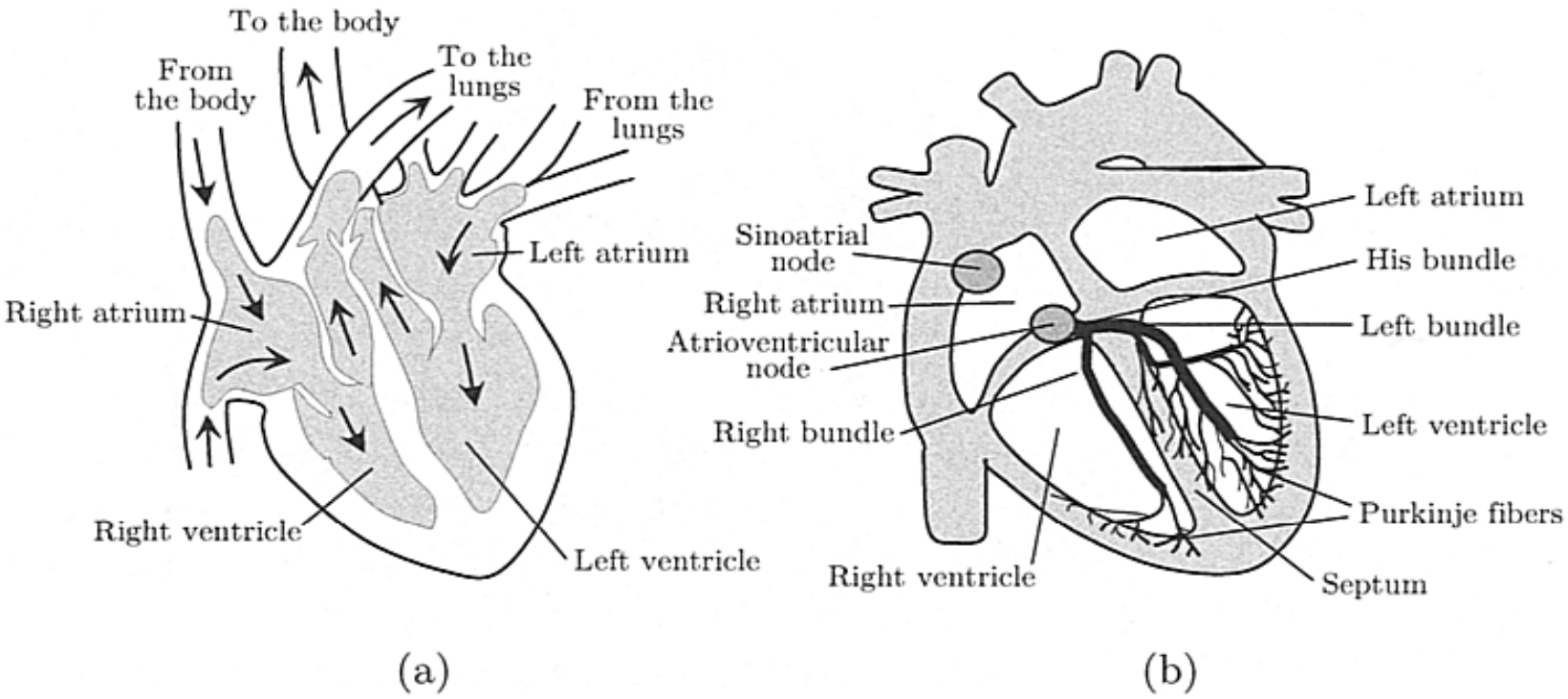
ELECTROCARDIOGRAM (ECG) AND DETECTING TRANSIENT ISCHAEMIA

- Electrical activity of the heart
- Depolarization and re-polarization
- ECG recording techniques
- ECG waves and time intervals
- Heart rhythms
- Detecting heart rhythms – aspects
- Basic stages of ECG signal processing
- Myocardial ischaemia
- Myocardial infarction
- Characteristics of transient ischaemic ST segment episodes
- Detecting transient ischaemia – aspects
- Basic stages of ECG signal processing
- Characteristics of transient ischaemic ST segment episodes
- Problems of automated ischaemia analysis
- (International reference databases)

Electrical activity of the heart

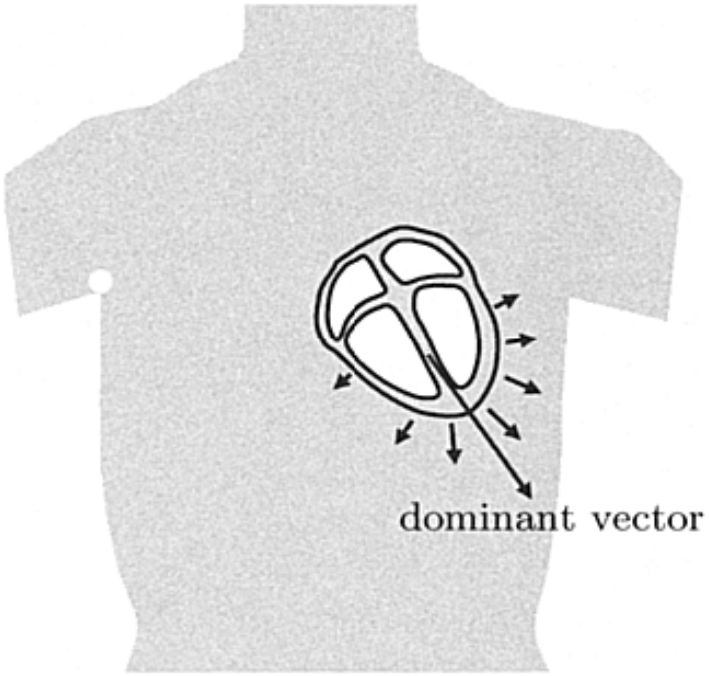
- Schematic illustration of (a) anatomy of the heart (the arrows indicate the directions of the blood flow into and out of the heart) and (b) its electrical conduction system



(Sornmo, Laguna)

Depolarization and re-polarization

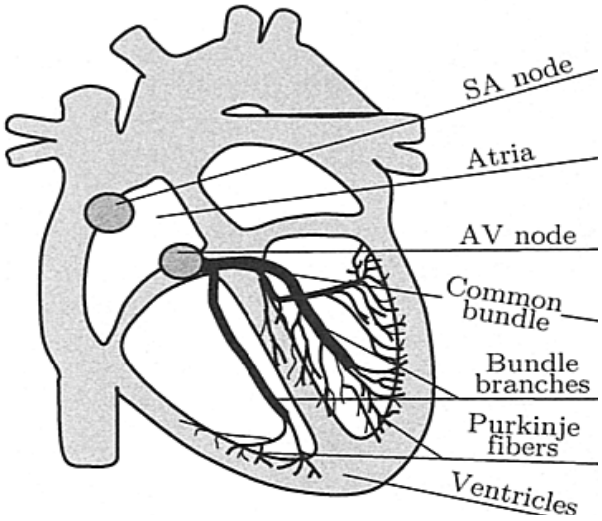
- The vector associated with each group of cells in the myocardium, during both depolarization and repolarization, can be summed into a dominant vector describing the main direction of the electrical impulse

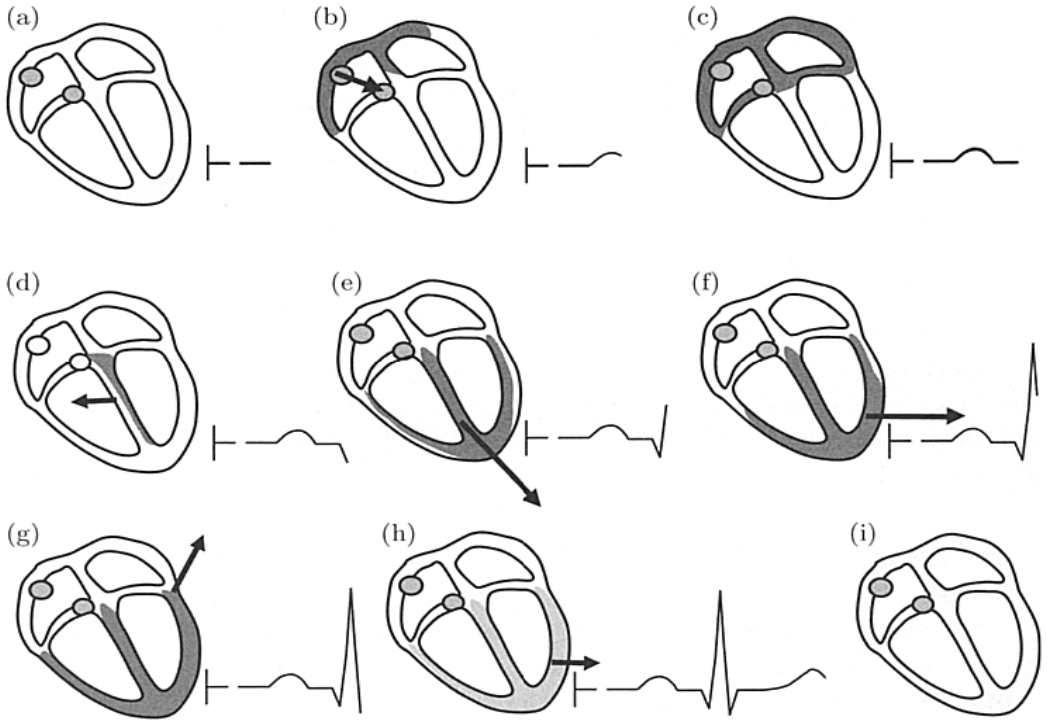


(Sornmo, Laguna)

Depolarization and re-polarization

- The ECG recorded in by an electrode positioned at the location of the symbol |- . (a) All cardiac cells at rest, (b) atrial depolarization, (c) the electrical impulse passing through the AV node, (d)-(g) ventricular depolarization, (h) ventricular repolarization, and (i) all cardiac cells again at rest





(Sornmo, Laguna)

ECG recording techniques

- Standard 12-lead ECG
- The bipolar limb leads:

  $I = V_{LA} - V_{RA}$

  $II = V_{LL} - V_{RA}$

  $III = V_{LL} - V_{LA}$

  $_L$ - left, $_R$ - right

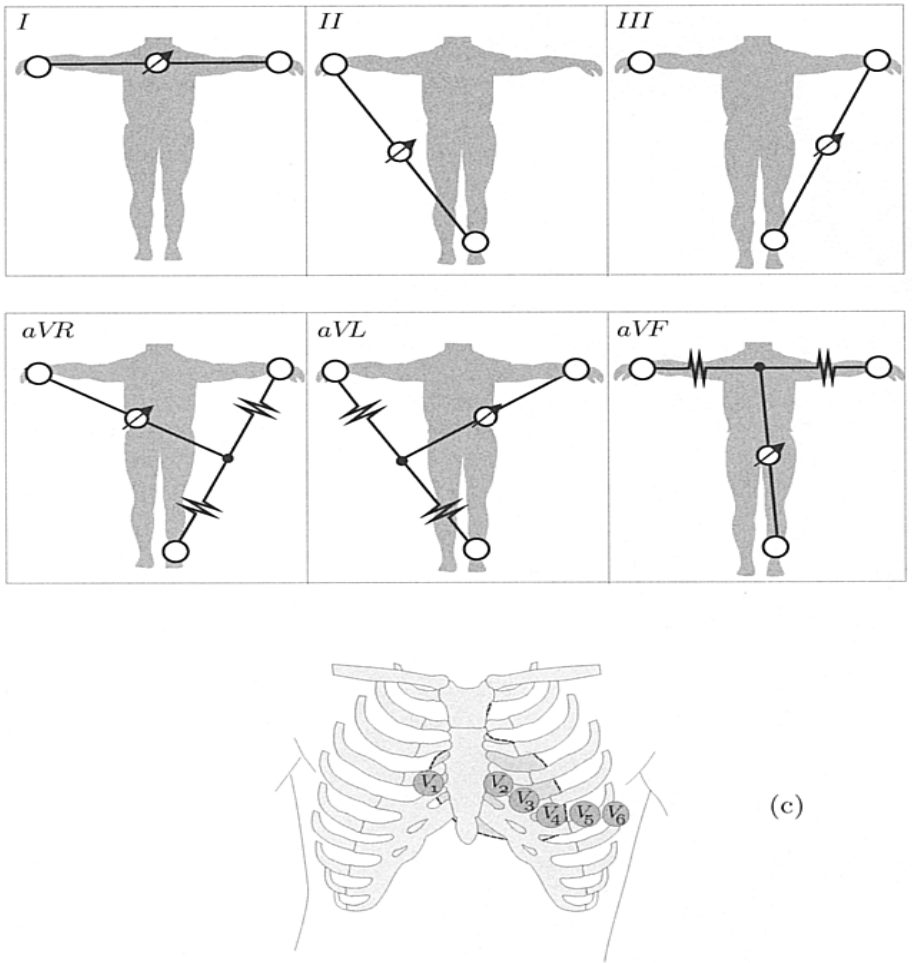
  $_L$ – leg, $_A$ - arm
- The augmented unipolar limb leads:

  $aVR = V_{RA} – (V_{LA} + V_{LL}) / 2$

  $aVL = V_{LA} – (V_{RA} + V_{LL}) / 2$

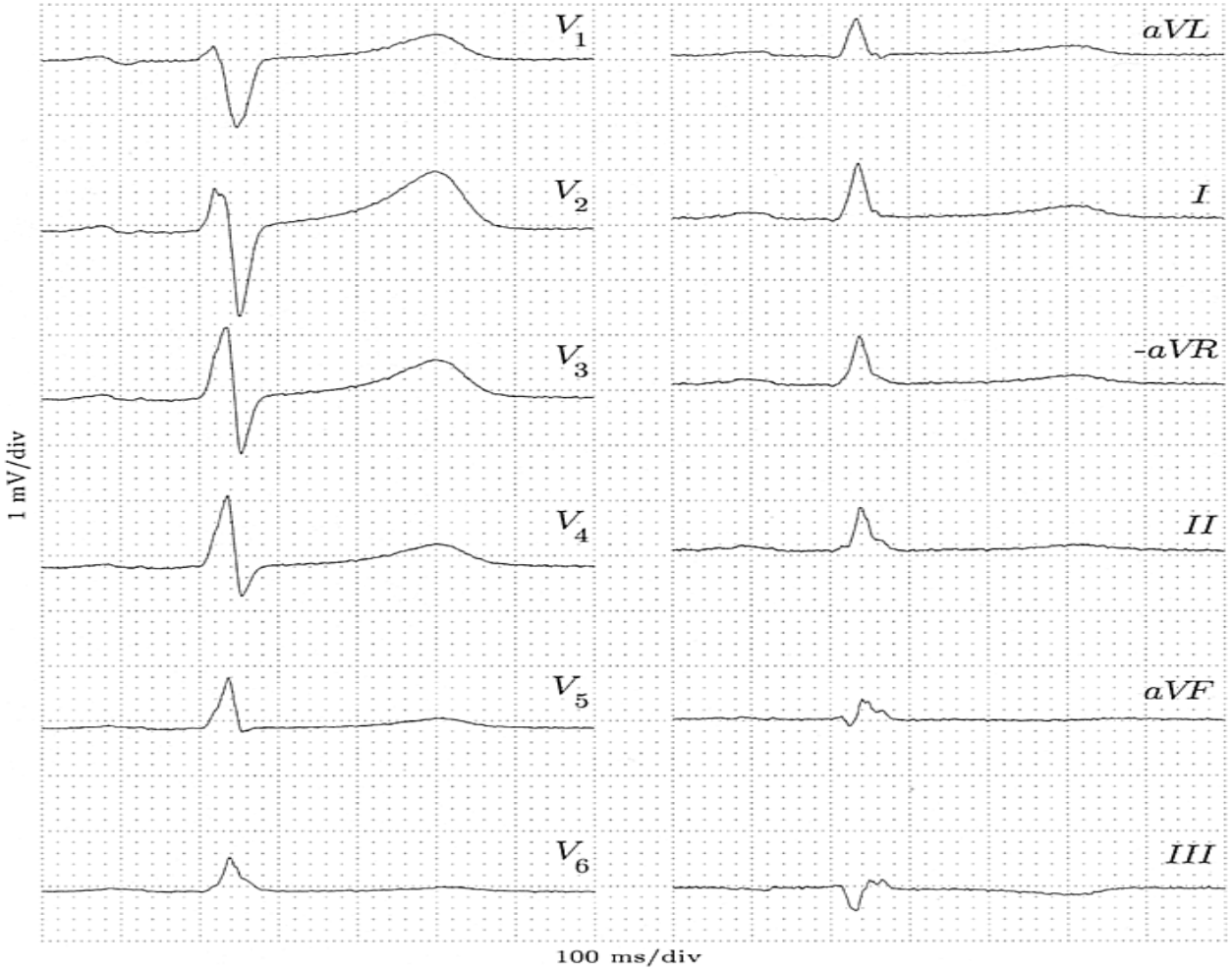
  $aVF = V_{LL} – (V_{LA} + V_{RA}) / 2$
- The precordial leads:

  $V1, …, V6$



(Sornmo, Laguna)

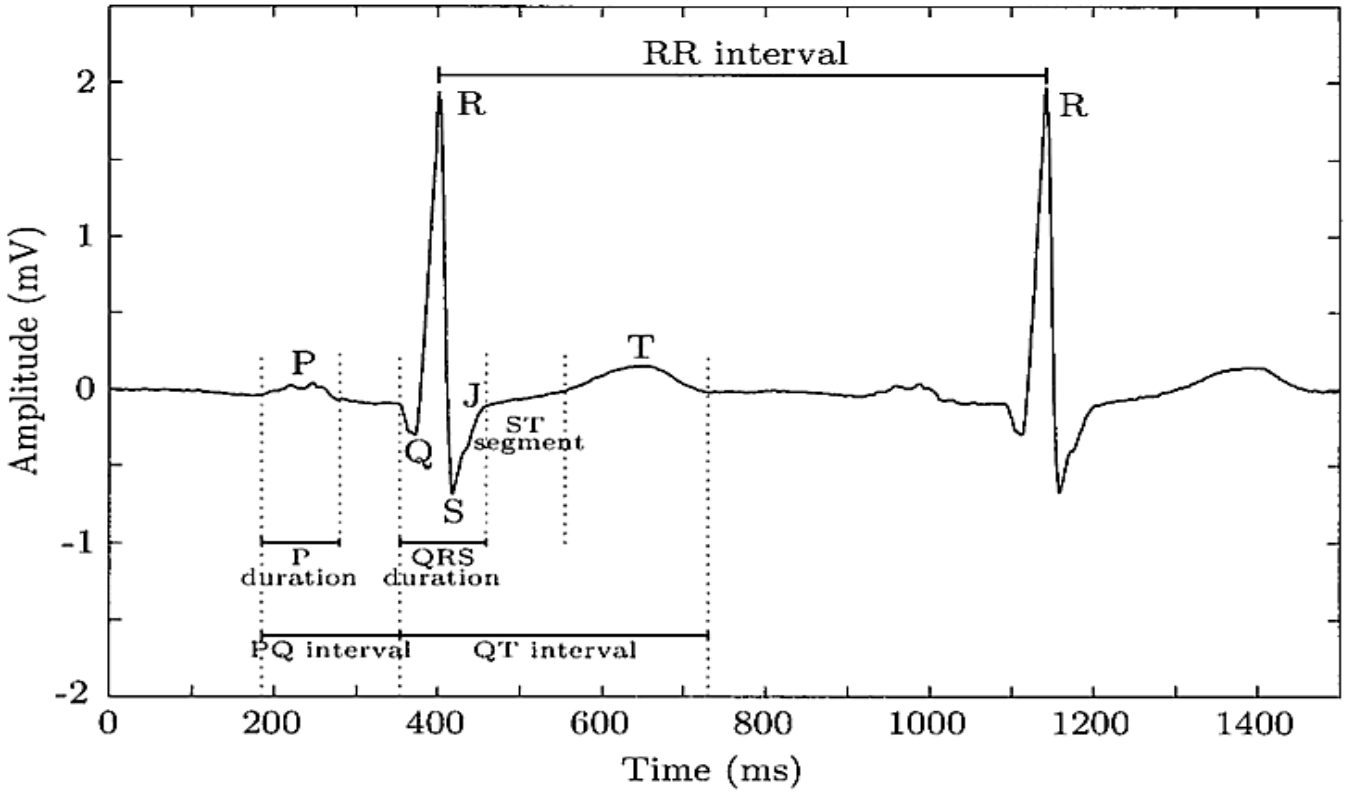
ECG recording techniques



(Sornmo, Laguna)

ECG waves and time intervals

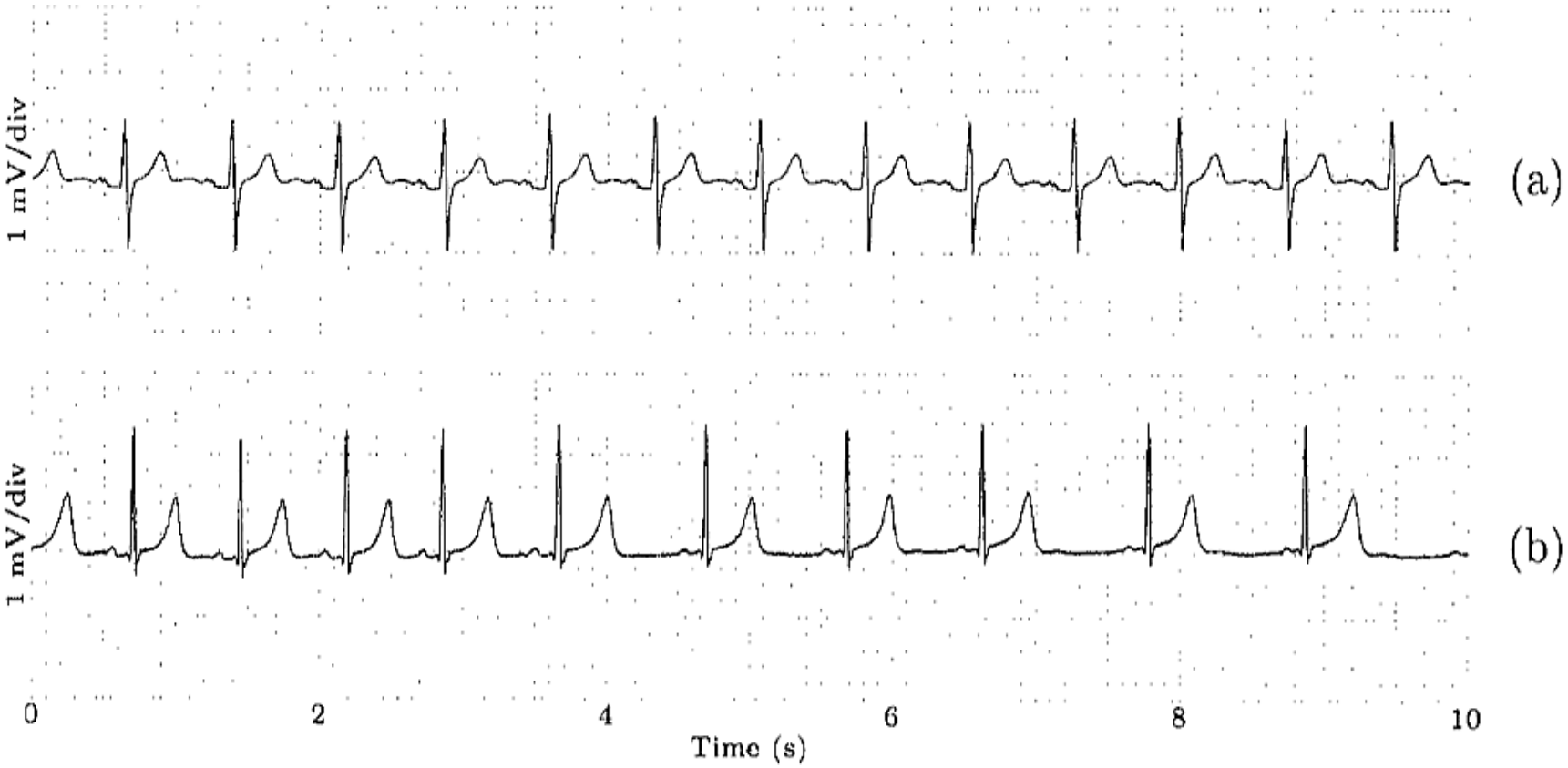
- Electrocardiogram (ECG) is projection of the mean electrical vector onto the lead axis



(Sornmo, Laguna)

Heart rhythms

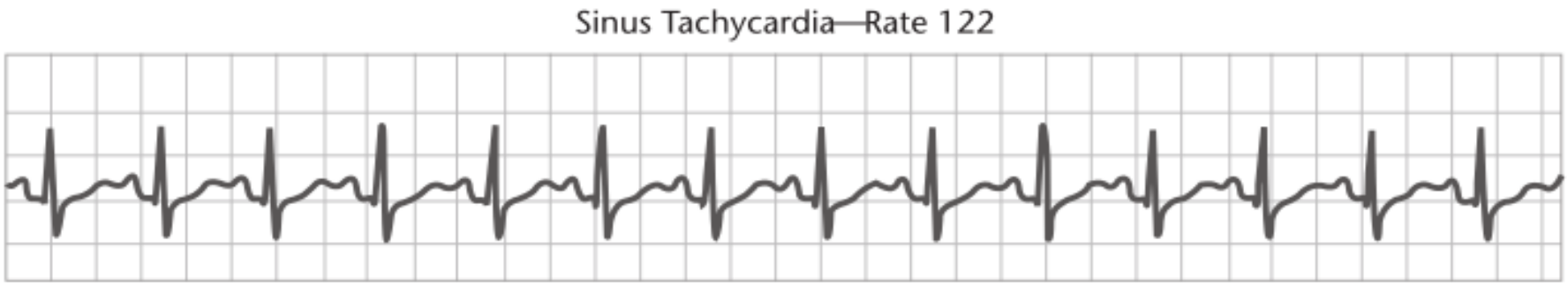
- (a) Normal sinus rhythm and (b) respiratory sinus arrhythmia.

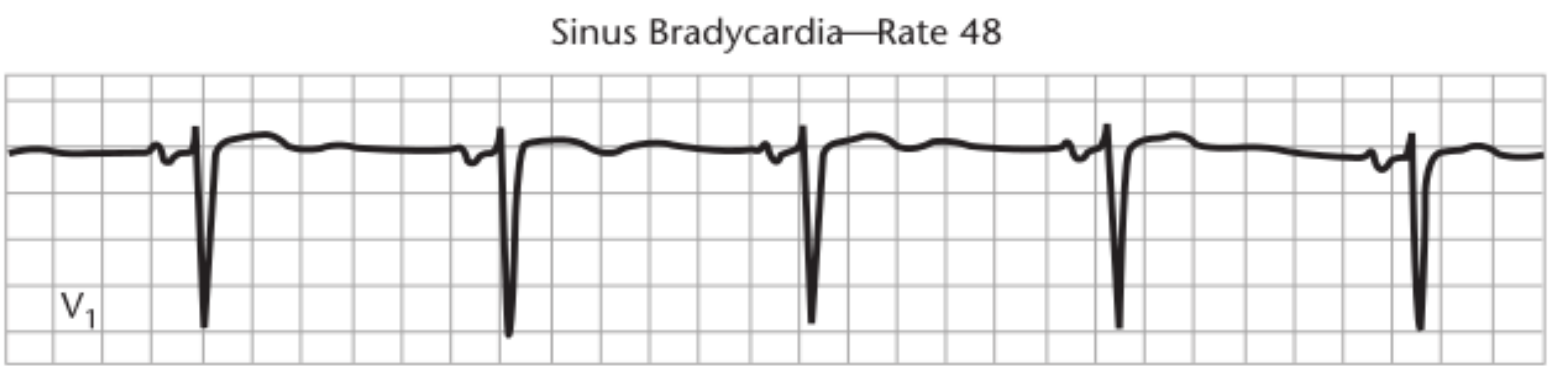


(Sornmo, Laguna)

Heart rhythms

- Sinus tachycardia and sinus bradycardia

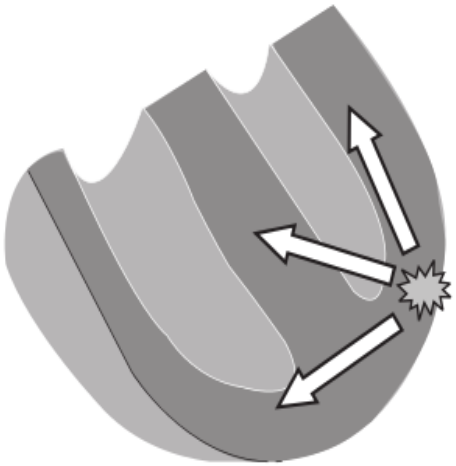




(Clifford, Azuaje, McSharry (editors))

Heart rhythms

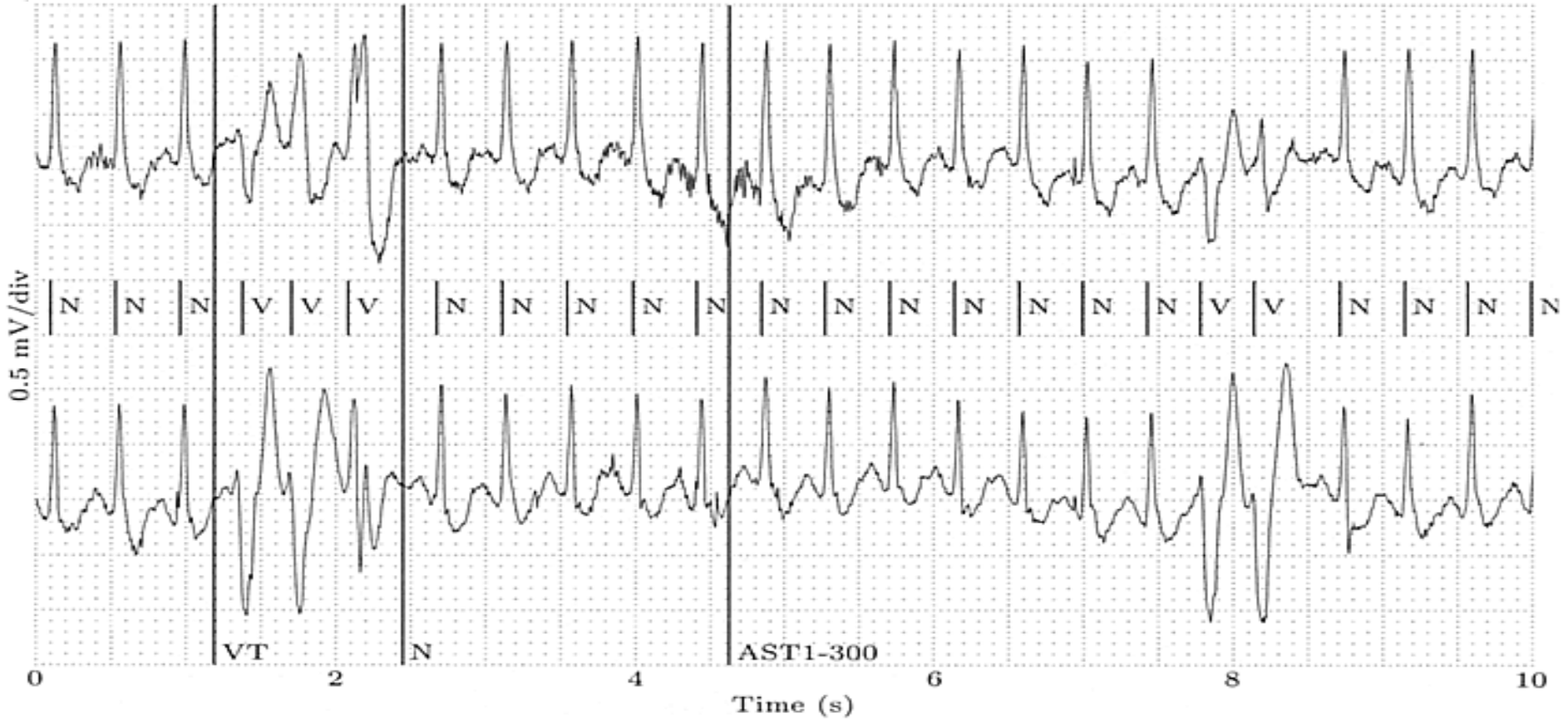
- Ectopic beats: (a) A supraventricular premature beat (b) A premature ventricular beat followed by a compensatory pause (c) Bigeminy (d) Trigeminy (e) An interpolated ventricular premature beat



(Sornmo, Laguna; Clifford, Azuaje, McSharry (editors))

Heart rhythms

- Ventricular tachycardia



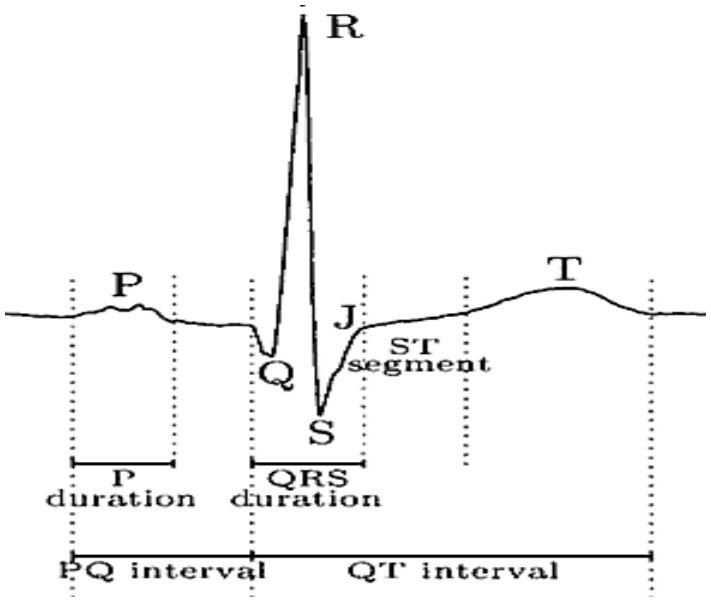
(Sornmo, Laguna)

Detecting heart rhythms - aspects

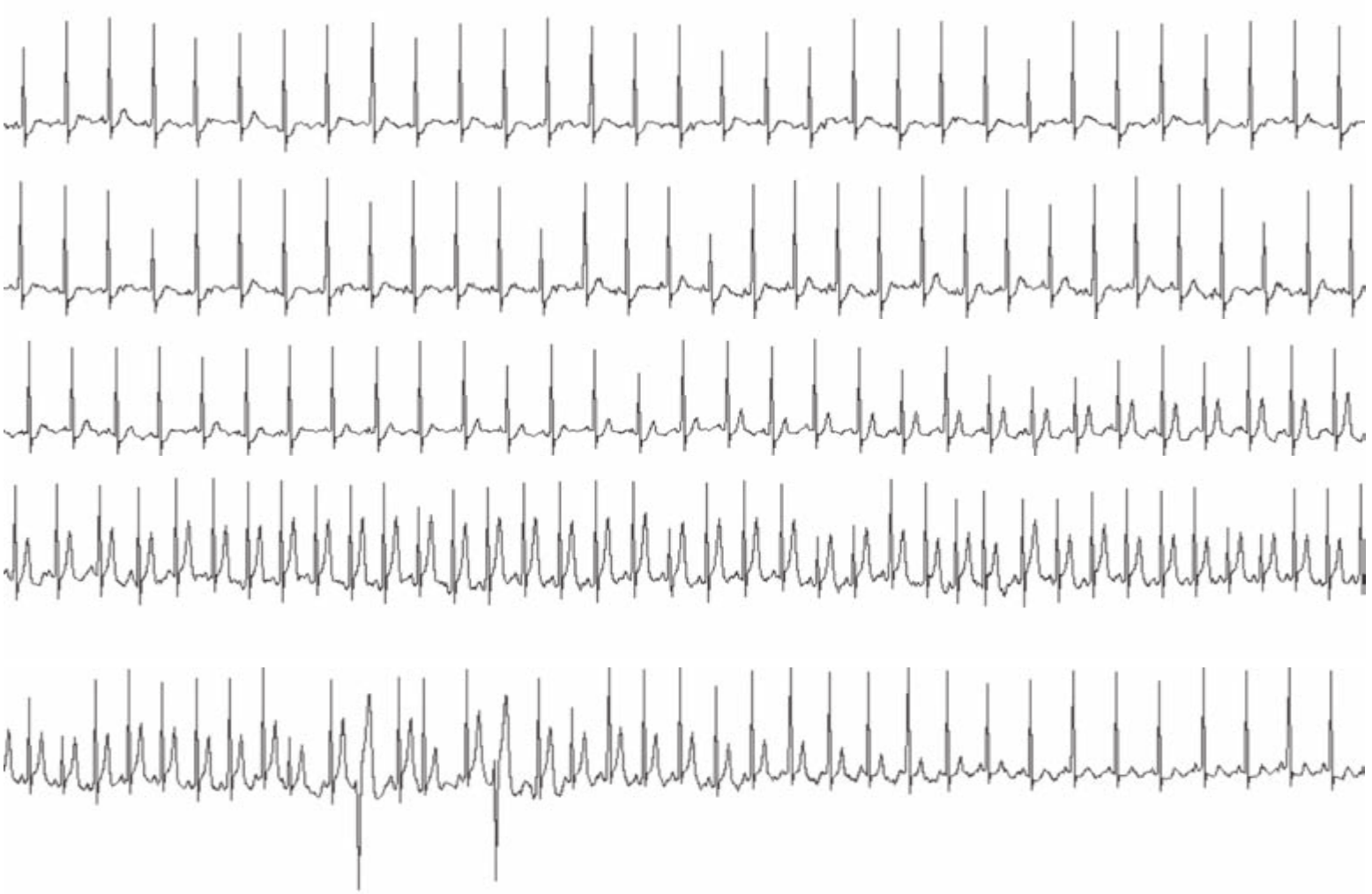
- Arrhythmias are one of the most terrible heart diseases and could lead into death
- It is very important to automatically follow cardiac function in coronary care and intensive care units

Basic stages of ECG signal processing

- ECG filtering
- *QRS complex detection*
  → (Wave delineation)
- *QRS complex classification*
  → (Rhythm classification)

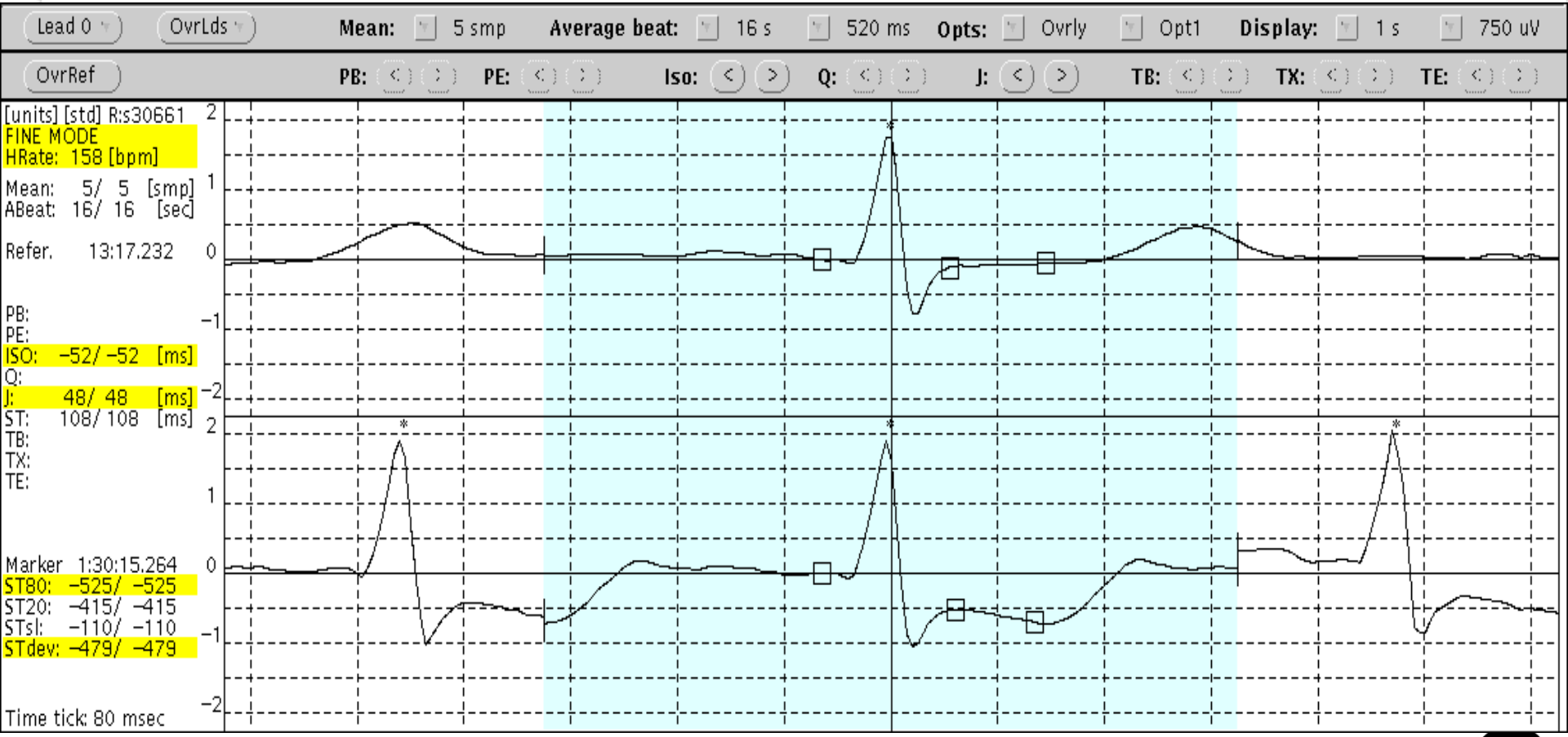


Myocardial ischaemia



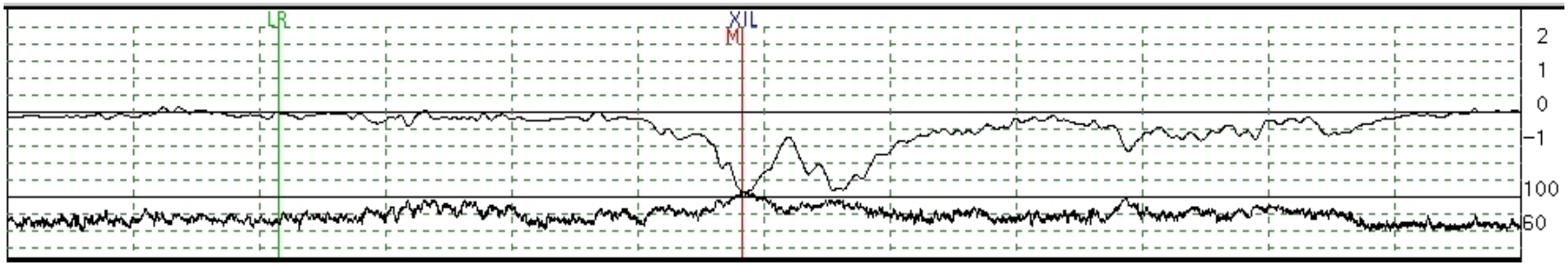
Myocardial ischaemia

- Ischaemic change of ST segment (isoelectric level, J point, J + 80 ms point)

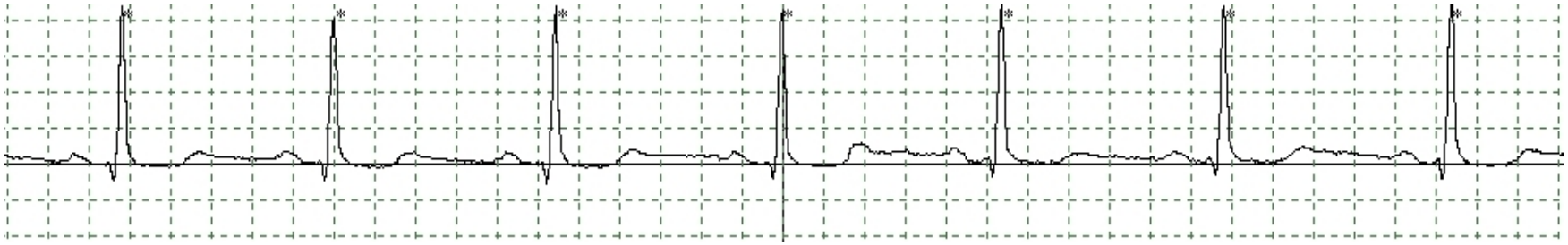


Myocardial ischaemia

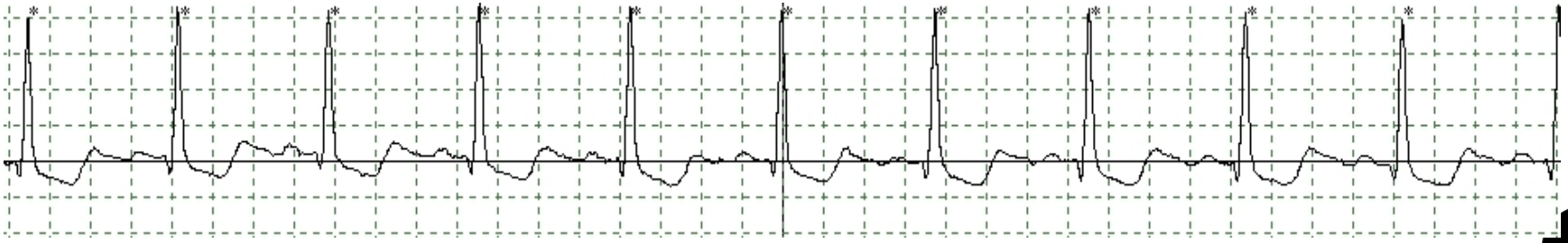
ST segment level and heart frequency



Local reference (LR)

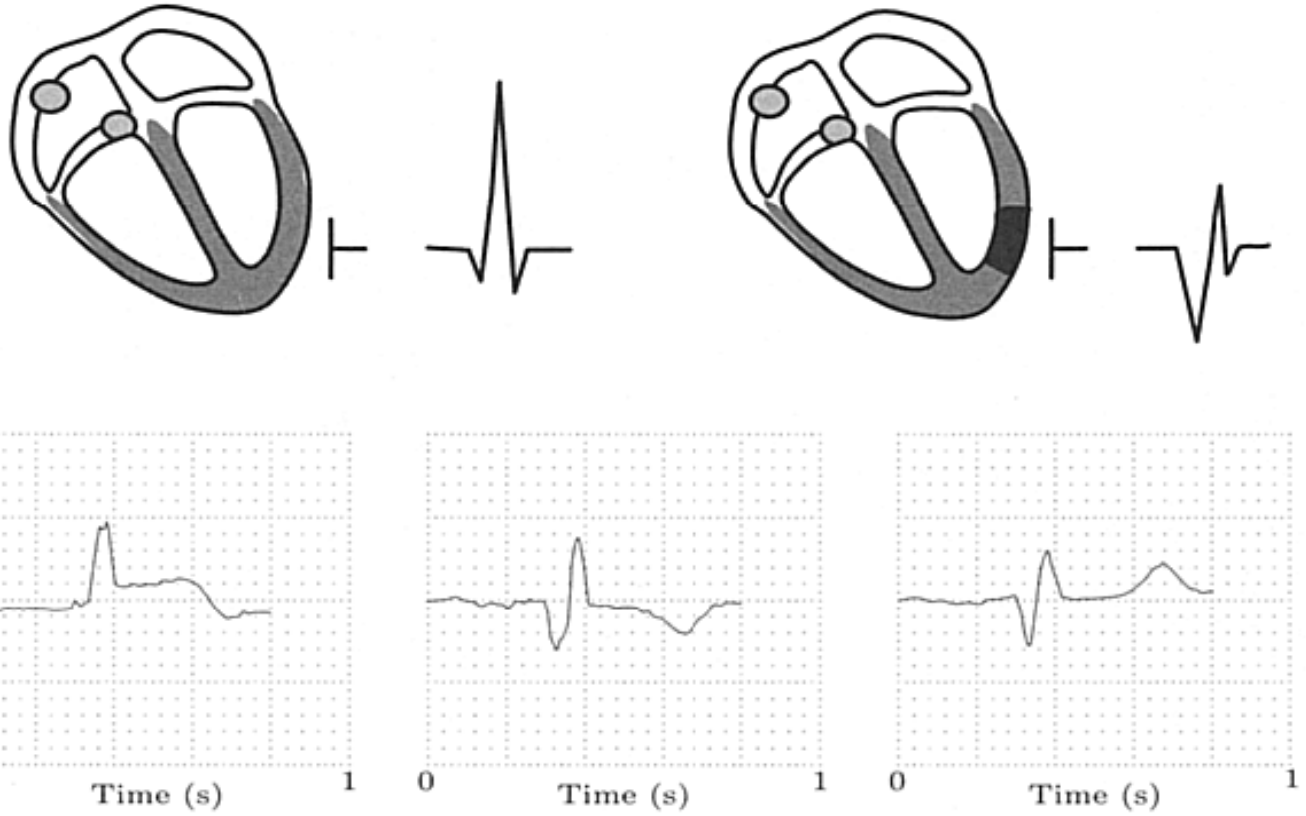


Marker (M) QRS ? ST ?



Myocardial infarction

- Healthy heart, infarction
- Infarction, after 10 days, after 6 months



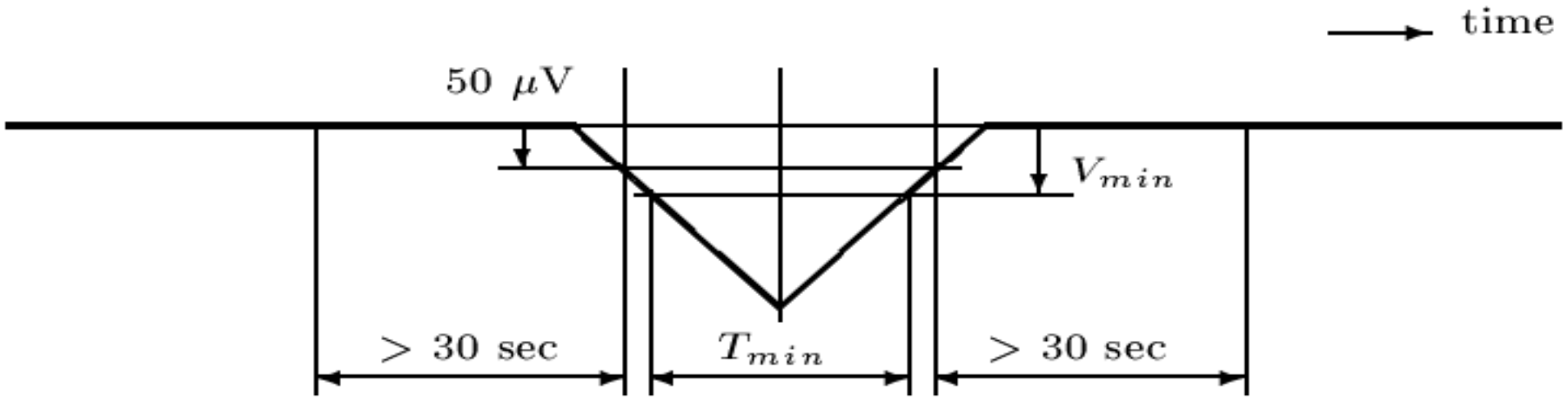
(Sornmo, Laguna)

Characteristics of transient ischaemic ST segment episodes

- Significant transient ischaemic ST segment episode existence criteria

  Time course of ST segment level, *stlev(i)* [μV], measured at the point J + 80 ms

  (Clinicaly important episode: *Tmin* = 30 *sec*, *Vmin* = 100 μV)

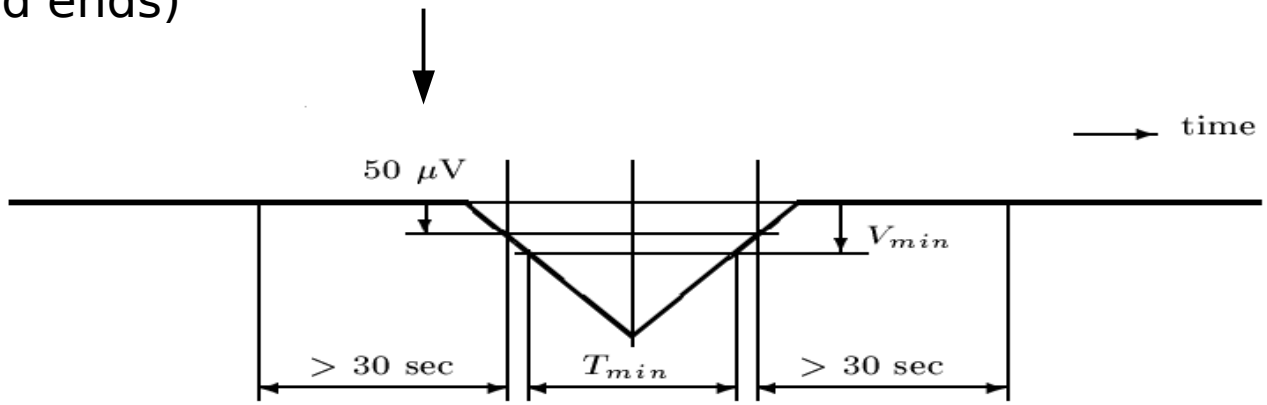


Detecting transient ischaemia - aspects

- Ischaemia (angina pectoris) is one of the most terrible heart diseases and could lead into infarct and death
- The most suitable to early detect silent ischaemia (80%) are 24-hour ambulatory records recorded during patient's usual daily activities (Holter records)
- The huge amount of data requires automated analysis

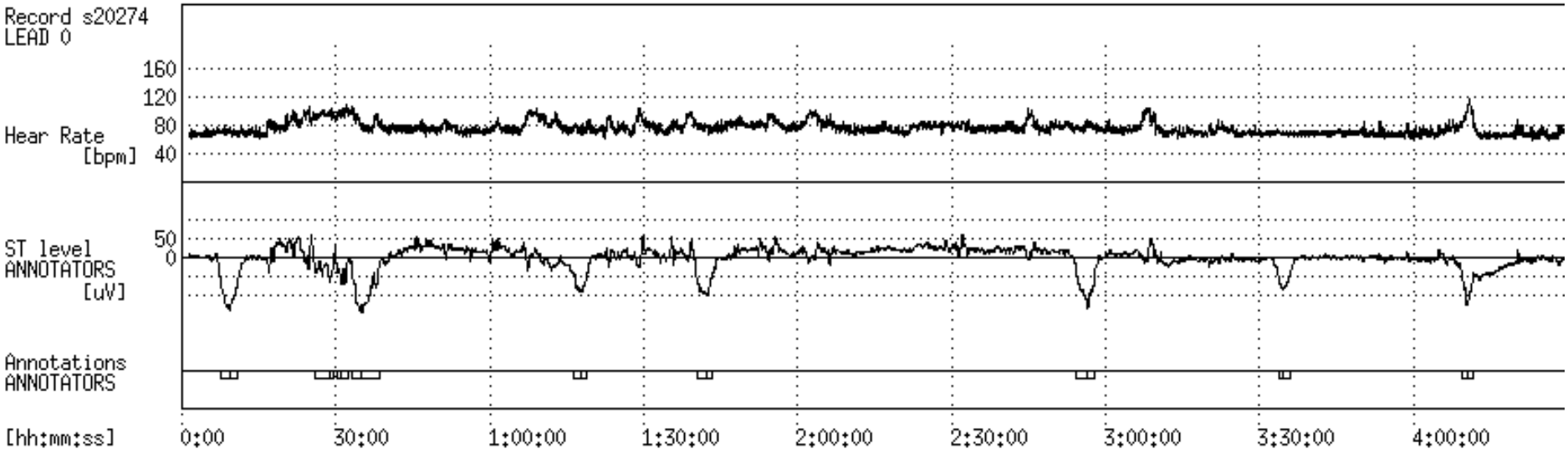
Basic stages of ECG signal processing

- ECG filtering
- *QRS complex detection*
  → (Wave delineation)
- *QRS complex classification*
  → (Rhythm classification)
  → *Ischaemia detection* (*classifying ischaemic events*, detecting transient ischaemic episodes, and their precise beginnings, extrema and ends)



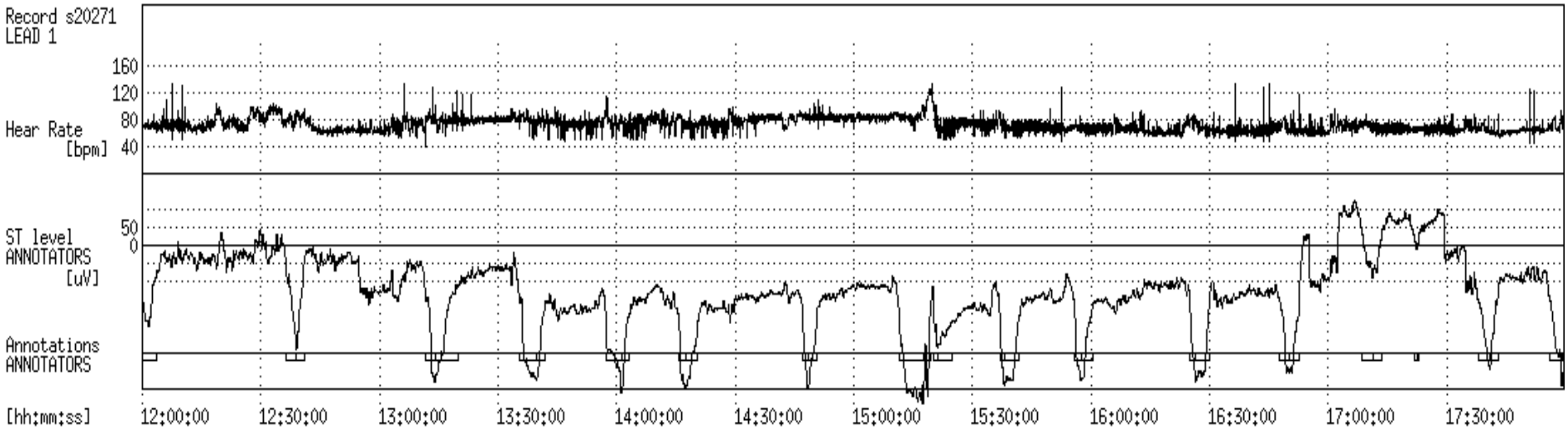
Characteristics of transient ischaemic ST segment episodes

- Transient ischaemic ST segment episodes
  (heart frequency, time course of ST segment level)



Problems of automated ischaemia analysis

- Time-varying reference zero ST segment level (ischaemic episodes and shifts of the mean electrical axis of the heart – body position changes)



(International reference databases)

- To develop and evaluate algorithms and analyzers for:
  QRS complex detection, heart beat classification and rhythm classification:

  - AHA DB (American Heart Association Database, 1980)
  - MIT-BIH DB (Massachusetts Institute of Technology – Beth Israel Hospital Database, 1982

- To develop and evaluate algorithms and analyzers for:
  QRS complex detection, heart beat classification and detecting transient ischaemic episodes:

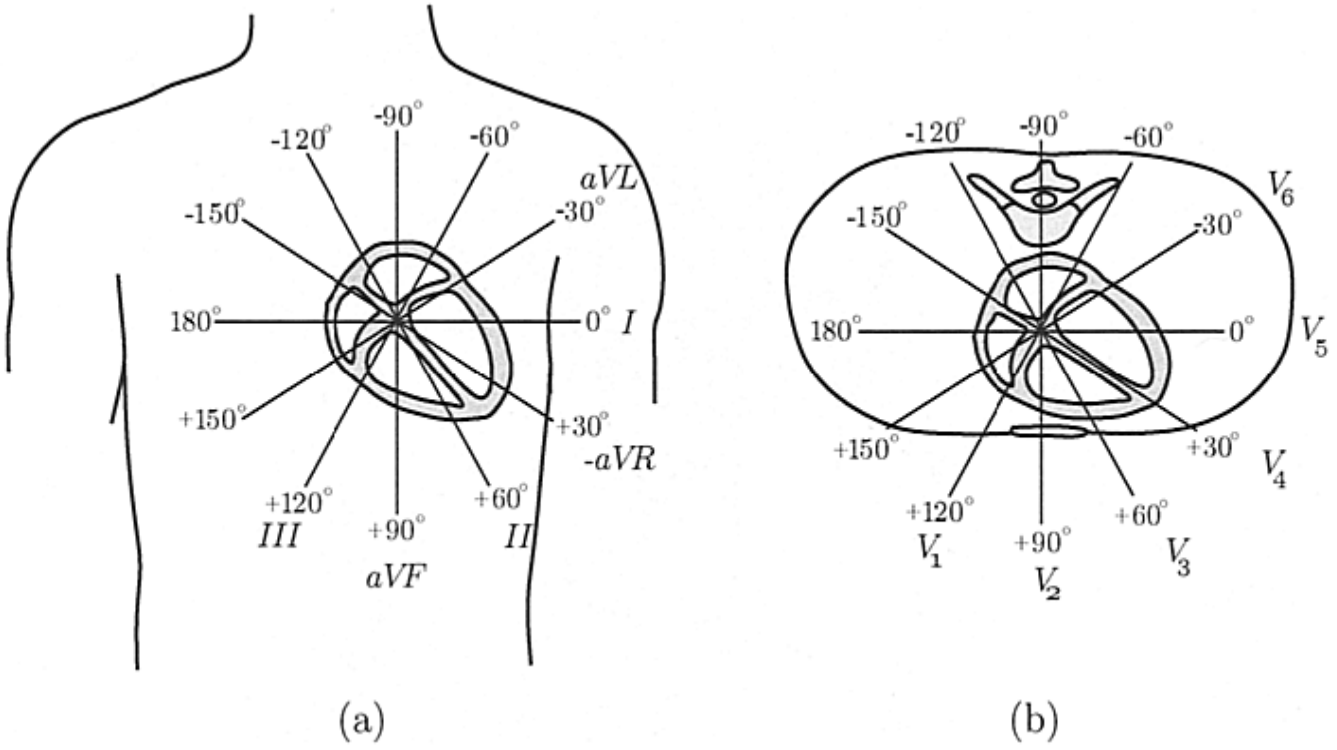
  - ESC DB (European Society of Cardiology ST-T Database, 1992)
  - LTST DB (Long-Term ST Database, 2002)

  http://www.physionet.org

(ECG recording techniques)

- (a) The directions of the bipolar limb leads and the augmented limb leads in the frontal plane.

  (b) The precordial leads are approximately 30º apart in the transversal plane.



(Sornmo, Laguna)