Electrocardiographic Characterization of Acute Myocardial Ischemia

Medical Motivation:
Improve diagnostic accuracy of ECG based early detection of myocardial ischemia in patients at risk of coronary artery disease.

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Clinical Setting - Patient Evaluation

1 Patient Symptoms
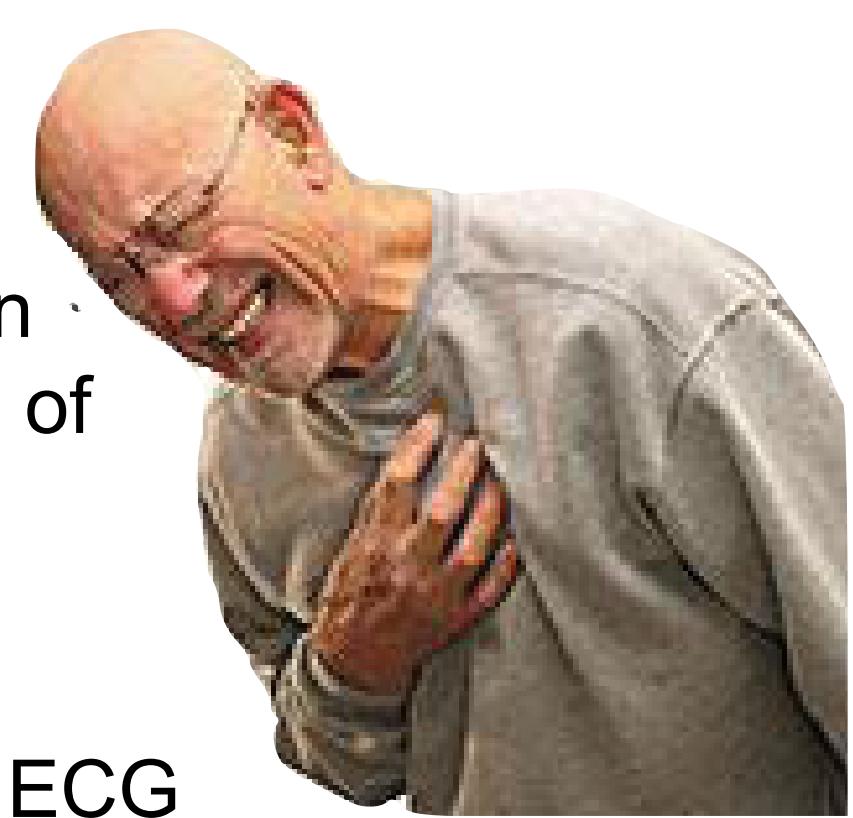
- Chest Pain
- Shortness of Breath
- Anxiery, Sweating
- Abnormal ECG

2 ECG Diagnostic Tests

Electrocardiogram (ECG)
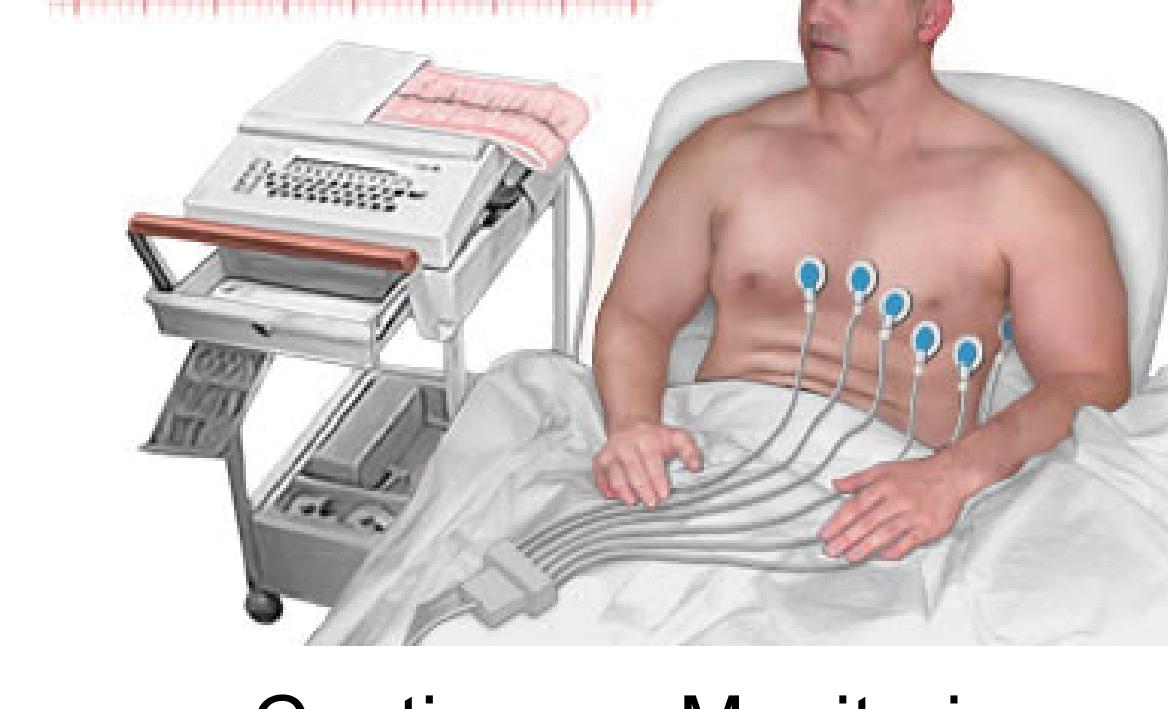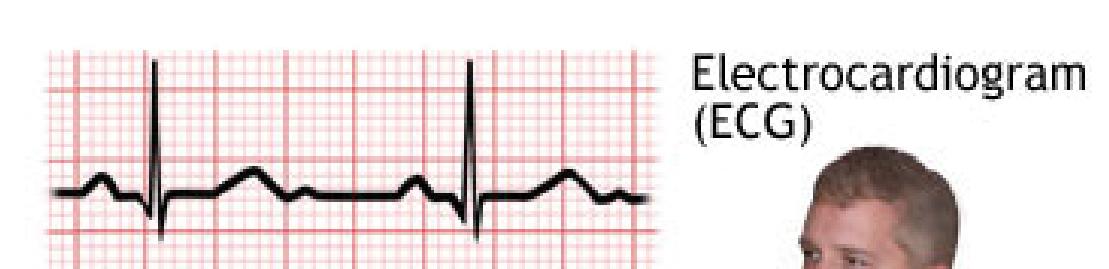
Continuous Monitoring　　　Exercise Stress Testing
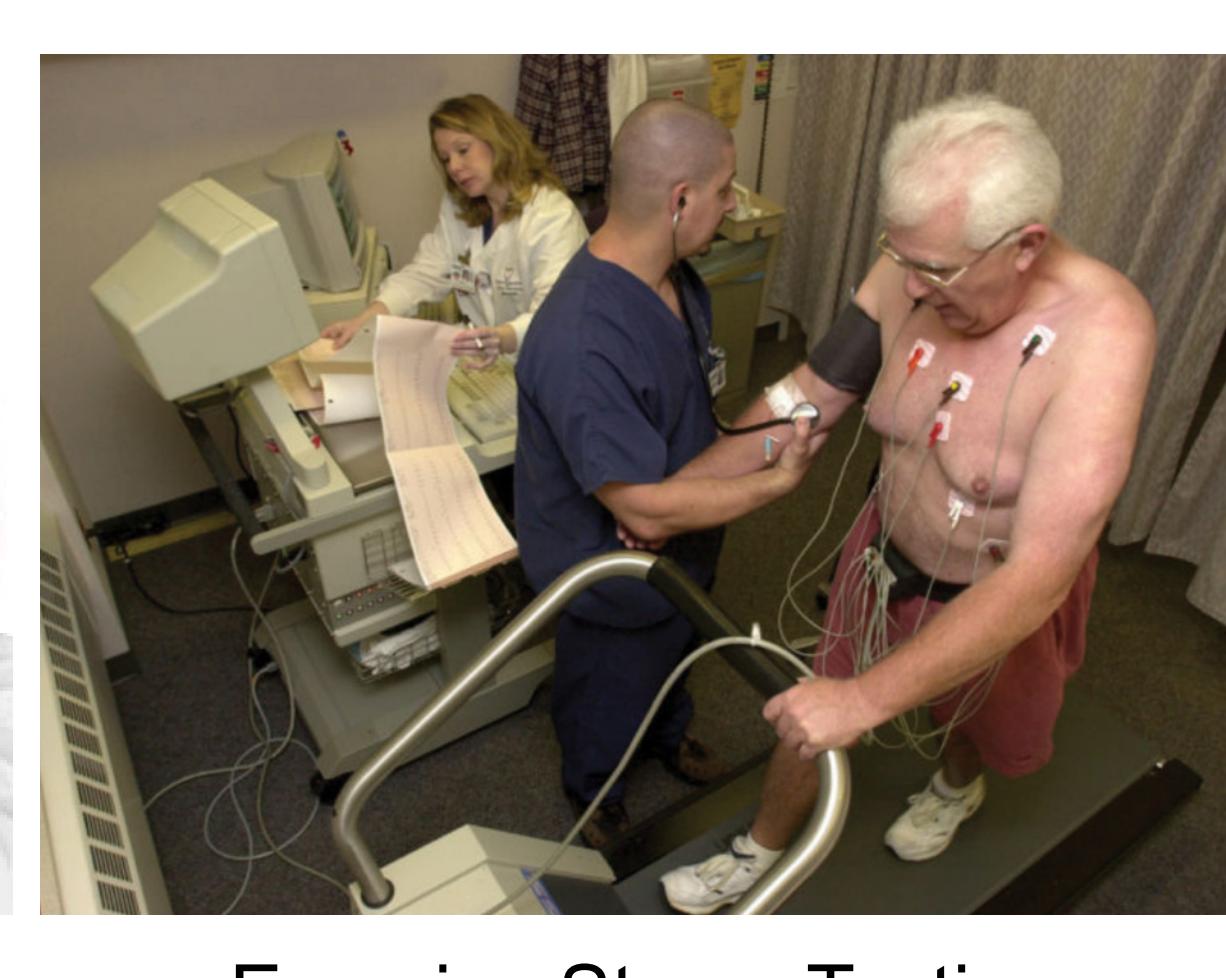
3 Patient Evaluation

ECG Nomenclature

P Wave — Activation of the atria
QRS Complex — Activation of the ventricles
T Wave — Recovery wave

Abnormal ECG Patterns

ST Elevation　　ST Depression　　Normal ST

???
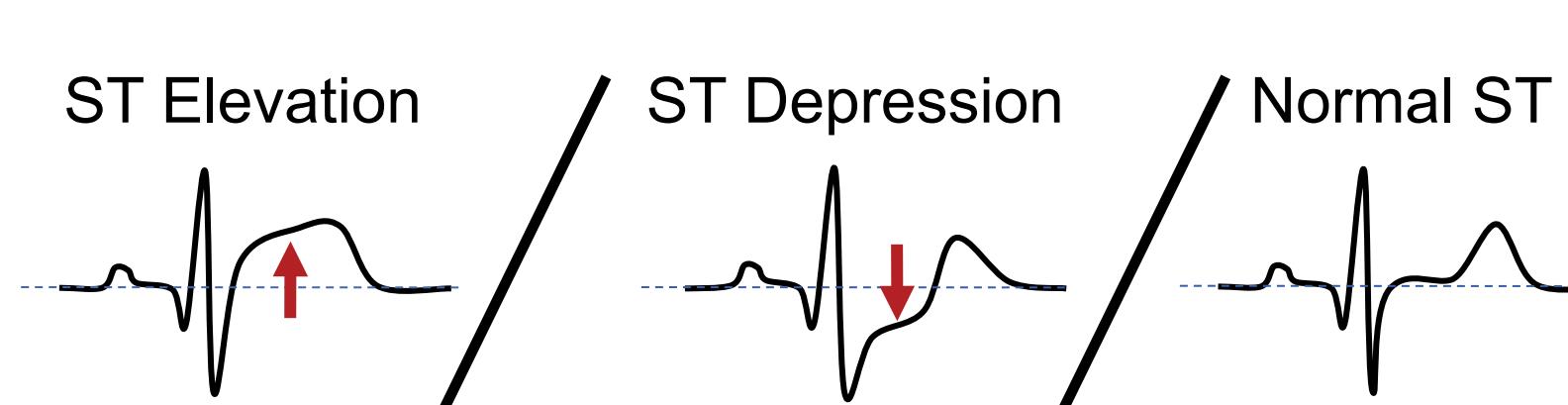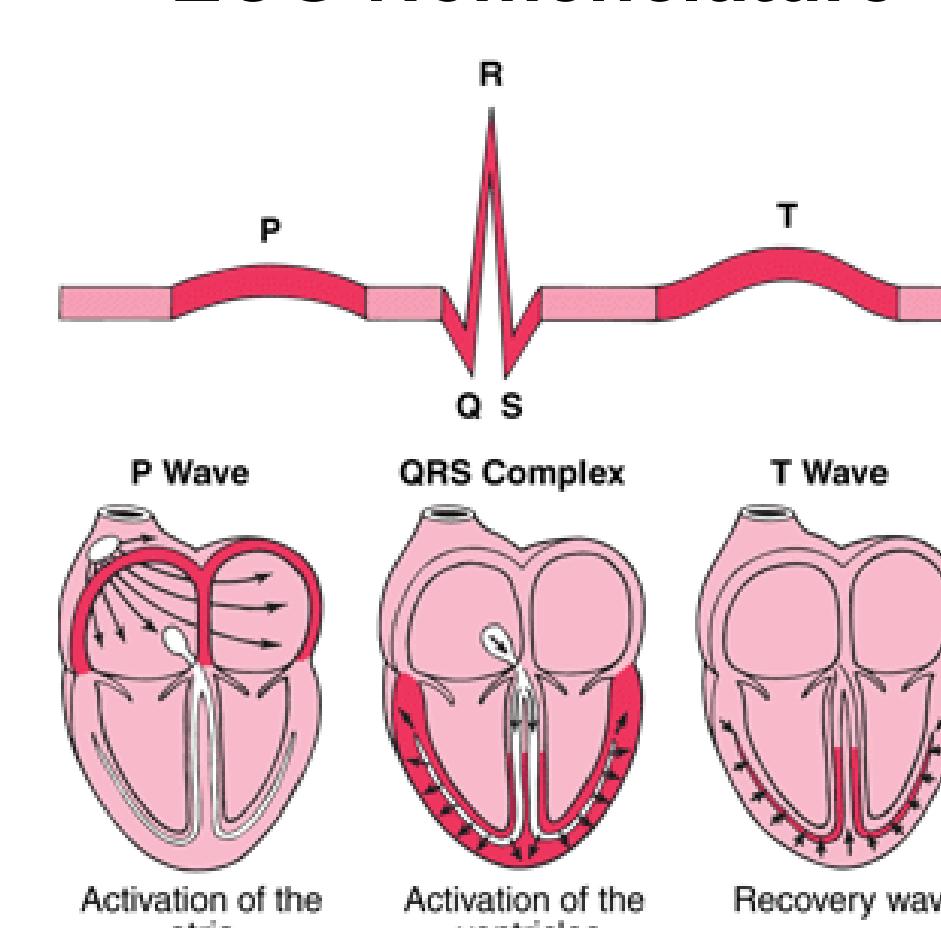
Patient Diagnosis

Heart Attack / Myocardial Ischemia / Acid Reflux / Unknown Causes

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Experimental Setting - Ischemia Characterization

Nora Eccles Harrison CARDIOVASCULAR Research & Training Institute CVRTI

1 Ischemia Profile

Normal coronary artery
Atherosclerosis
Atherosclerosis with blood clot
Coronary spasm

Supply — Demand
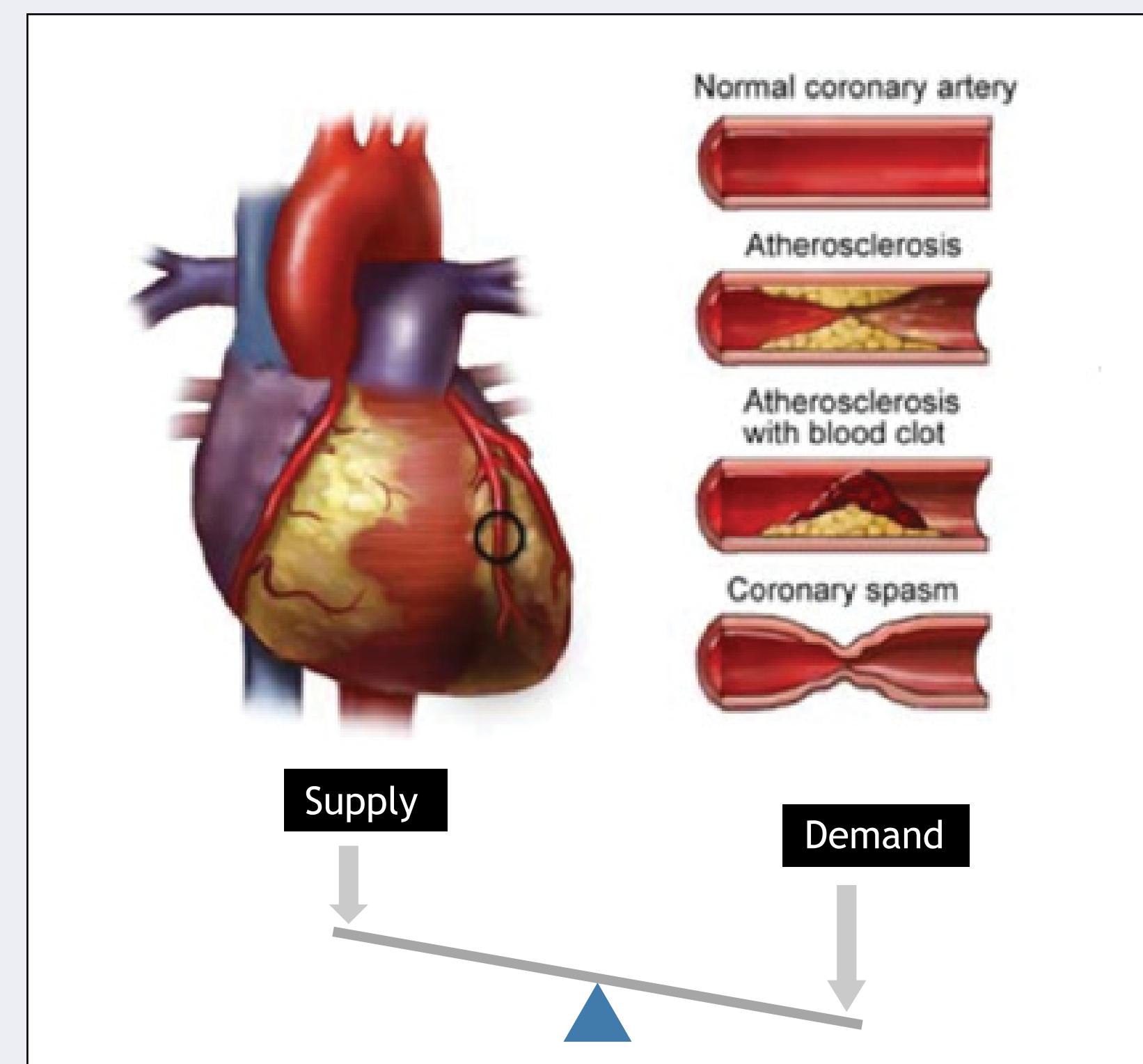
Ischemia = imbalance between blood supply and metabolic needs of the heart

2 Experiments

Canine Heart
Cannula
Blood Pump
Electrodes
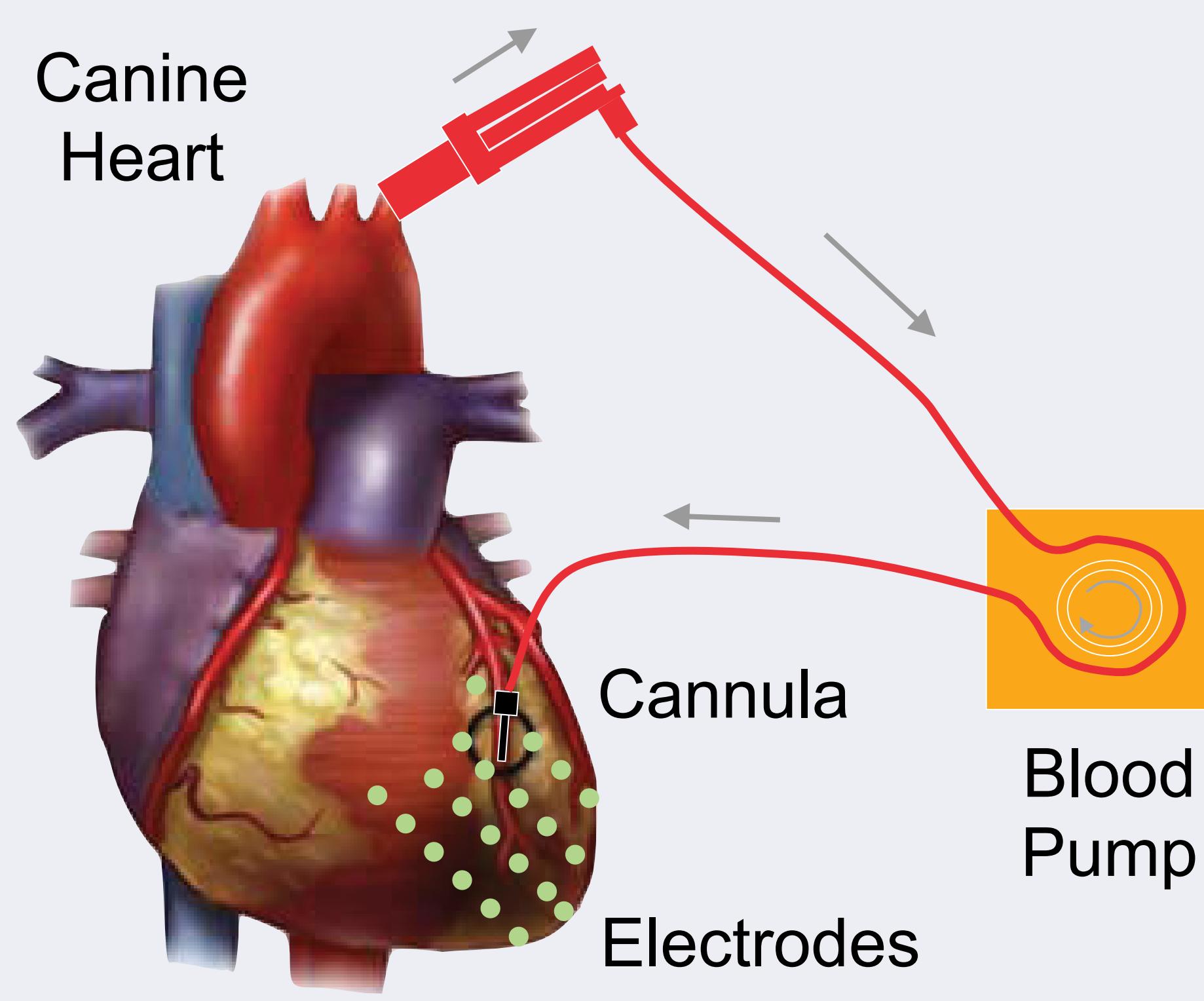
Measurement of electric fields form the heart during ischemia

3 Electrical Profile of Ischemia

Intramural Ischemic Region(s)
Control　A　B　C　D

Epicardial ST40% Potential Map

Heart Volume

Color Scale (mV)
-5.3　-4　-2.6　-1.3　0　1.3　2.6　4　5.3

133 BPM　150 BPM　171 BPM　200 BPM
0s　60s　120s　180s　240s
Demand Ischemia Episode @ 0 ml/min
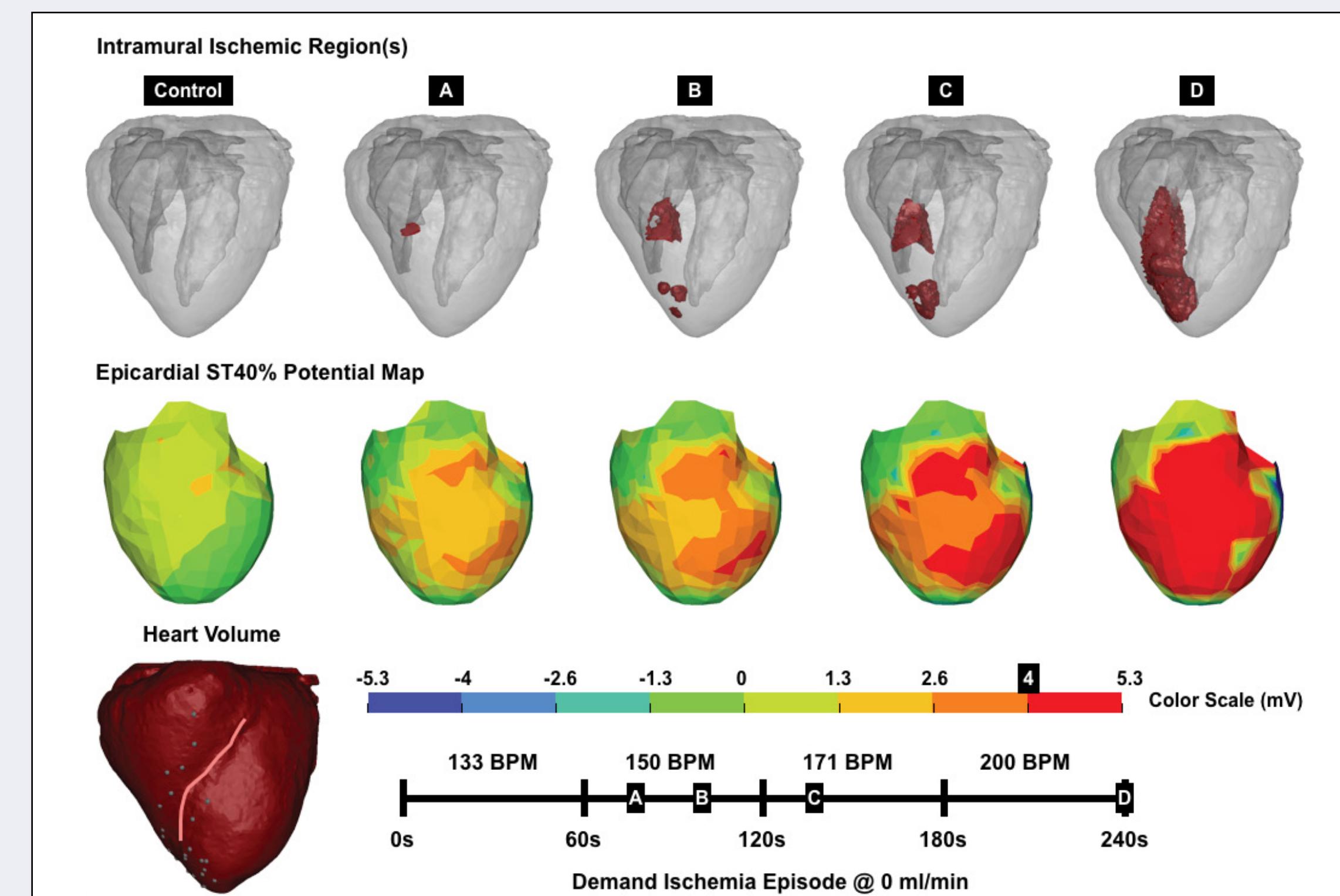
High Resolution 3D mapping of Ischemia

In Silico Setting - Ischemia Modeling

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1 Ischemia Simulation

Forward Problem

Bioelectric Source ↔ Volume Conductor ↔ Surface Potentials

Inverse Problem
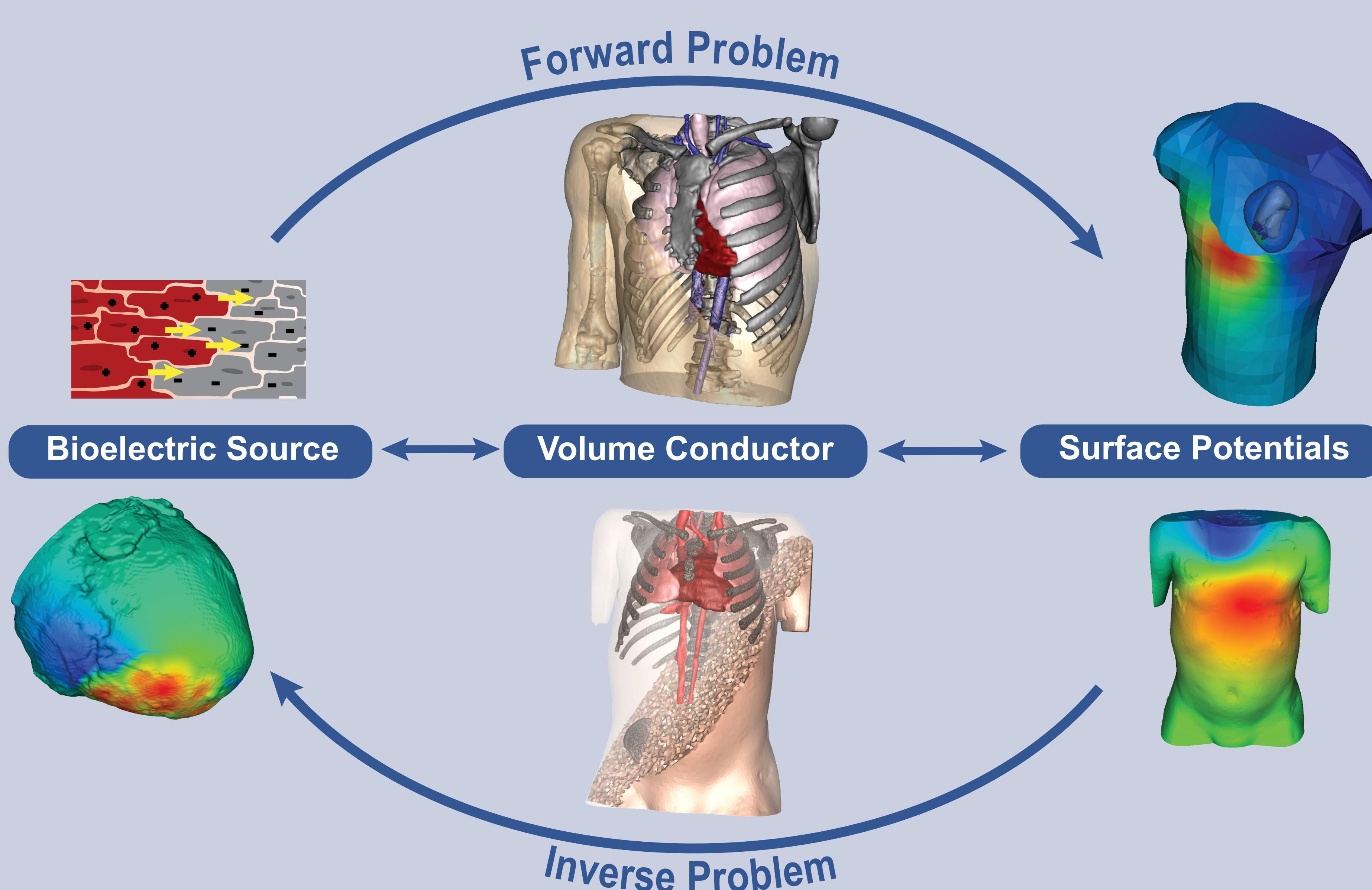
2 Ischemia simulation to improve patient diagnosis

Patient
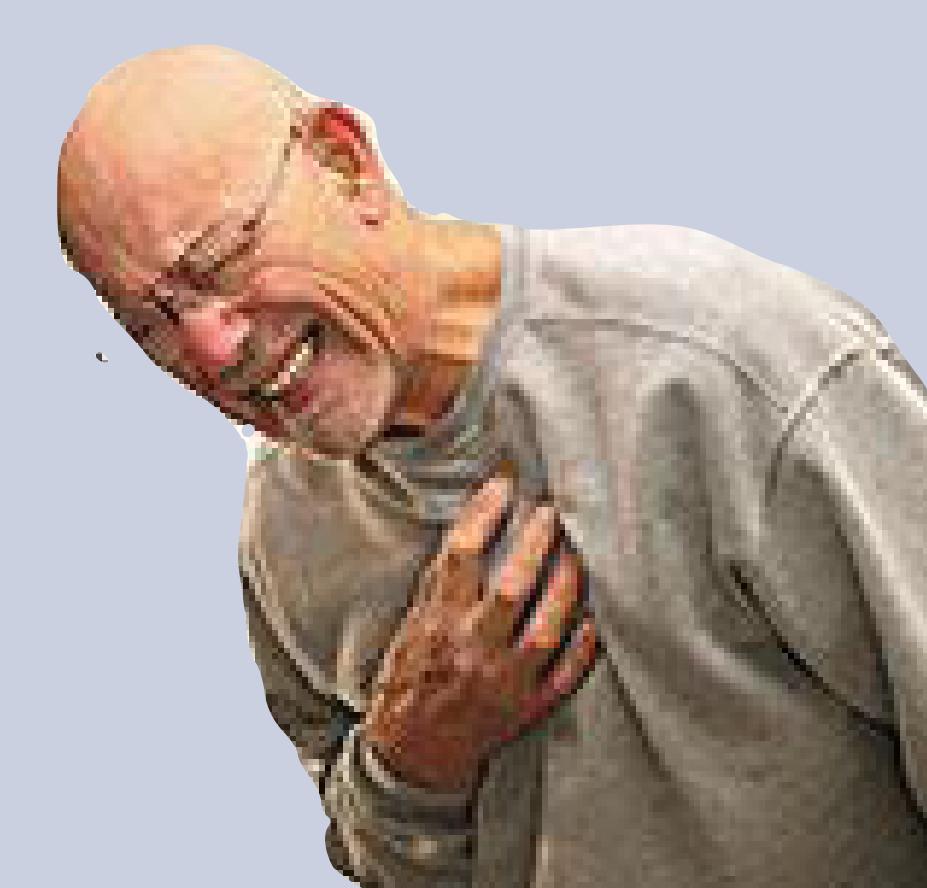
ECG Diagnostic Tests

ST Elevation

ST Depression

Abnormal ECG Patterns

Ischemia Simulation

Amplitude (mV)
V1 V2 V3 V4 V5
Time (ms)
0　75　150　225　300　375　450

Ischemia Diagnosis

YES / NO

Extent of Ischemia

Patient Treatment