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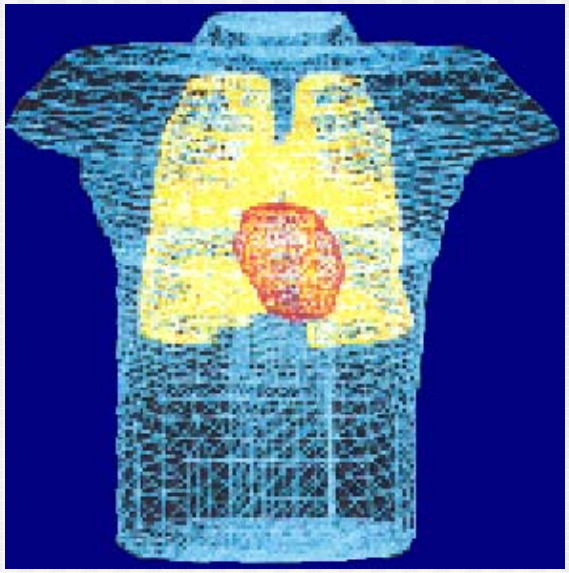
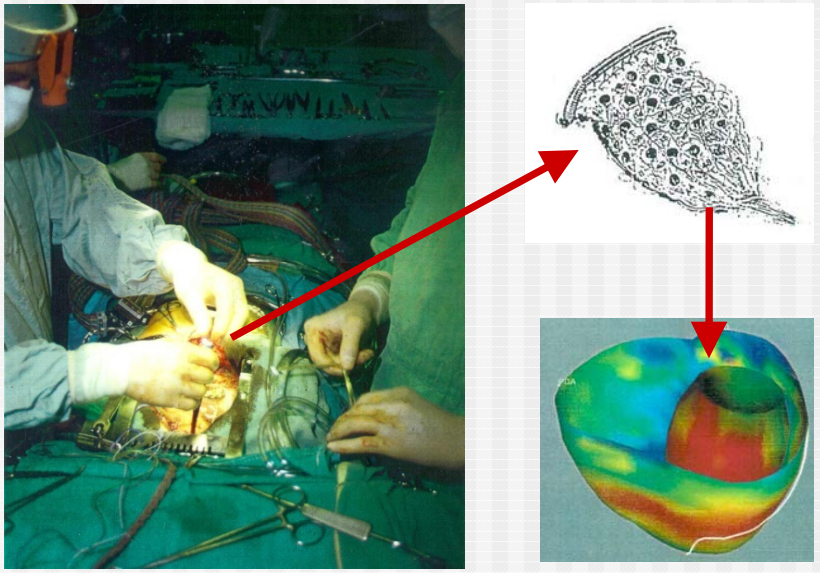
- Research experience
- The heart
- Immediate effects of TASER shocks
- Does heart disease increases the risk of death after TASER shocks?
- Conclusions

Research experience



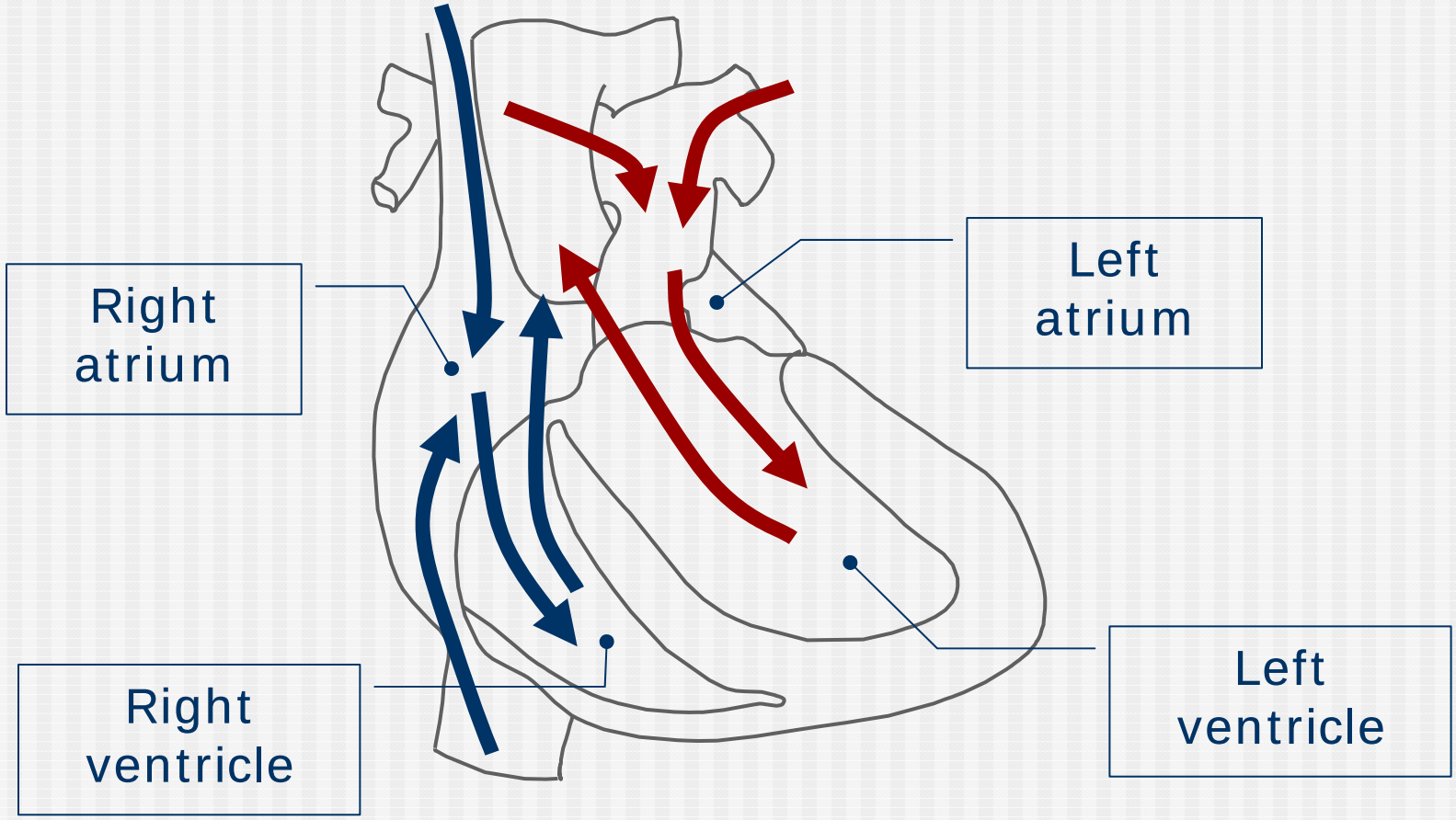
Modeling the electrocardiogram



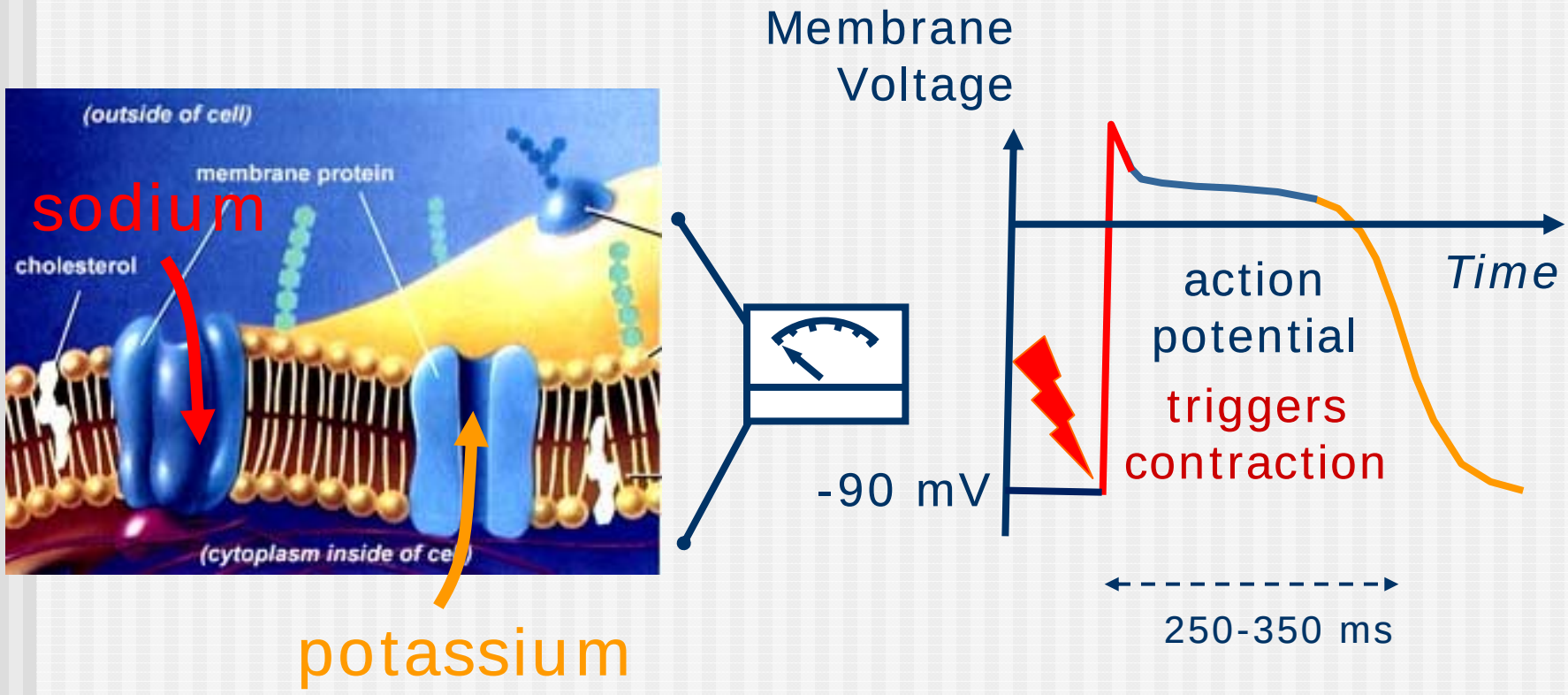
Cardiac activation mapping to guide arrhythmia surgery

Identification of patients with a higher risk of sudden death after myocardial infarction (2600 patients)

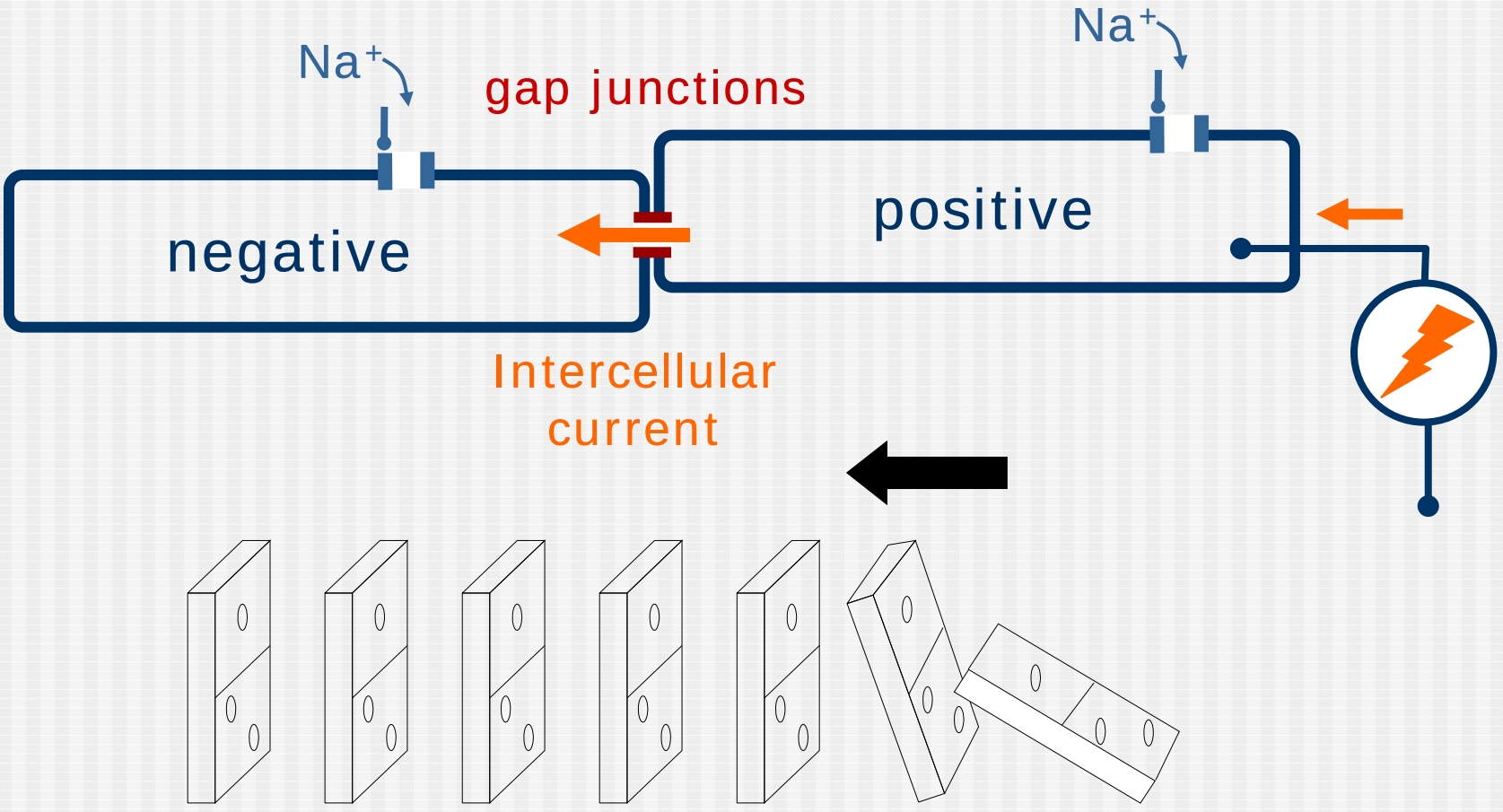
The heart: a pump



Electrical activity of cardiac cells

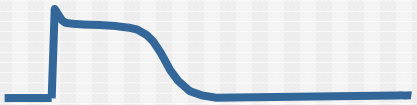


Propagation of cardiac electrical activation

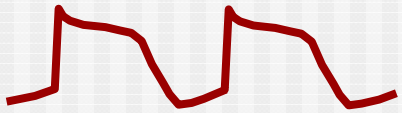


Normal electrical activation

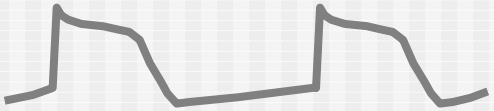
muscle (silent)

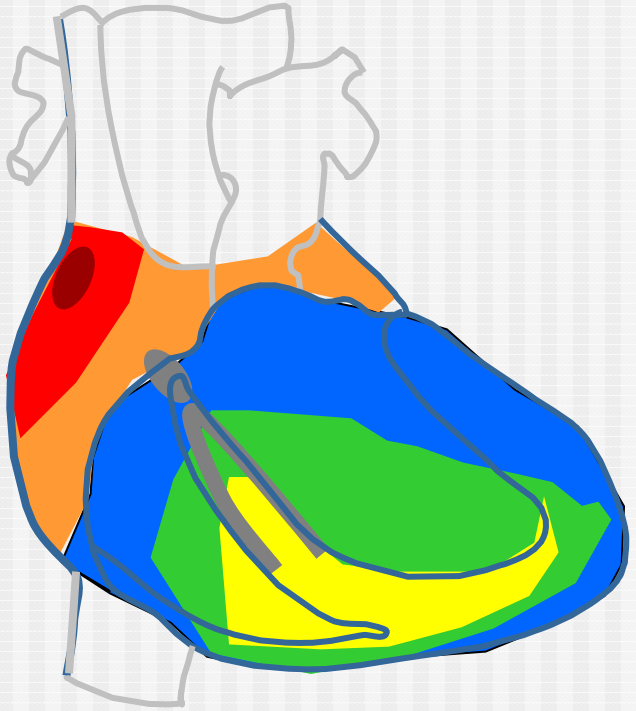


sinus node (automatic)

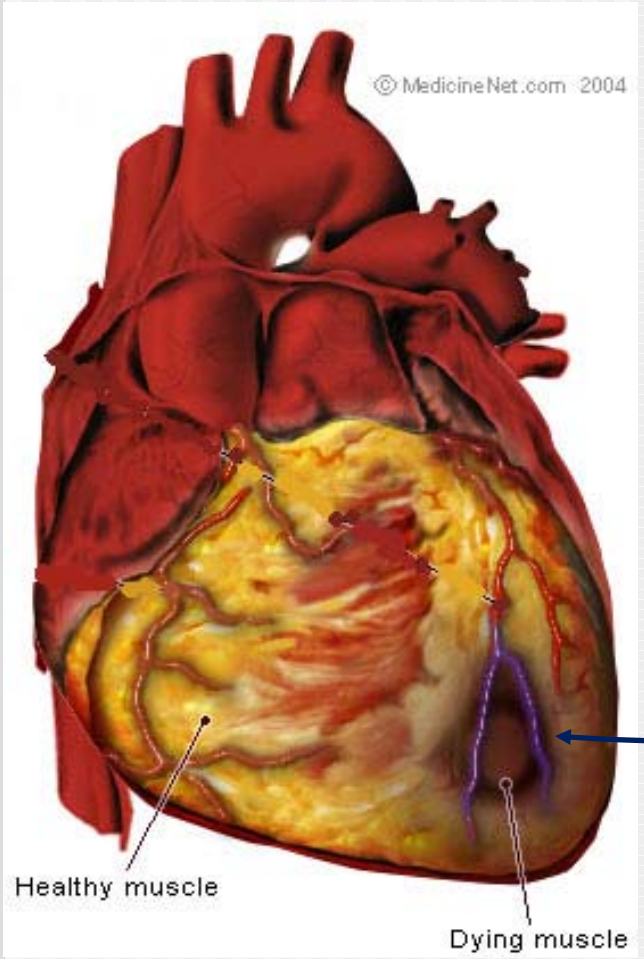


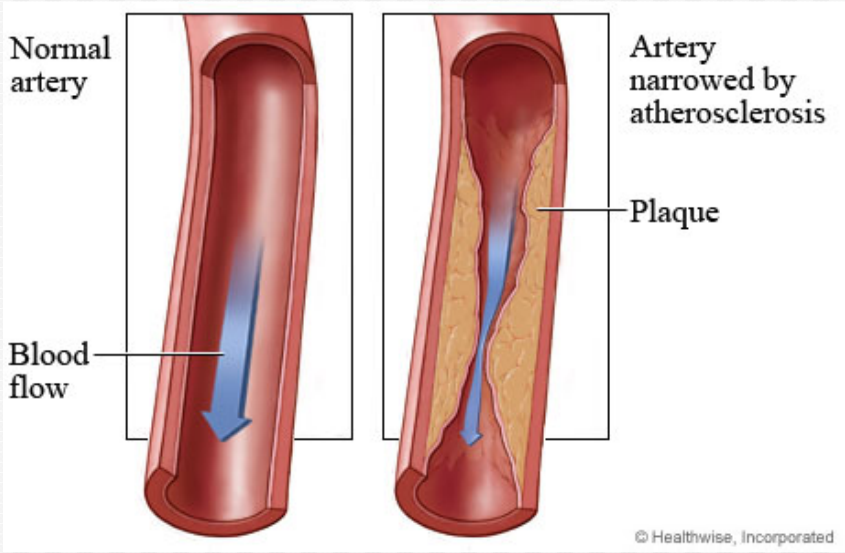
conduction network





Coronary artery disease

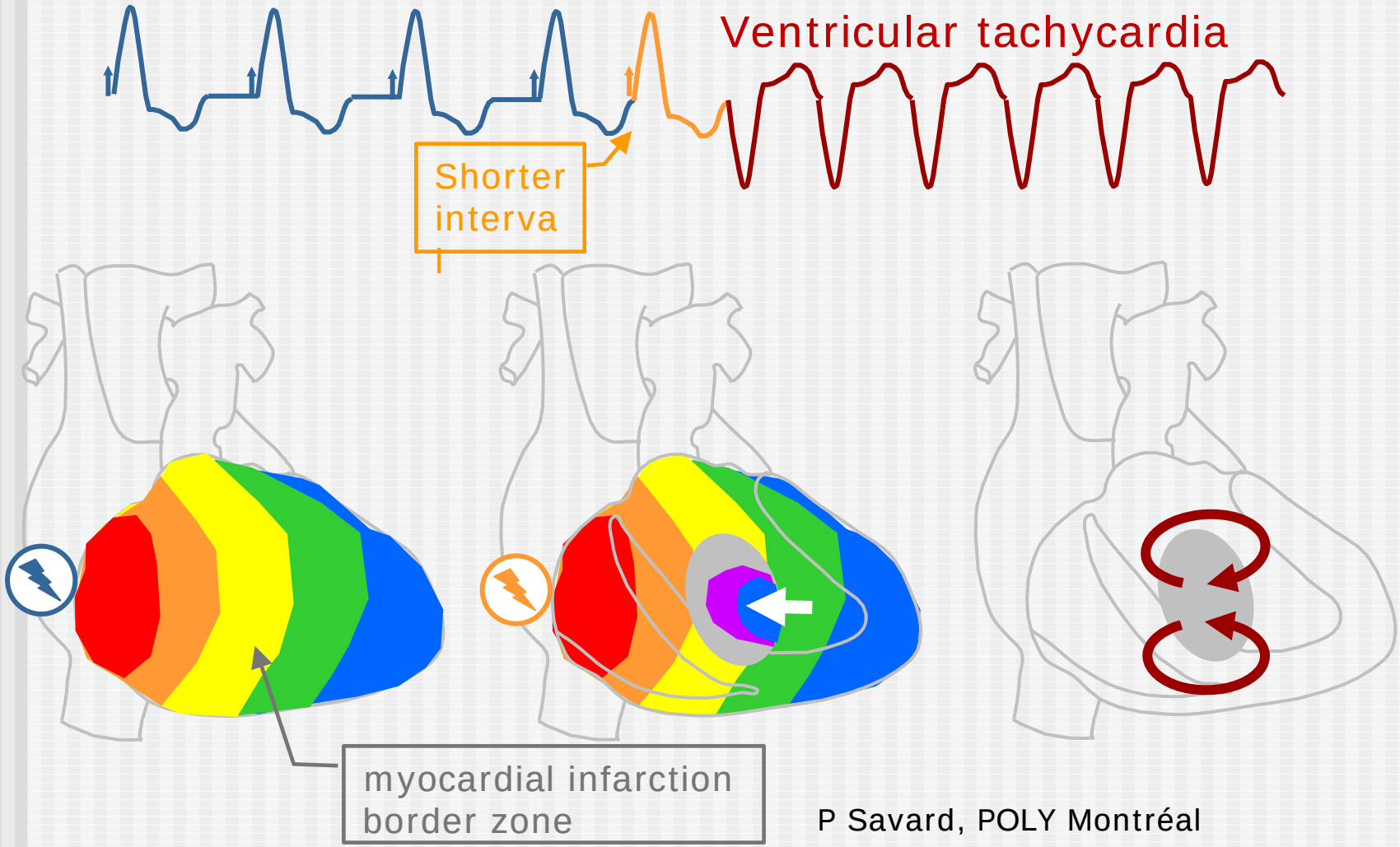




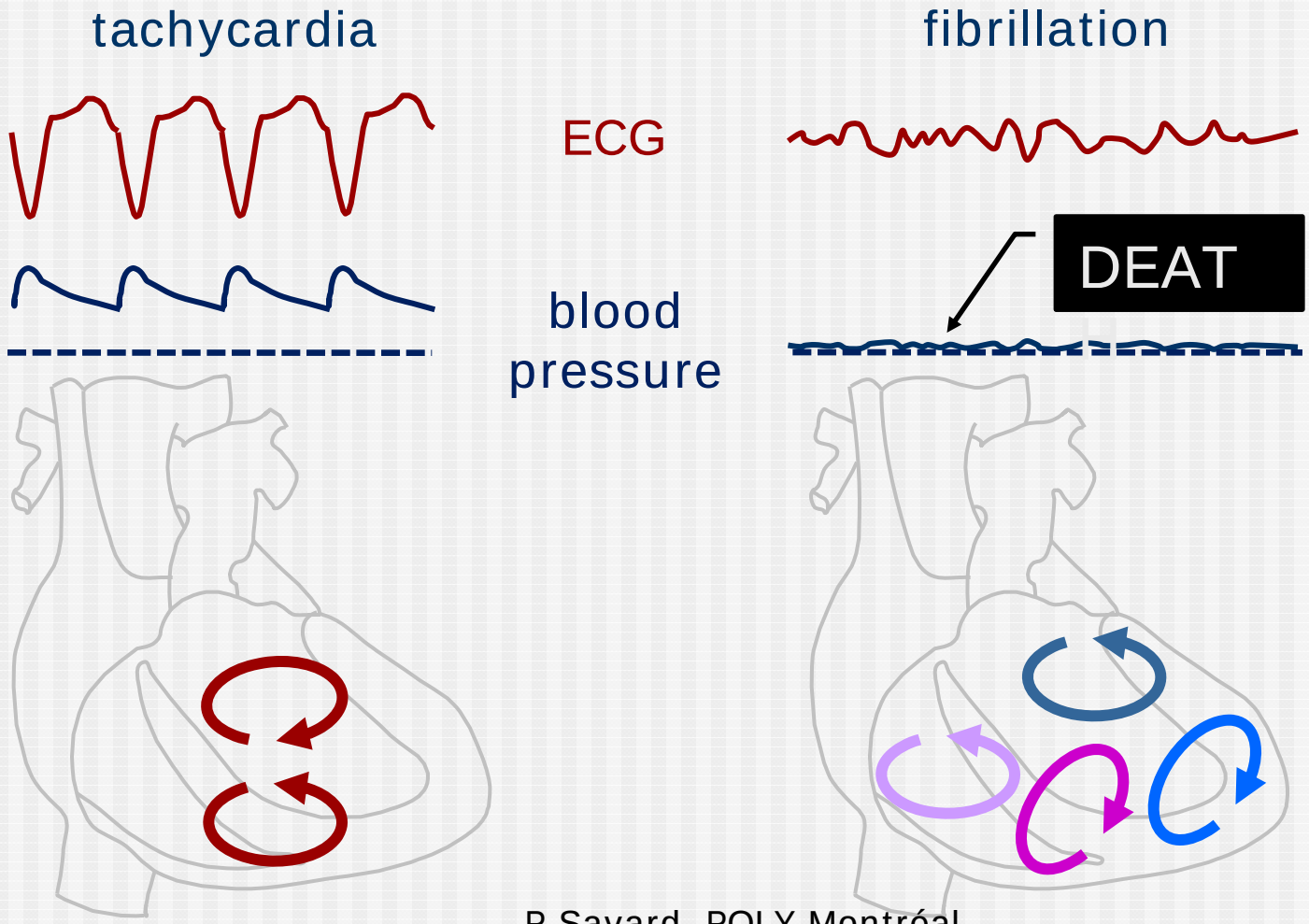
Partial occlusion: ischemia

Complete occlusion: infarction (scar)

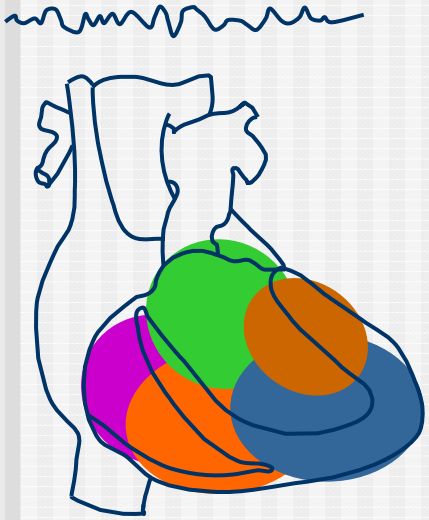
Abnormal propagation: reentry

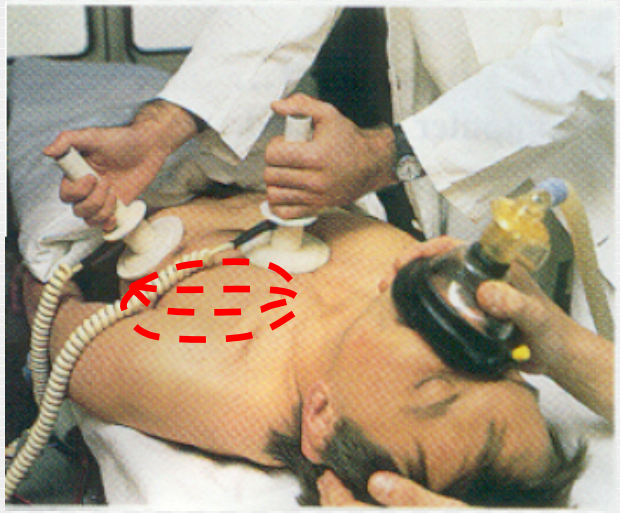


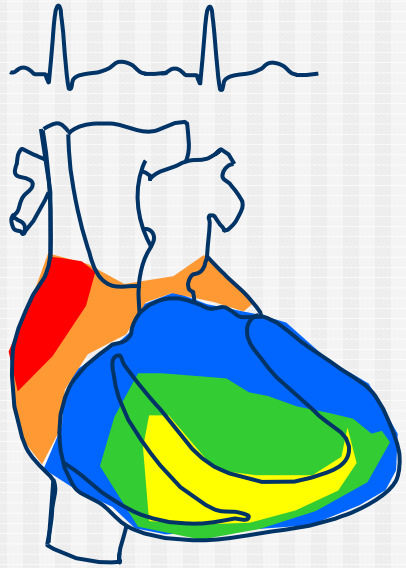
Ventricular fibrillation

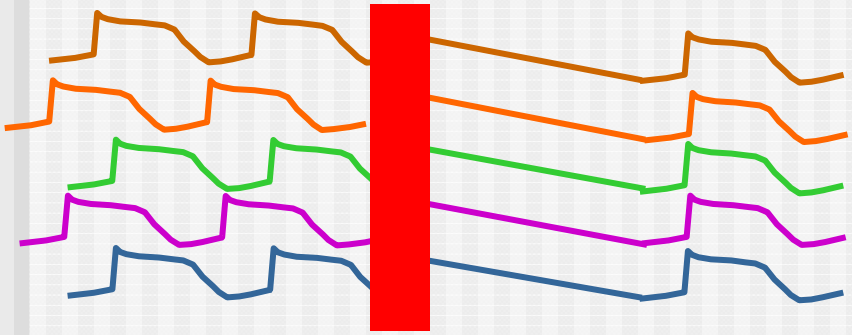


Ventricular defibrillation









Research experience

The heart

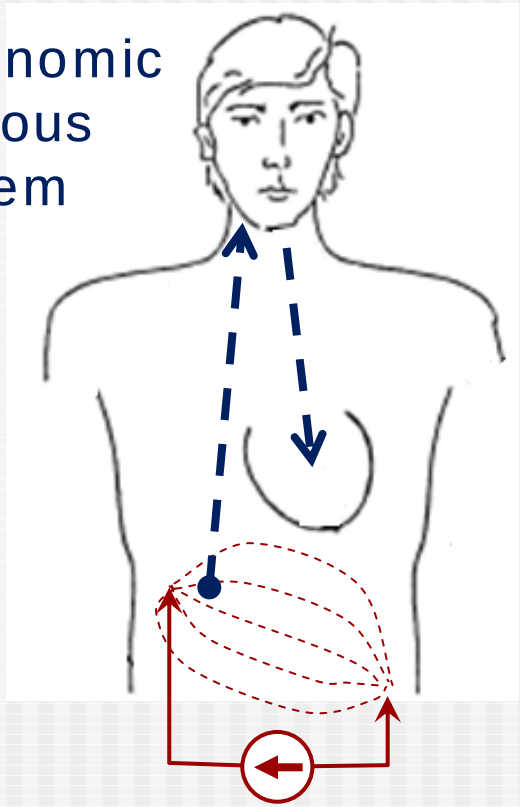
Immediate effects of TASER shocks

Does heart disease increases the risk of death after TASER shocks?

Conclusions

TASER: increased heart rate due to nervous stimulation

Autonomic nervous system



IN ALL CASES

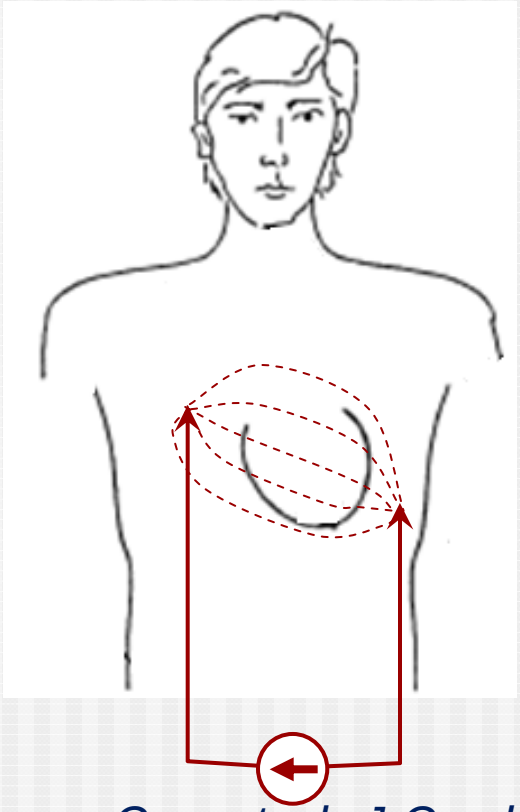
137 beats/min

↑

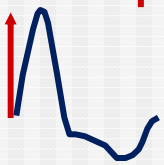
72 beats/min

Levine et al. J Emerg Med. 2007; 33(2):113-7

TASER: increased heart rate due to direct stimulation



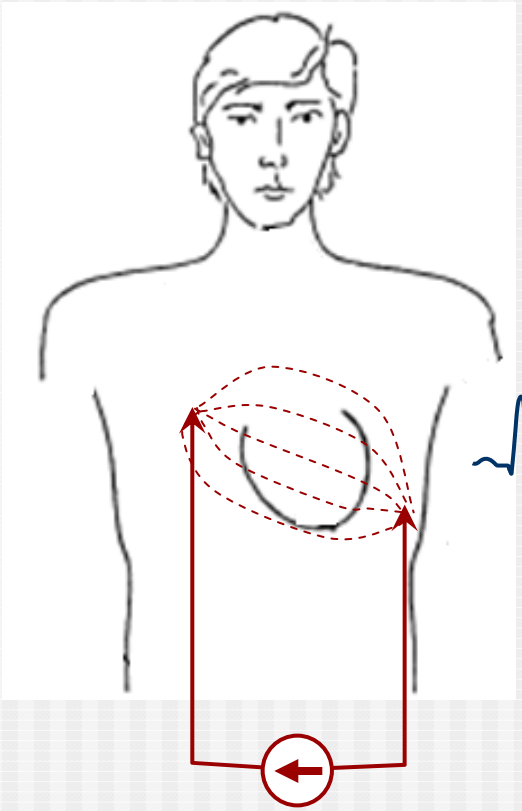
IN CASES WHERE SUFFICIENT CURRENT FLOWS IN THE HEART



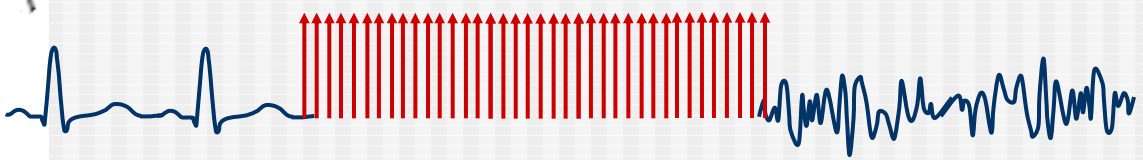
capture

In man: Cao et al. J Cardiovasc Electrophysiol. 2007;18(8):876-9
In pigs: Nanthakumar et al. J Am Coll Cardiol. 2006; 15;48(4):798-804

TASER: possibility of ventricular fibrillation



UNLIKELY BECAUSE OF INSUFFICIENT CURRENT FROM A NORMAL TASER



VF in pigs: Nanthakumar et al. J Am Coll Cardiol. 2006; 15;48(4):798
Wu et al. IEEE Trans Biomed Eng. 2007;54(3):503-8.

Research experience

The heart

Immediate effects of TASER shocks

Does heart disease increases the risk of death after TASER shocks?

Conclusions

Does heart disease increases the risk of death after TASER ?

An epidemiological approach:

- Statistical associations between TASER related deaths and heart diseases
- Analogy between TASER and :
  1. Stress test
  2. Programmed electrical stimulation protocol
- Plausible mechanisms

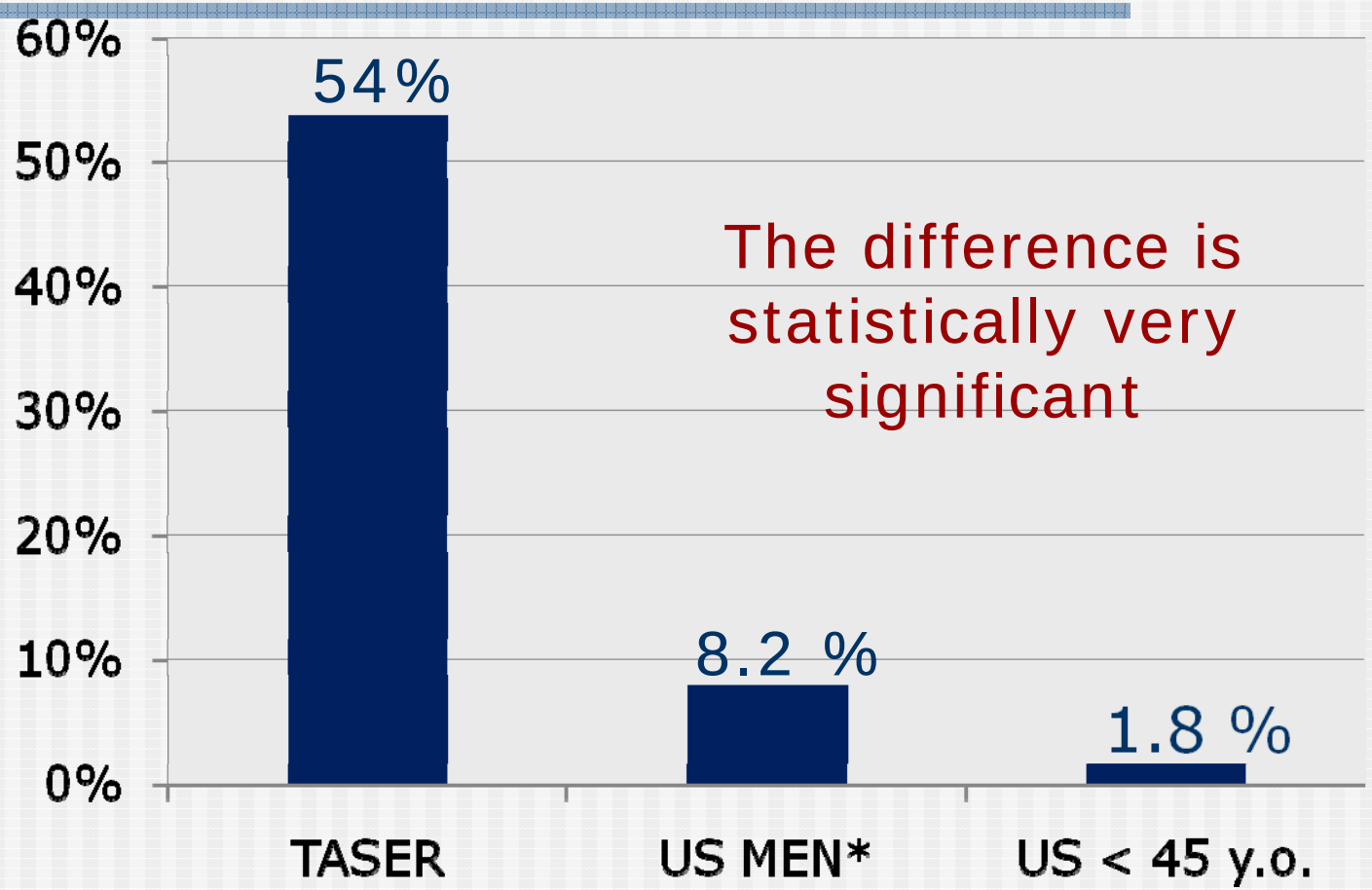
TASER related deaths

Strote & Range Hutson, Univ. Of Washington Medical Center

(Prehosp Emerg Care. 2006;10(4):447-50)

Period of study	2001-2004
'Unexplained' fatalities < 24 h after TASER shocks	75
Autopsy reports available	37
Coronary disease, cardiomyopathy	54%
Illegal substance	78%
Excited delirium diagnosis	76%
TASER: a potential or contributory cause of death	27%

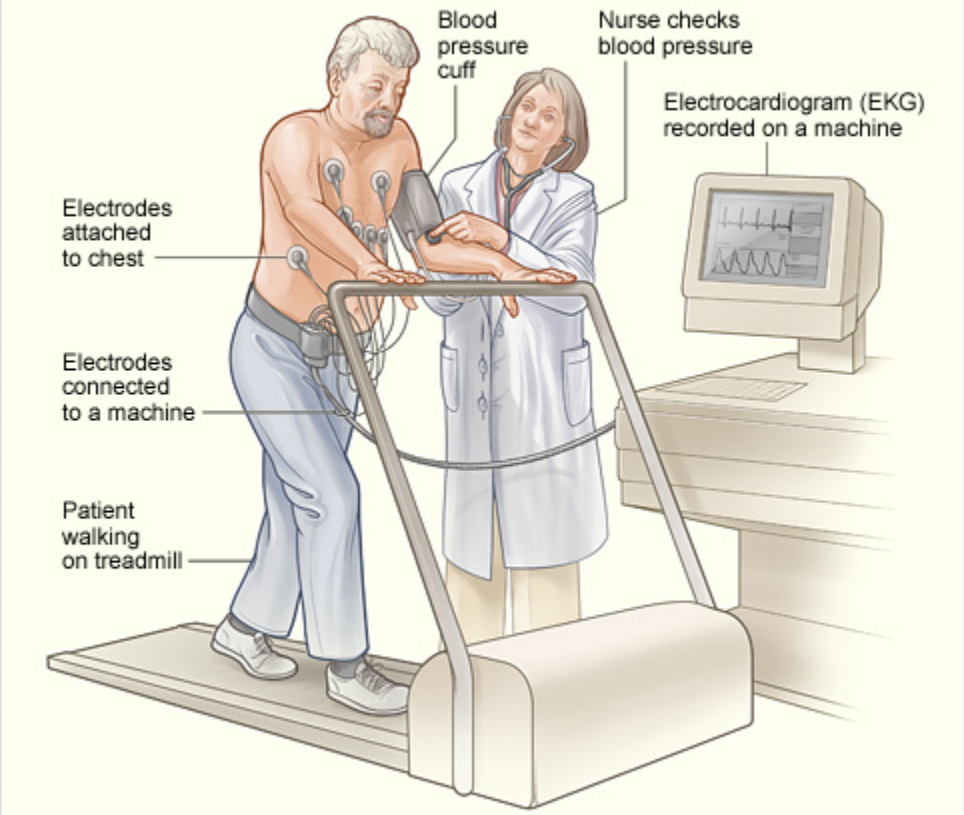
Prevalence of heart disease



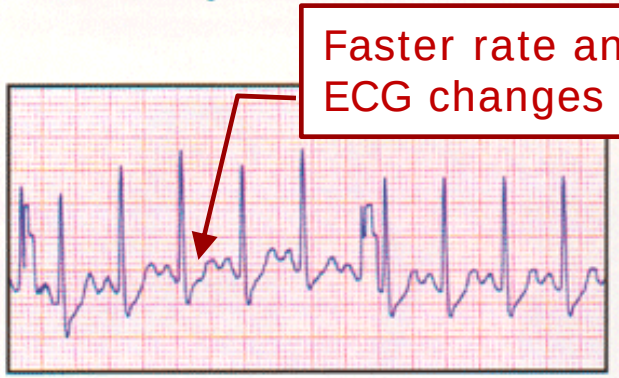
(MI/angina/CHD, Center for Disease Control and Prevention, 2005)*

Analogy #1: stress test

To detect coronary artery disease



An ECG showing a heart at rest.



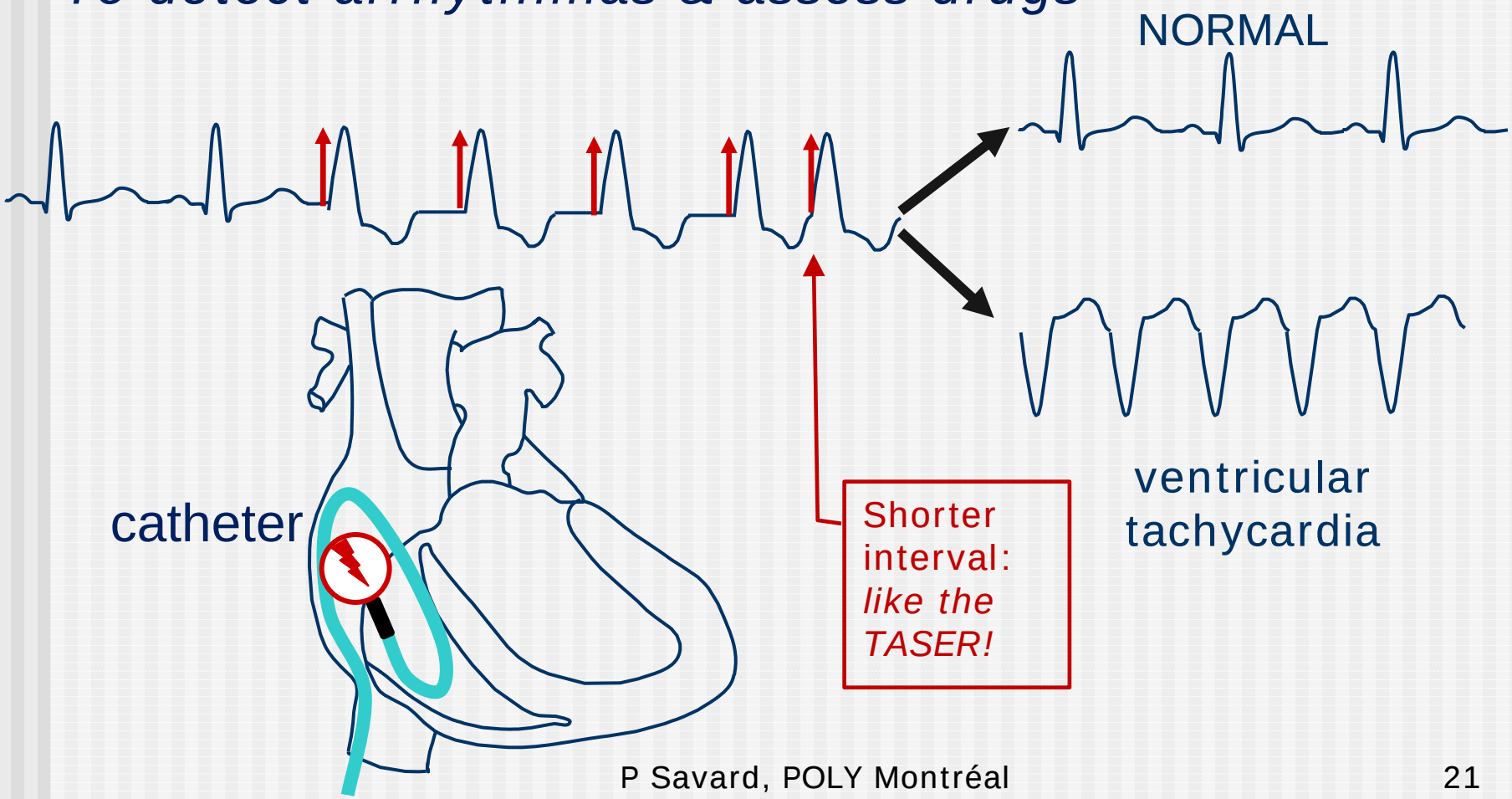
An ECG showing a heart beating faster during exercise.

Plausible mechanism #1

- TASER shocks *(like stress tests)* increase the heart rate through the autonomic nervous system
- In subjects with coronary artery disease:
  - The blood flow is insufficient to satisfy the increased cardiac metabolic needs (ischemia)
  - Some ischemic tissue may show abnormal automaticity and generate ventricular tachycardia, that can be followed by ventricular fibrillation
- *A defibrillator is always on standby during stress tests!*

Analogy #2: Programmed electrical stimulation protocol

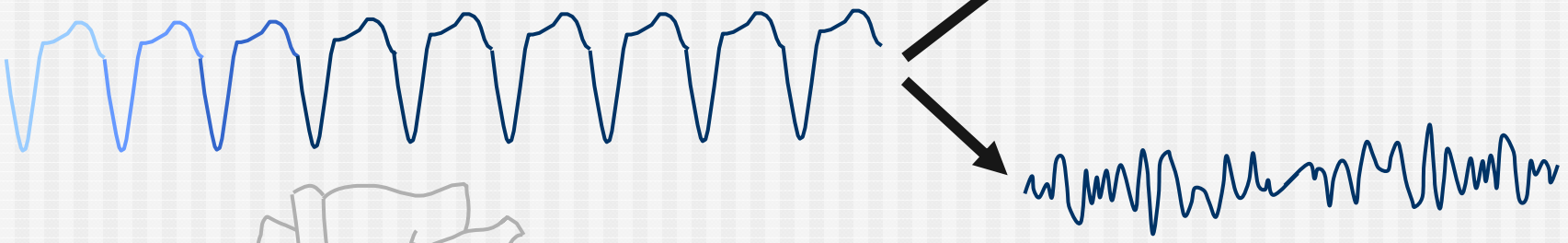
To detect arrhythmias & assess drugs



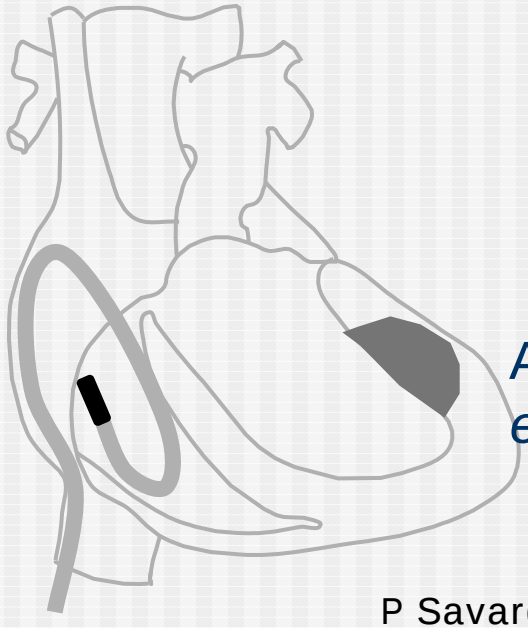
Analogy #2: Programmed electrical stimulation protocol

ventricular tachycardia

NORMAL



ventricular fibrillation



Abnormal substrate:
e.g. myocardial infarction

Plausible mechanism #2

- TASER shocks *(like programmed electrical stimulation)* can produce shorter coupling intervals between heart beats
- In patients with old myocardial infarction, cardiomyopathy, WPW syndrome, etc.:
  - Shorter intervals can produce conduction blocks and reentrant activation
  - This abnormal propagation can produce ventricular tachycardia, followed later by fibrillation
- *A defibrillator is always on standby during programmed stimulation!*

Conclusions (1)

- A strong statistical association between TASER related deaths and heart diseases can be implied from the paper of *Strote & Range Hutson*
  - Possible limitations: a single study (but the largest) with possible selection bias (not all subjects were included) and some confounding factors (drugs, excited delirium)
- The known effects of the TASER on the heart rate are similar to those of two standard cardiology tests that necessitate the use of defibrillators because of their inherent risk:
  - Stress test
  - Programmed electrical stimulation protocol

Conclusions (2)

- Two plausible mechanisms can explain the delay between TASER shocks and death in subjects with heart diseases :
  - Ischemia, in subjects with coronary artery disease
  - Induced ventricular tachycardia, in arrhythmia-prone subjects (old myocardial infarction, cardiomyopathy, Wolff-Parkinson-White syndrome, etc.)
- Other mechanisms are also plausible:
  - Rupture of an aneurysm due to increased arterial pressure caused by the increased heart rate

Conclusions (3)

- Heart disease increases the probability of death after TASER shocks
- Studies on healthy subjects or healthy animals are insufficient to conclude that the TASER is completely safe

TASER INTERNATIONAL
saving lives every day

Product Warnings – Law Enforcement

IMPORTANT SAFETY AND HEALTH INFORMATION

Read, understand, and follow the training, safety instructions, and warnings before using the TASER device. (*These warnings are effective March 1, 2007, and supersede all prior revisions for TASER devices.)*[1] The most current warnings and instructions are available online at www.TASER.com.

This warning label appears on newer TASER device models.

TASER® electronic control devices are weapons designed to incapacitate a person from a safe distance while reducing the likelihood of serious injuries or death. Though they have been found to be a safer and more effective alternative when used as directed to other traditional use of force tools and techniques, it is important to remember that the very nature of use of force and physical incapacitation involves a degree of risk that someone will get hurt or may even be killed due to physical exertion, unforeseen circumstances and individual susceptibilities.

*It is important to remember that the very nature of use of force and physical incapacitation involves a degree of risk that someone will get hurt or **may even be killed** due to physical exertion, unforeseen circumstances and **individual susceptibilities***

Questions

A reentry circuit

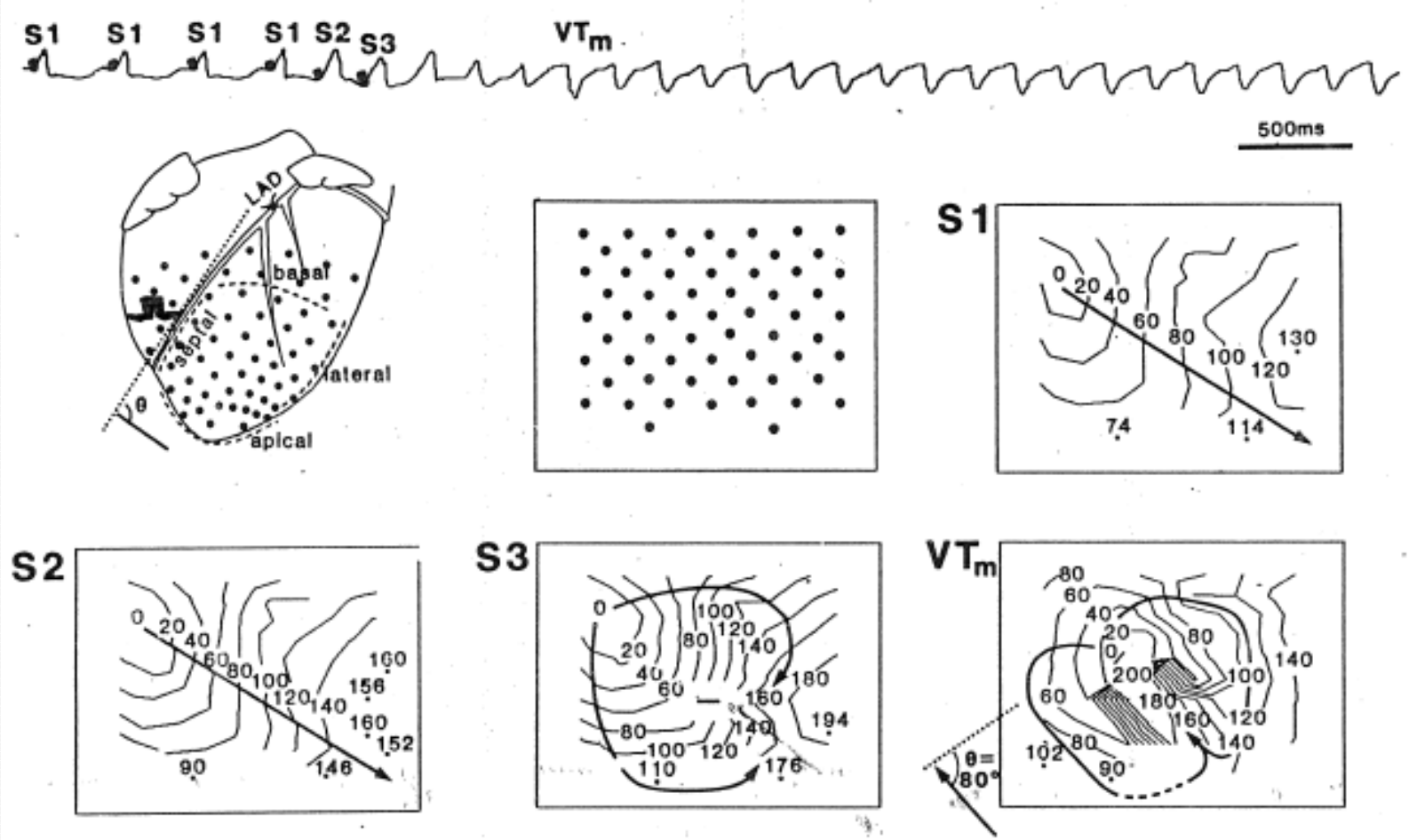


FIGURE 3 Induction of monomorphic ventricular tachycardia by premature impulses conducted in the longitudinal direction

X26

TASER® X26E (Law Enforcement)	26019	Clear

Specifications

1. Output characteristics[3,8]:
   Wave form: Complex shaped pulse
   Pulse rate: 19 pulses per second (PPS)
   Pulse duration: 100 microseconds
   The trigger activates a 5-second cycle. The cycle can be stopped by placing the safety lever in the safe position.
   Peak open circuit arcing voltage: 50,000 V
   Peak loaded voltage: 1,200 V, avg. voltage over duration of main phase 400 V, avg. over full phase 350 V, avg. over one second 0.76 V.
   Current: 2.1 mA average
   Energy per pulse:
   Nominal at main capacitors: 0.36 joules
   Delivered into load: 0.07 joules
   Power rating:
   Nominal at main capacitors: 6.84 watts
   Delivered into load: 1.33 watts

M26

ADVANCED TASER® M26 (Law Enforcement)	44005

Specifications[3]

1. Output characteristics[9]:
   Wave form: Damped oscillation /"blunt" pulse with 17 µs decay time constant.
   Pulse rate:
   20 PPS ± 25% with NiMH rechargeable cells
   15 PPS ± 25% with alkaline cells
   Pulse duration: 40 microseconds full waveform 10 microseconds primary phase
   The trigger activates a 5-second cycle. The cycle can be stopped by placing the safety lever in the safe position.
   Peak open circuit arcing voltage: 50,000 V
   Peak loaded voltage: 5,000 V, avg. voltage over duration of main phase 3400 V, avg. over full phase 320 V, avg. over one second 1.3 V.
   Current: 3.6 mA average
   Energy per pulse:
   Nominal at main capacitor: 1.76 joules
   Delivered into load: 0.50 joules
   Power rating:
   Nominal at main capacitor: 26 watts at 15 PPS
   Nominal delivered into load: 7.39 watts at 15 PPS
2. Power source: 8AA NiMH[7] or alkaline cells

Stimulation threshold for a current pulse