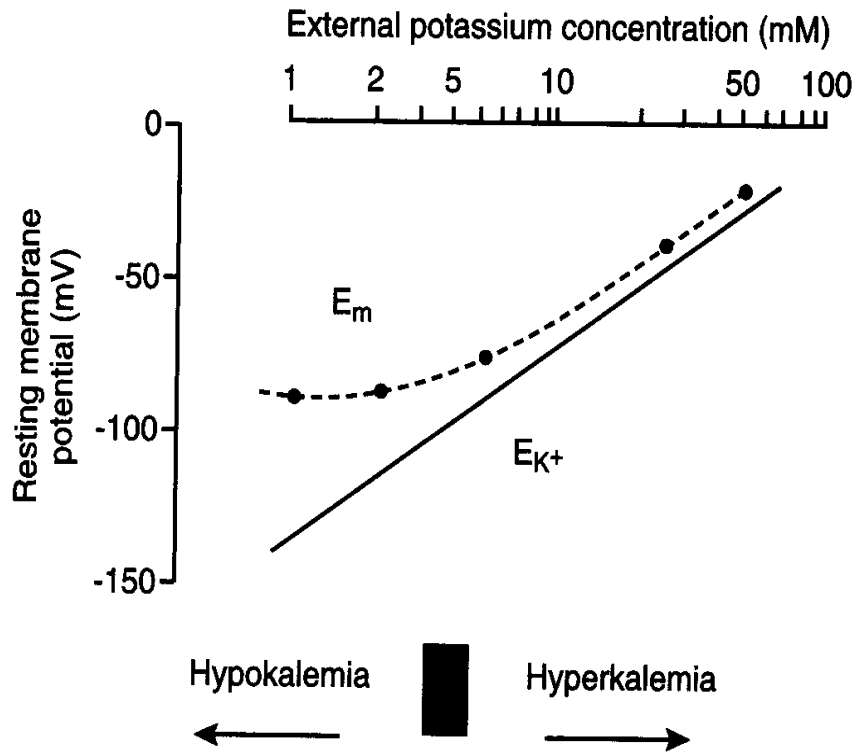
ECG alterations



Normal level: 3.5 to 5.2 mmol/L

$[K^+]_e > 7.5 \text{ mM}$: cardiac arrest!

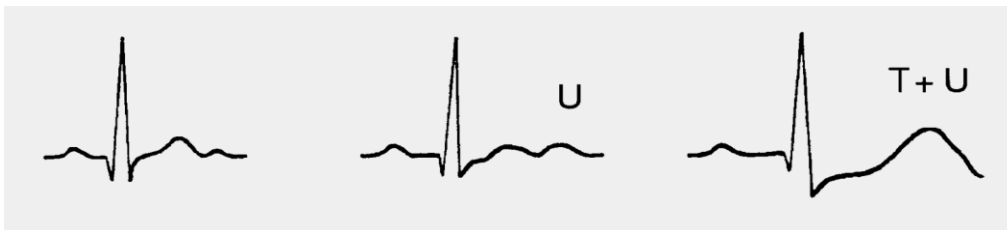
Hypokalaemia and cardiac excitability



$[K^+]_e < 2.7 \text{ mM}$:

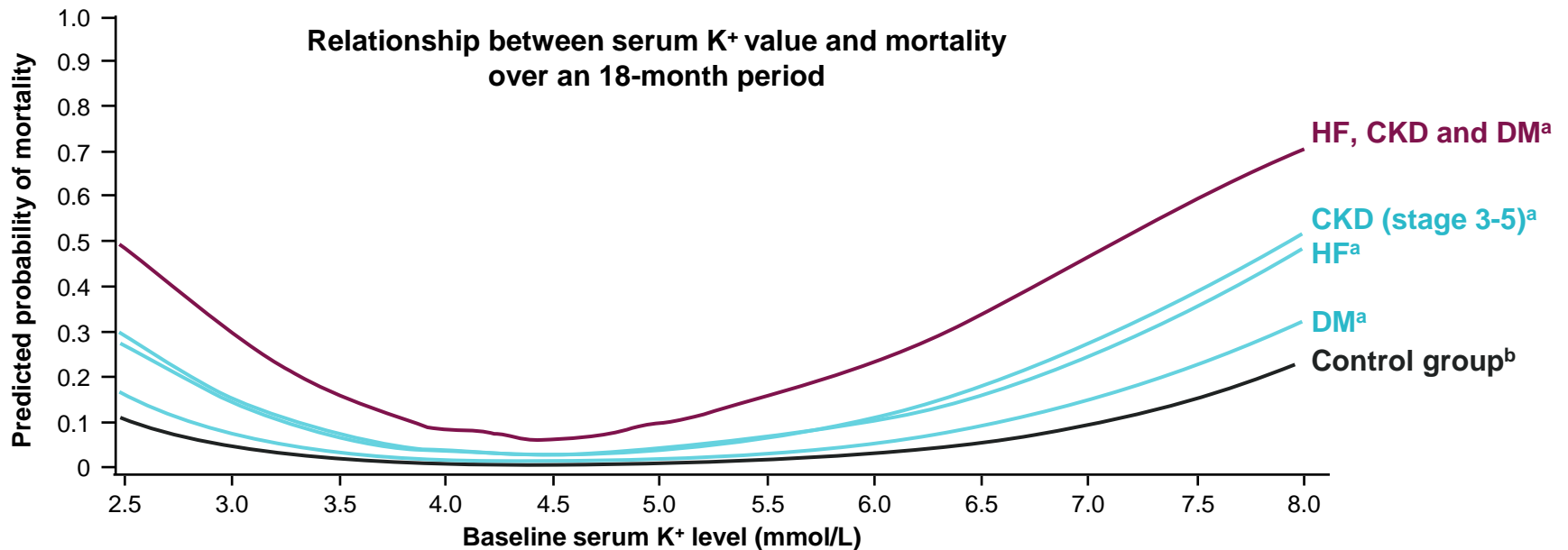
prolonged repolarization
unstable resting potential
ectopic activity ↑
ventricular ES
ventricular tachycardia
ventricular fibrillation

ECG alterations



Hypo- and hyperkalemia associated mortality is higher with comorbidities

Analysis of electronic medical record data from multiple US integrated health delivery networks of 911,698 patients with ≥ 2 potassium measurements between 2007 and 2012

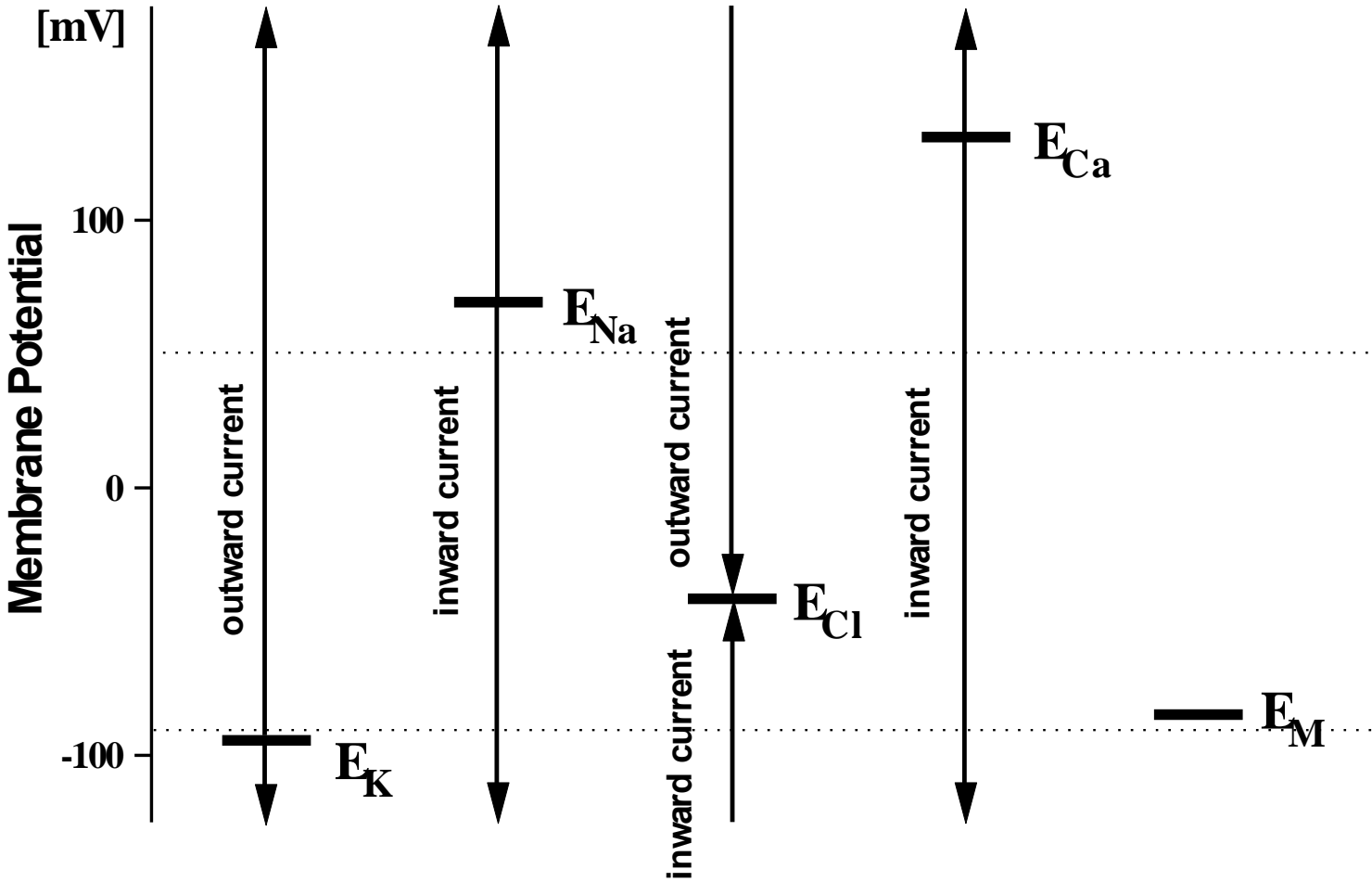


^aSignificant vs. control group; ^bControl group comprised of individuals without known HF, CKD, DM, CVD, or HTN.

CKD = chronic kidney disease; CVD = cardiovascular disease; DM = diabetes mellitus; HF = heart failure; HTN = hypertension; US = United States.

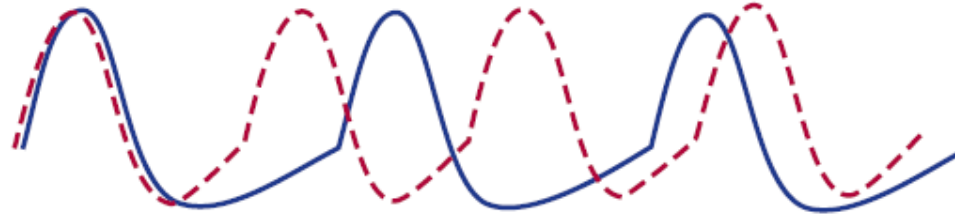
Collins AJ et al. *Am J Nephrol.* 2017;46:213–221.

Ionic currents and membrane potential changes

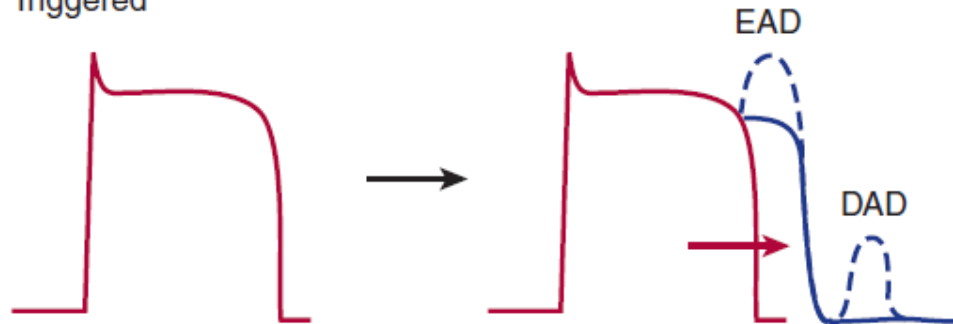


Basic arrhythmogenic mechanisms

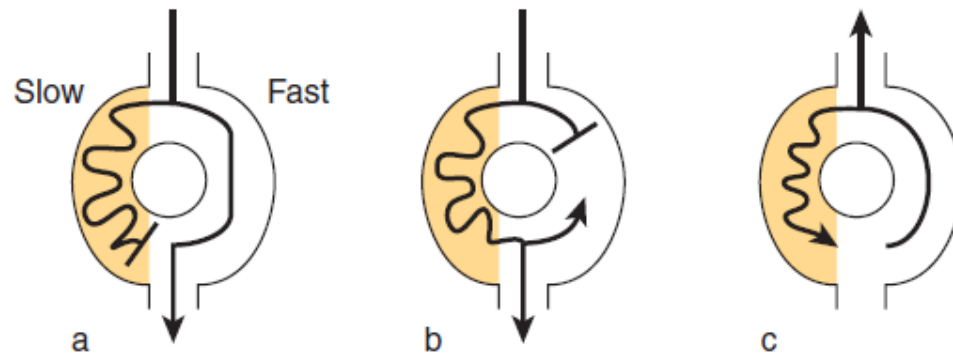
Increased automaticity



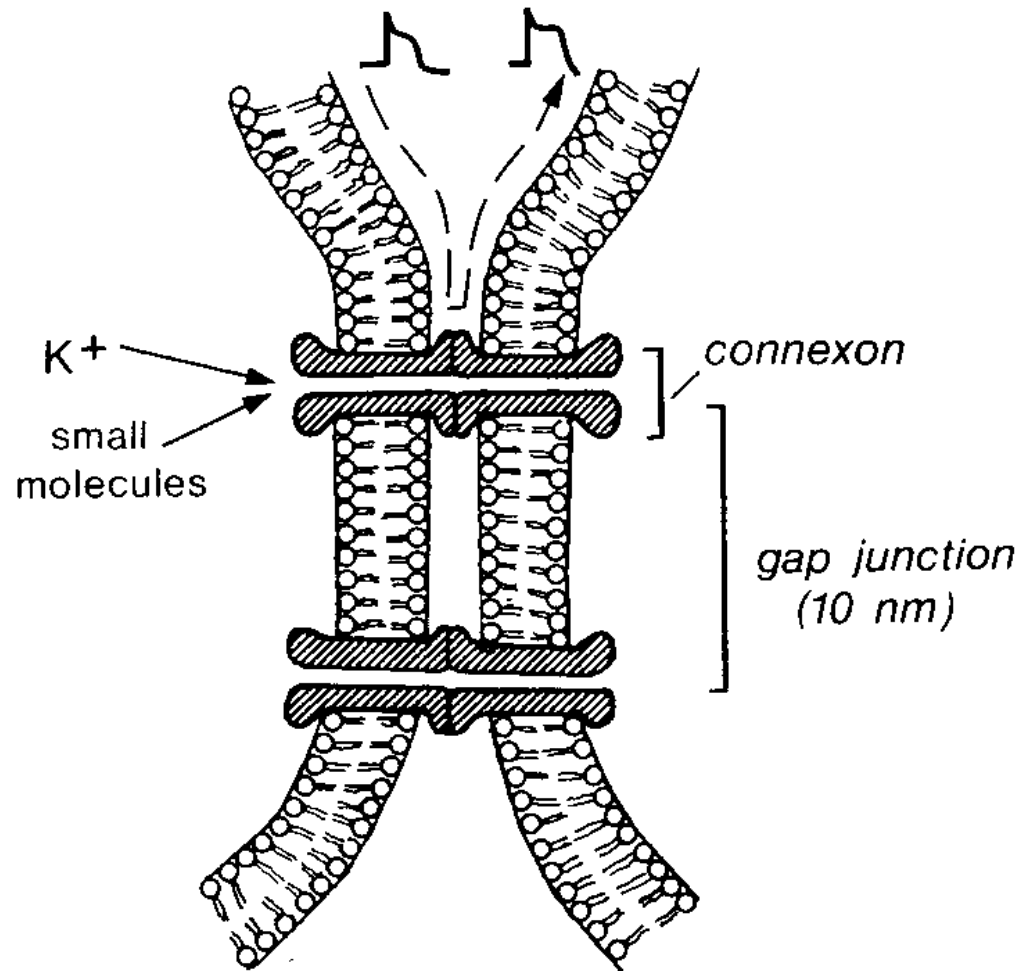
Triggered



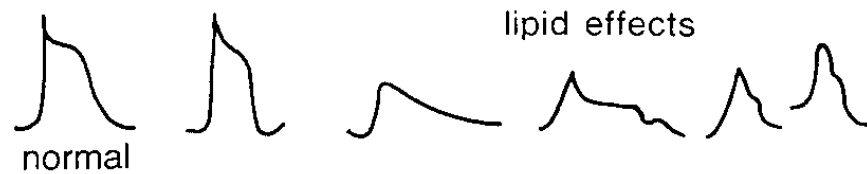
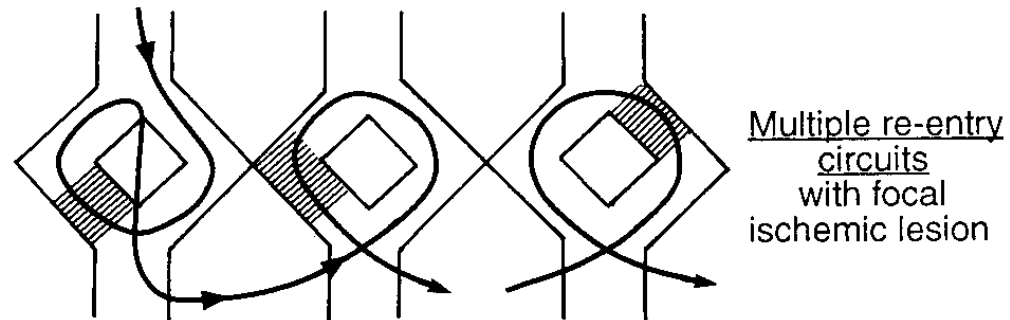
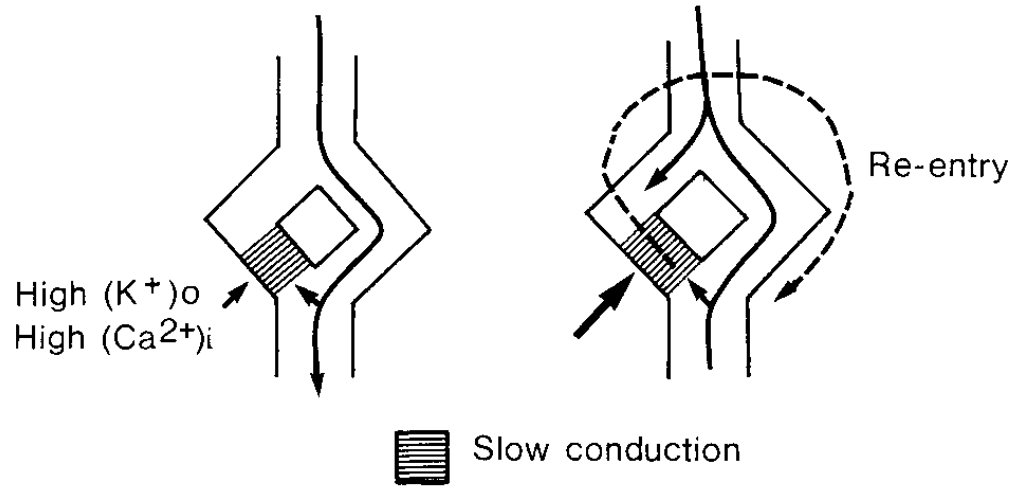
Reentry



Cardiac gap junctions



Re-entry



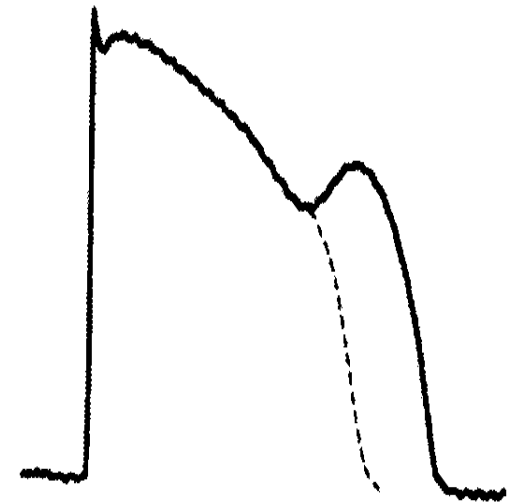
Afterdepolarizations (triggered activity)

P.G.A. Volders et al. / Cardiovascular Research 46 (2000) 376-392

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$[Ca^{2+}]_{cyt}$ - dependent inward current (I_{Tl})

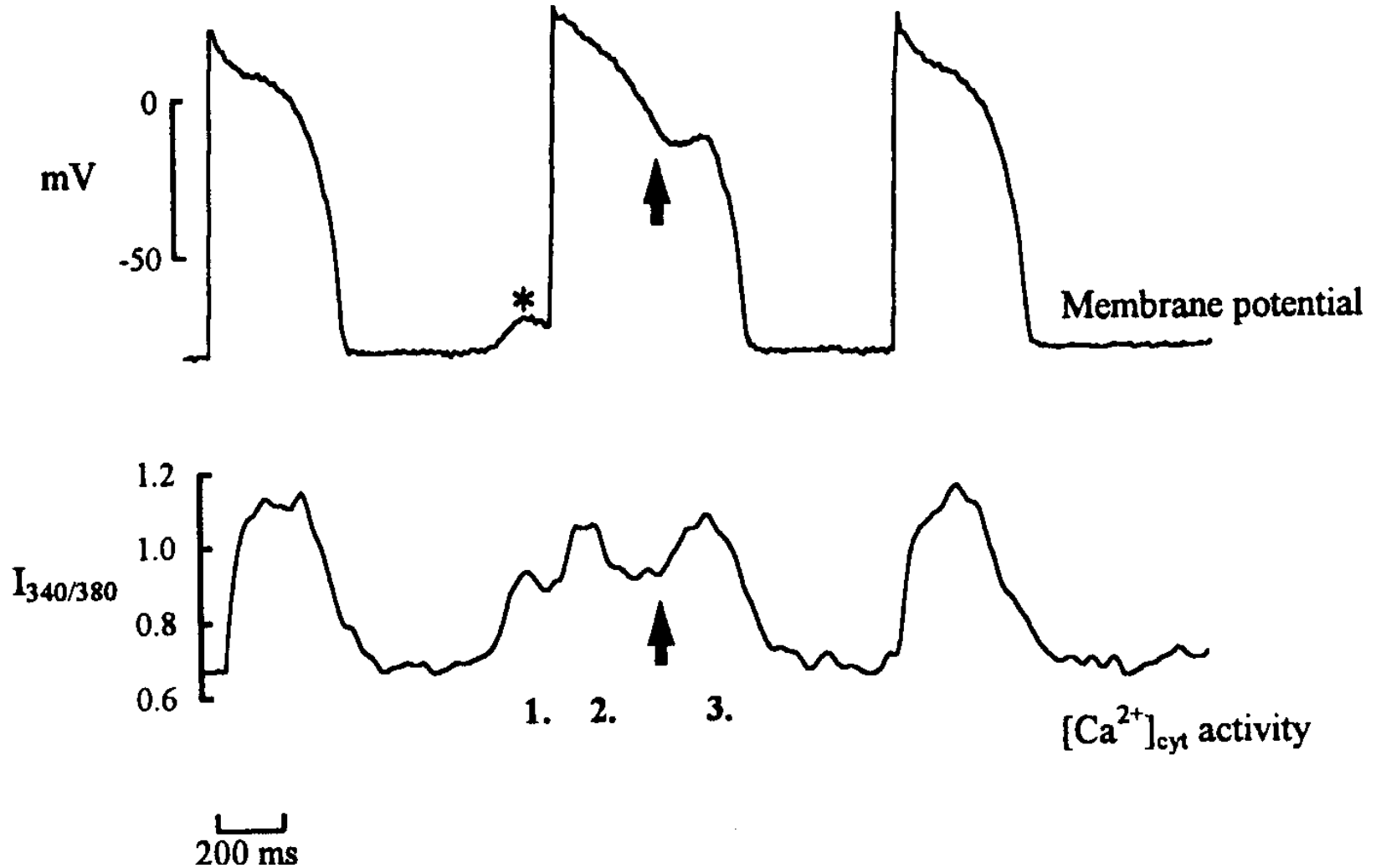


conditioning phase | EAD upstroke

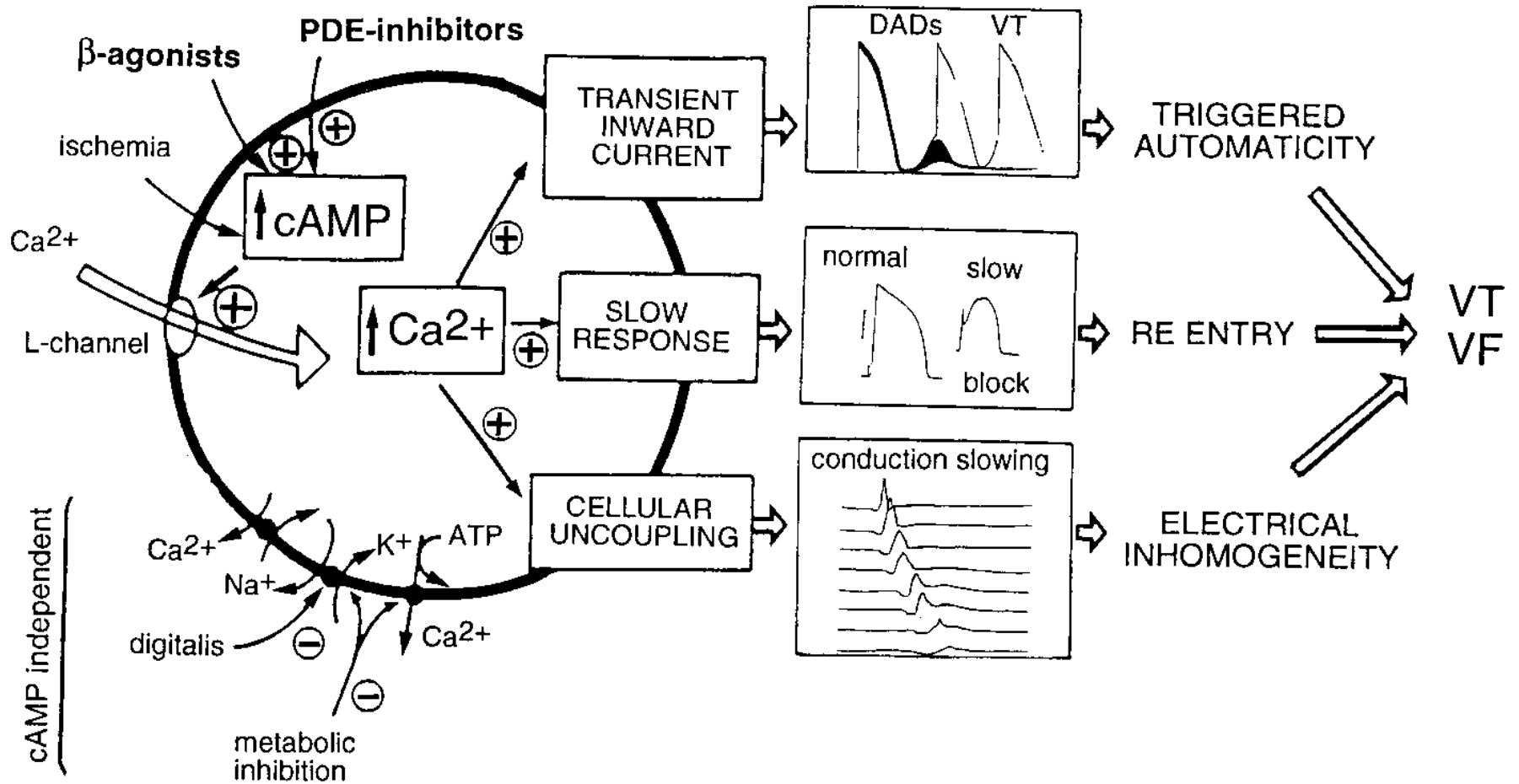


$[Ca^{2+}]_{cyt}$ - dependent inward current | I_{Na} and/or I_{CaL}

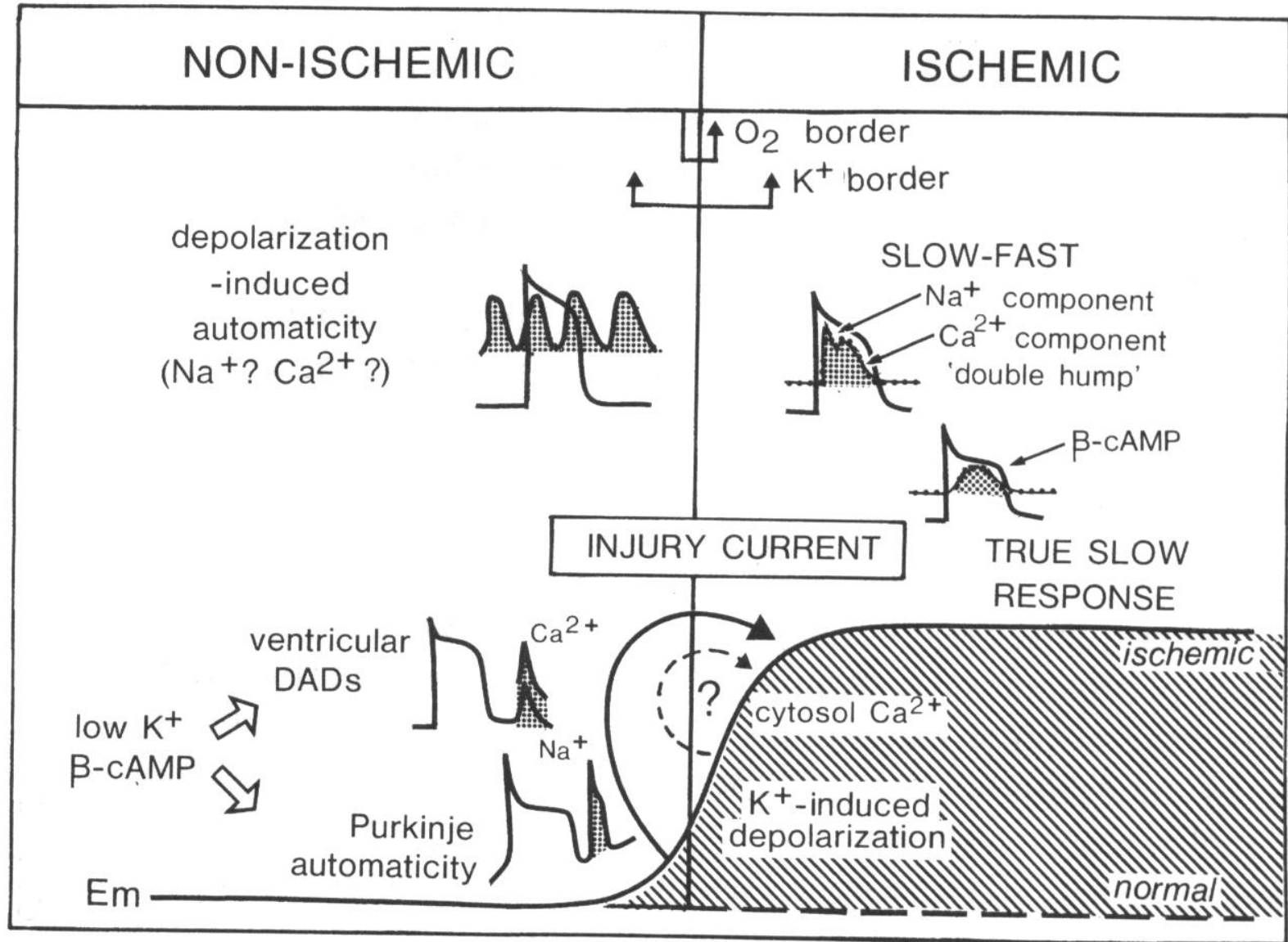
Afterdepolarizations are triggered by spontaneous Ca^{2+} release from the SR



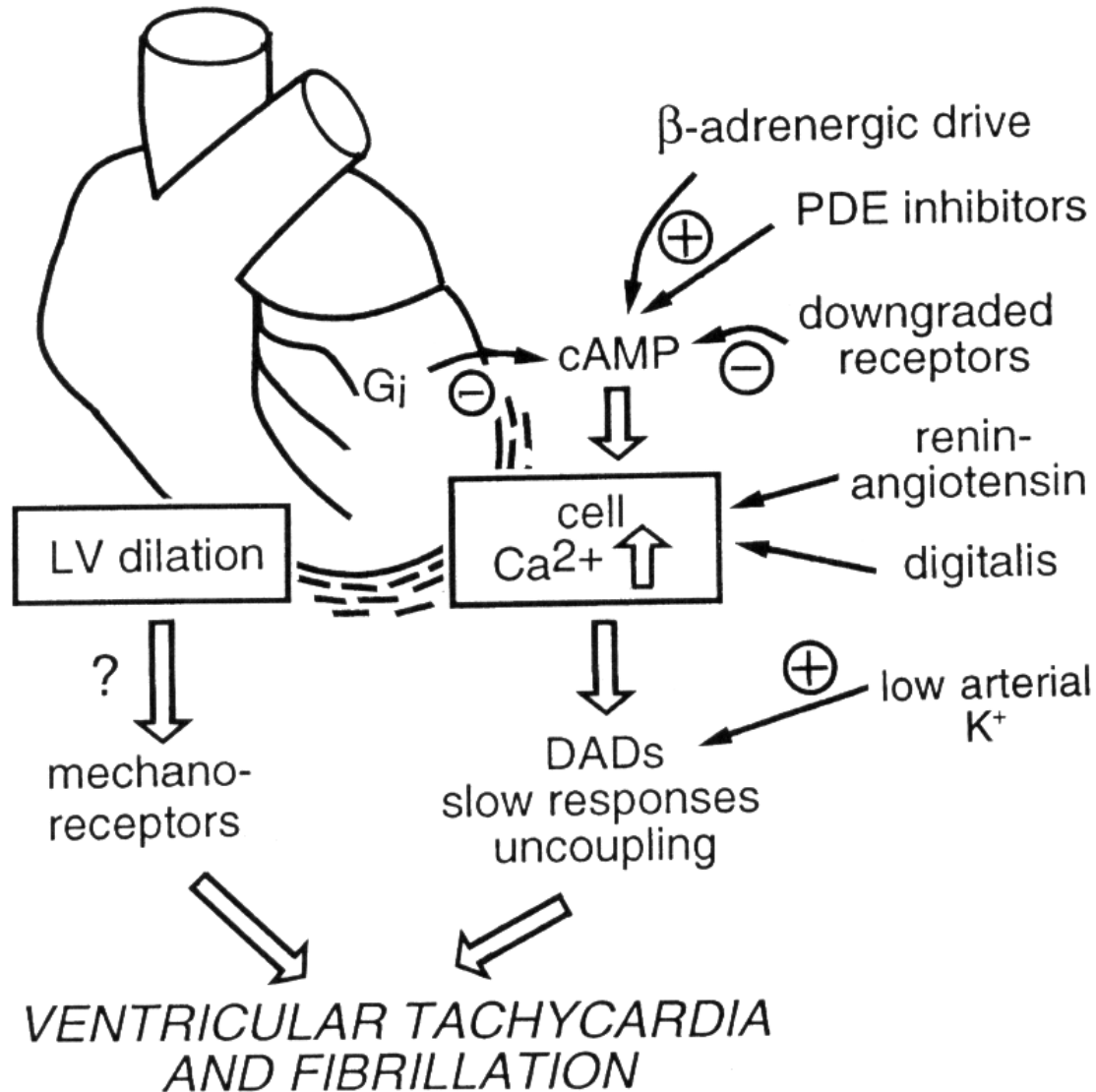
[Ca²⁺]_i –dependent arrhythmogenic mechanisms



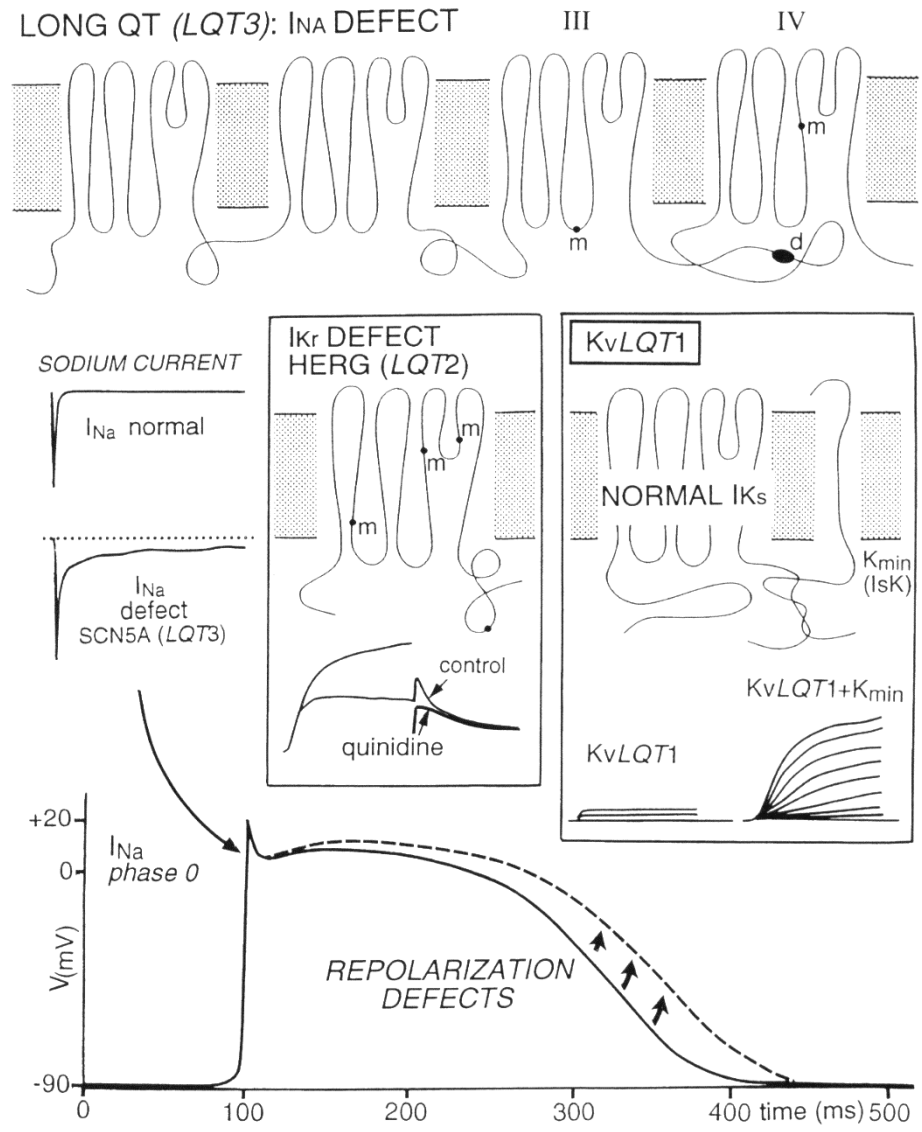
Myocardial infarction and arrhythmias



Chronic heart failure and arrhythmias



Inherited long QT syndromes



The beginning of evidence-based medicine



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ORIGINAL ARTICLE

f X in

Mortality and Morbidity in Patients Receiving Encainide, Flecainide, or Placebo — The Cardiac Arrhythmia Suppression Trial

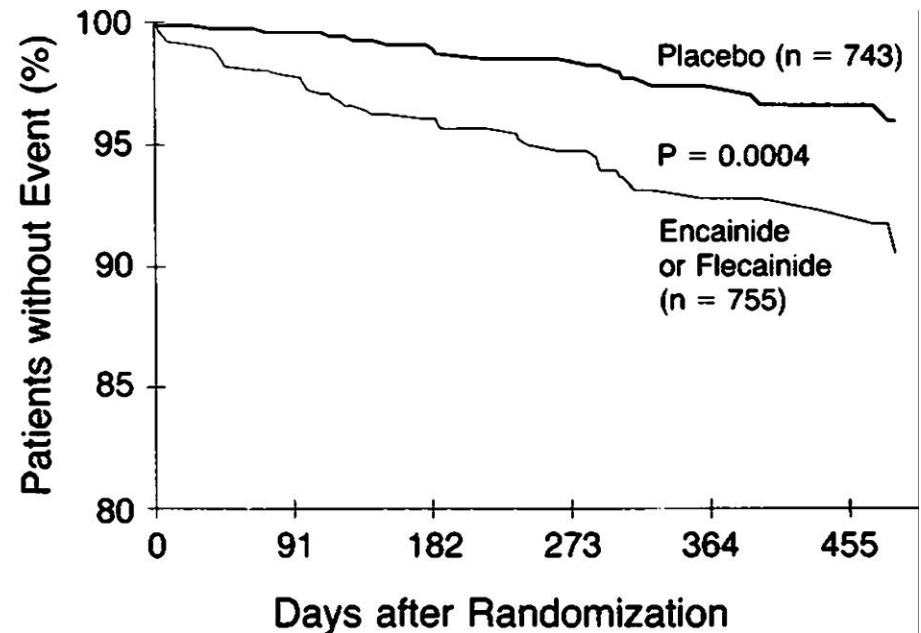
Authors: Debra S. Echt, M.D., Philip R. Liebson, M.D., L. Brent Mitchell, M.D., Robert W. Peters, M.D., Dulce Obias-Manno, R.N., Allan H. Barker, M.D., Daniel Arensberg, M.D., [45](#), and the CAST Investigators * [Author Info & Affiliations](#)

Published March 21, 1991 | N Engl J Med 1991;324:781-788 | DOI: 10.1056/NEJM199103213241201

[VOL. 324 NO. 12](#)

CAST = Cardiac Arrhythmia Suppression Trial

RCT = randomized clinical trial



Placebo	743	632	516	412	292	201
Active drug	755	631	507	392	286	198

Antiarrhythmic drugs

