

# Introduction to Clinical Physiology

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

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## Clinical Physiology

Zoltán Papp M.D. Ph.D. D.Sc.  
professor, head of division  
Department of Cardiology  
Division of Clinical Physiology  
Tel.: +36-52-411-717 / 54329  
e-mail: [pappz@med.unideb.hu](mailto:pappz@med.unideb.hu)

Academic advisor:  
general med. and dentistry:  
Miklós Fagyas MD. Ph.D.  
associate professor,  
e-mail: [fagyasmiklos@med.unideb.hu](mailto:fagyasmiklos@med.unideb.hu)

Lectures of Clinical Physiology are  
available on the internet:

[klinfiz.unideb.hu](http://klinfiz.unideb.hu)

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## Clinical Physiology

### Lectures

#### Semester II: 14 lectures

Circulation (9 lectures)  
Respiratory system (2 lectures)  
Nutrition (1 lecture)  
Nervous system (2 lectures)

(9<sup>th</sup> week: self control )  
(14<sup>th</sup> week: self control )

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**Clinical Physiology**

**Seminars**

Seminars are compulsory!

Semester II (week 1-14):

Electrocardiography  
(10<sup>th</sup> week: self control)

Respiratory functions  
Echocardiography  
Cardiac catheterisation

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**Clinical Physiology**

**Exam at the end of semester II**

“A” exam: written  
“B” exam: written  
“C” exam: oral

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**Clinical Physiology**

**Exam results in 2022:**

|                              | final: | 2nd self-control: |
|------------------------------|--------|-------------------|
| English program gen. med.:   | 3.03   | fail: 8.2%        |
| Hungarian program gen. Med.: | 3.29   | fail: 4.9%        |

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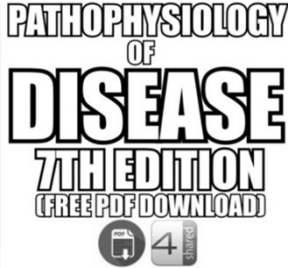
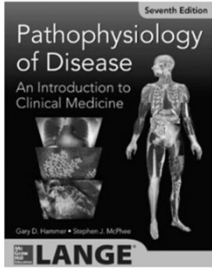
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**Clinical Physiology**

**Recommended textbooks**



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**Klinikai Fiziológia**

<https://klinfiz.unideb.hu/en>

**Recommended text  
For the seminars:**

Written by:  
László Balogh M.D.  
University of Debrecen Clinical Center  
Institute of Cardiology and Cardiac Surgery



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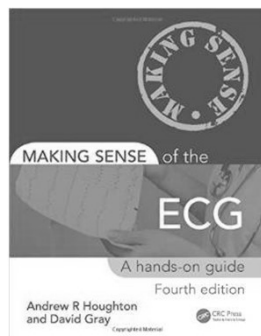
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**Making Sense of the ECG (4<sup>th</sup> edition, 2014)**

**Date of publication:** 2014  
**Publisher:** CRC Press  
ISBN-13: 978-1444181821  
ISBN-10: 1444181823



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# Cellular and molecular factors of pathologic cardiac excitability

Dr. Zoltán Papp  
 UD Faculty of Medicine  
 Department of Cardiology  
 Division of Clinical Physiology

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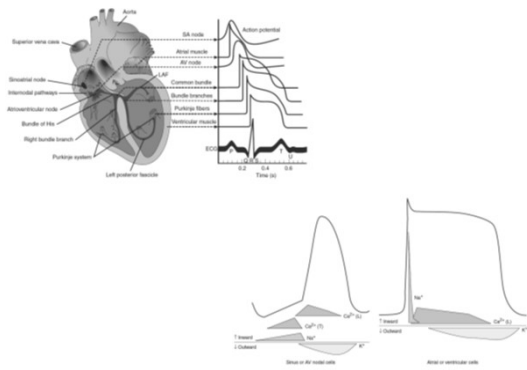
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## Physiological background




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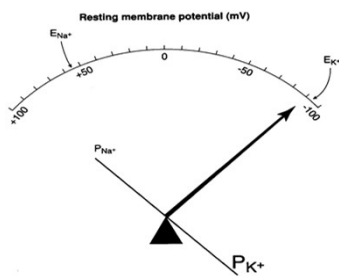
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## K<sup>+</sup> balance and membrane potential

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




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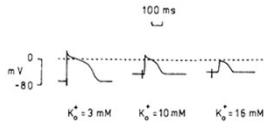
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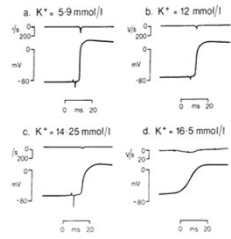
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## Hyperkalaemia and cardiac excitability

### Depolarization



### Na<sup>+</sup> channel blockade



### ECG alterations



**[K<sup>+</sup>]<sub>e</sub> > 7.5 mM: cardiac arrest!**

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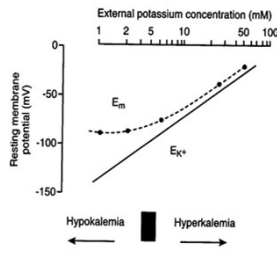
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## Hypokalaemia and cardiac excitability



**[K<sup>+</sup>]<sub>e</sub> < 2.7 mM:**  
 prolonged repolarization  
 unstable resting potential  
 ectopic activity↑  
 ventricular ES  
 ventricular tachycardia  
 ventricular fibrillation

### ECG alterations




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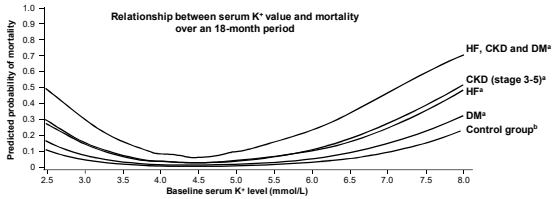
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## Hypo- and hyperkalaemia associated mortality is higher with comorbidities

Analysis of electronic medical record data from multiple US integrated health delivery networks of 911,688 patients with ≥2 potassium measurements between 2007 and 2012



<sup>1</sup>Significant vs. control group; <sup>2</sup>Control 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. Colton AJ et al. Am J Hypertens. 2017;30(2):213-221.

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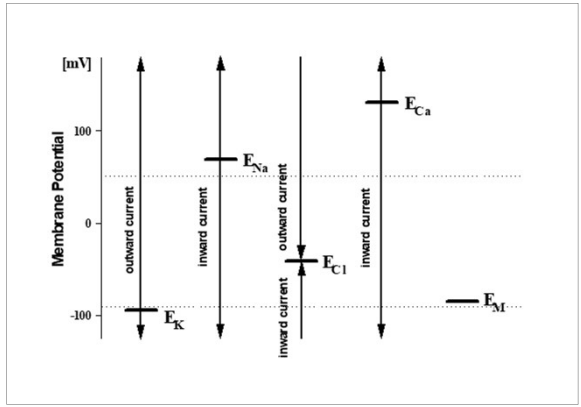
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### Ionic currents and membrane potential changes




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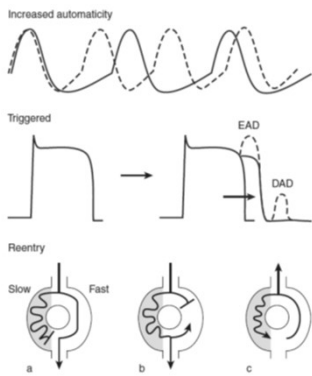
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### Basic arrhythmogenic mechanisms




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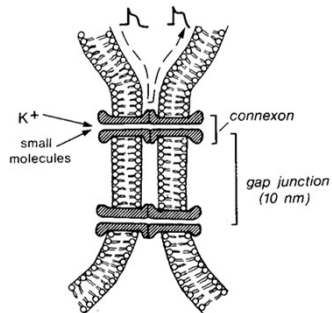
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### Cardiac gap junctions




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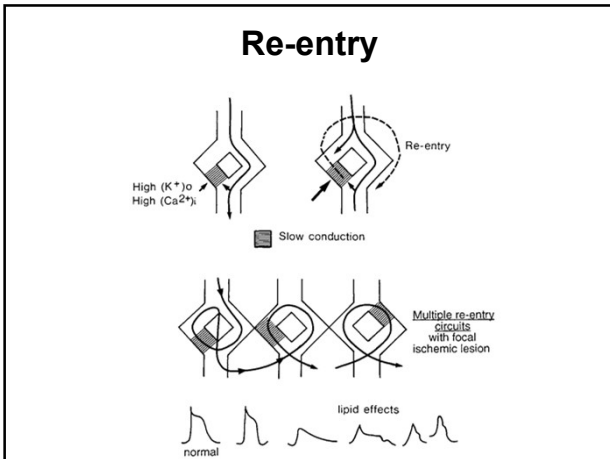
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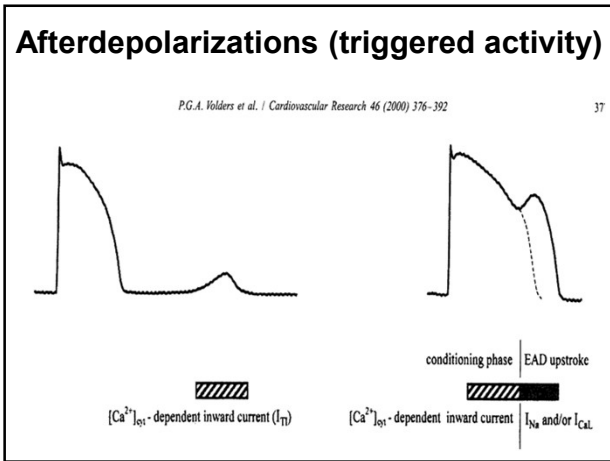
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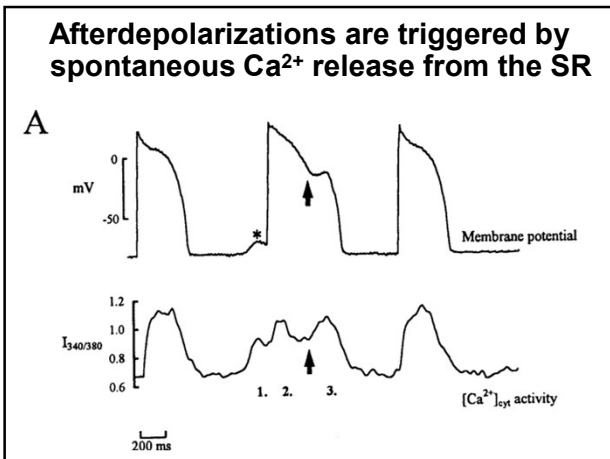
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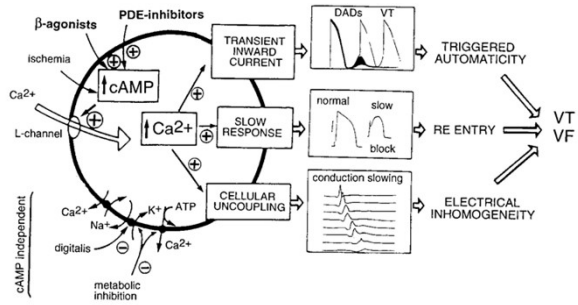
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## [Ca<sup>2+</sup>]<sub>i</sub> –dependent arrhythmogenic mechanisms




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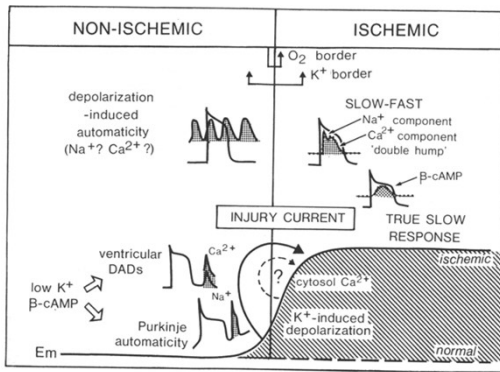
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## Myocardial infarction and arrhythmias




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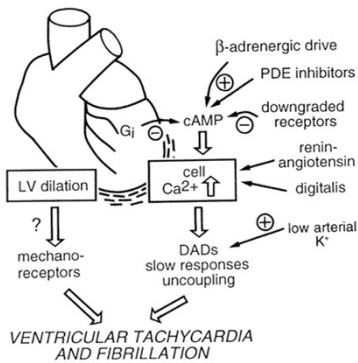
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## Chronic heart failure and arrhythmias




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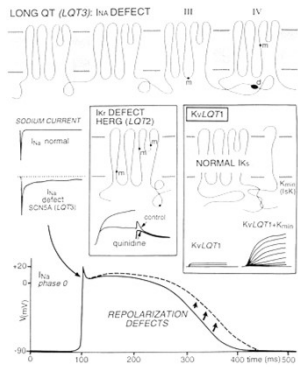
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## Inherited long QT syndromes




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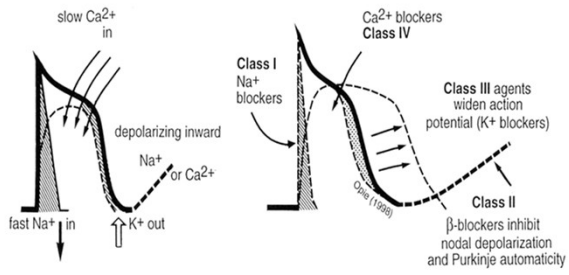
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## Antiarrhythmic drugs




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