EE 4BD4 Lecture 21

Cardiac Pacing

Electrical Pathways of the Heart

TABLE 8.1 The Function of Autorhythmic (Pacemaker) Cells Is to Initiate and Conduct Action Potentials That Are Responsible for the Contraction of the Heart Muscle Cells[a]

Tissue	Action Potentials per Minute
SA node	60–80
AV node	40–60
Bundle of His	20–40
Purkinje fibers	20–40

[a]Since the sinoatrial node is capable of depolarizing at the highest rate, its activity usually controls the rate of the entire heart.

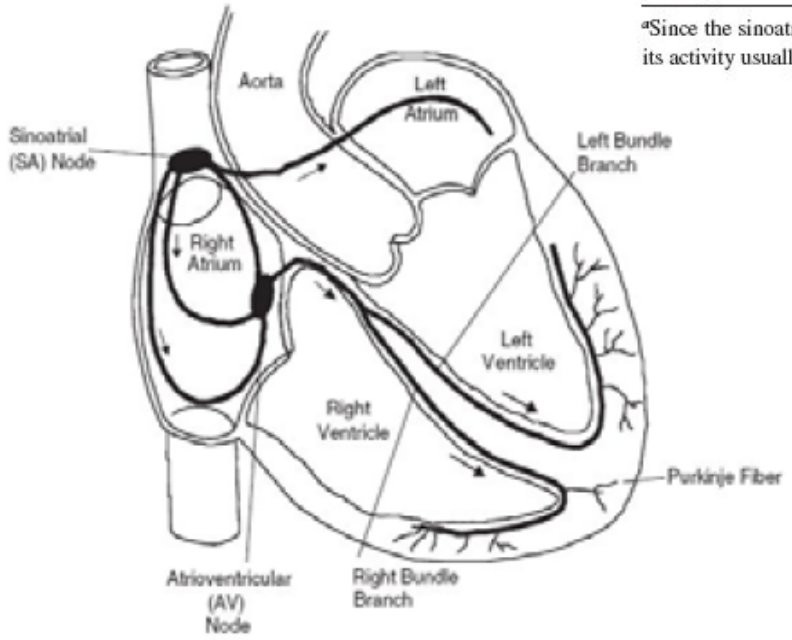
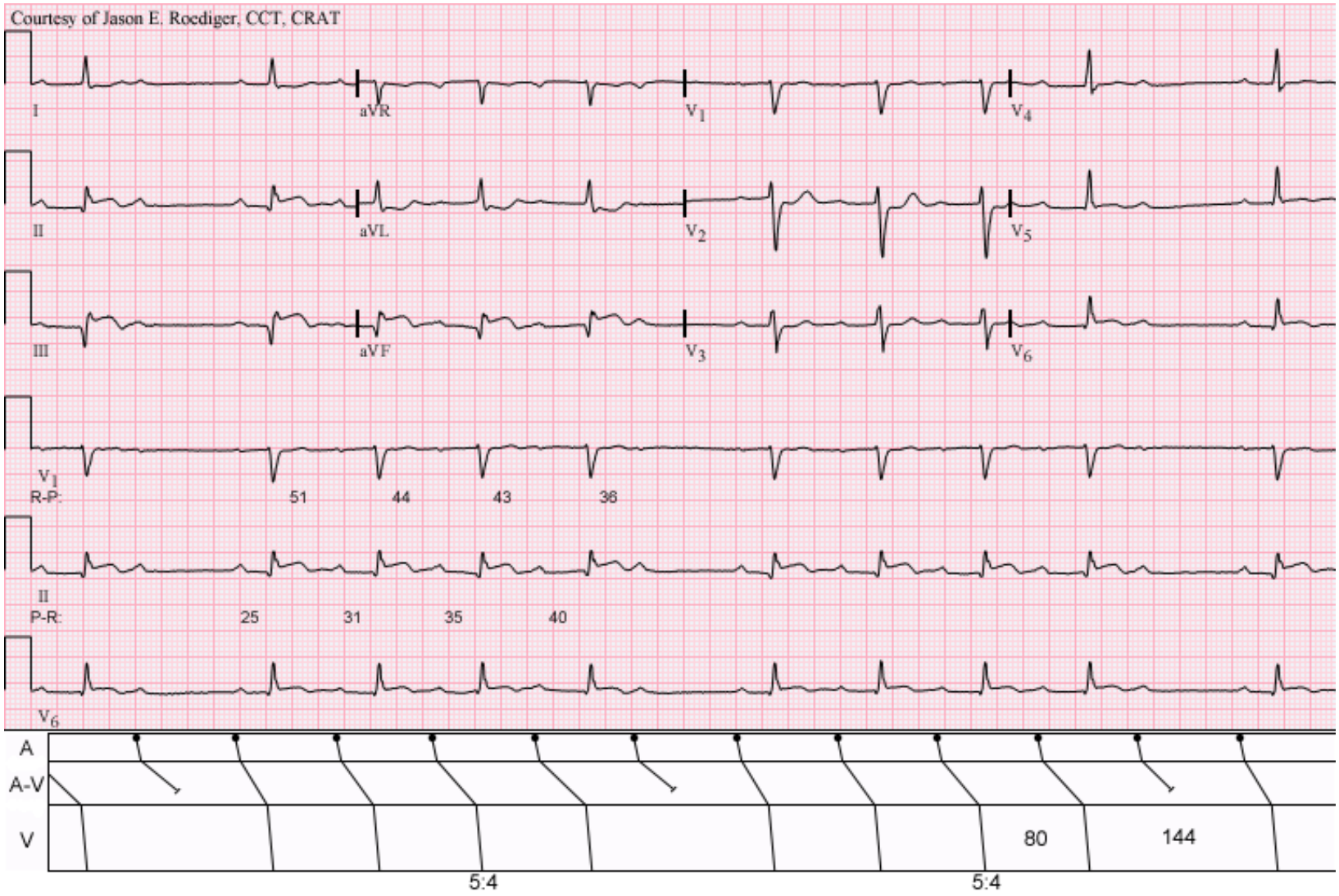


Figure 8.1 The human heart has four chambers, two on the left side and two on the right side. Each side is further divided into a receiving chamber (atrium) and a pumping chamber (ventricle). One-way valves separate the atria from the ventricles. The right side of the heart pumps blood to the lungs (via the pulmonary artery), and the left side pumps blood to the rest of the organs (via the aorta).

AV-Block

- 1st degree
  - Excessive delay through the AV node (>200ms)
    - Normal “delay” : 120 – 200ms
  - No treatment is required

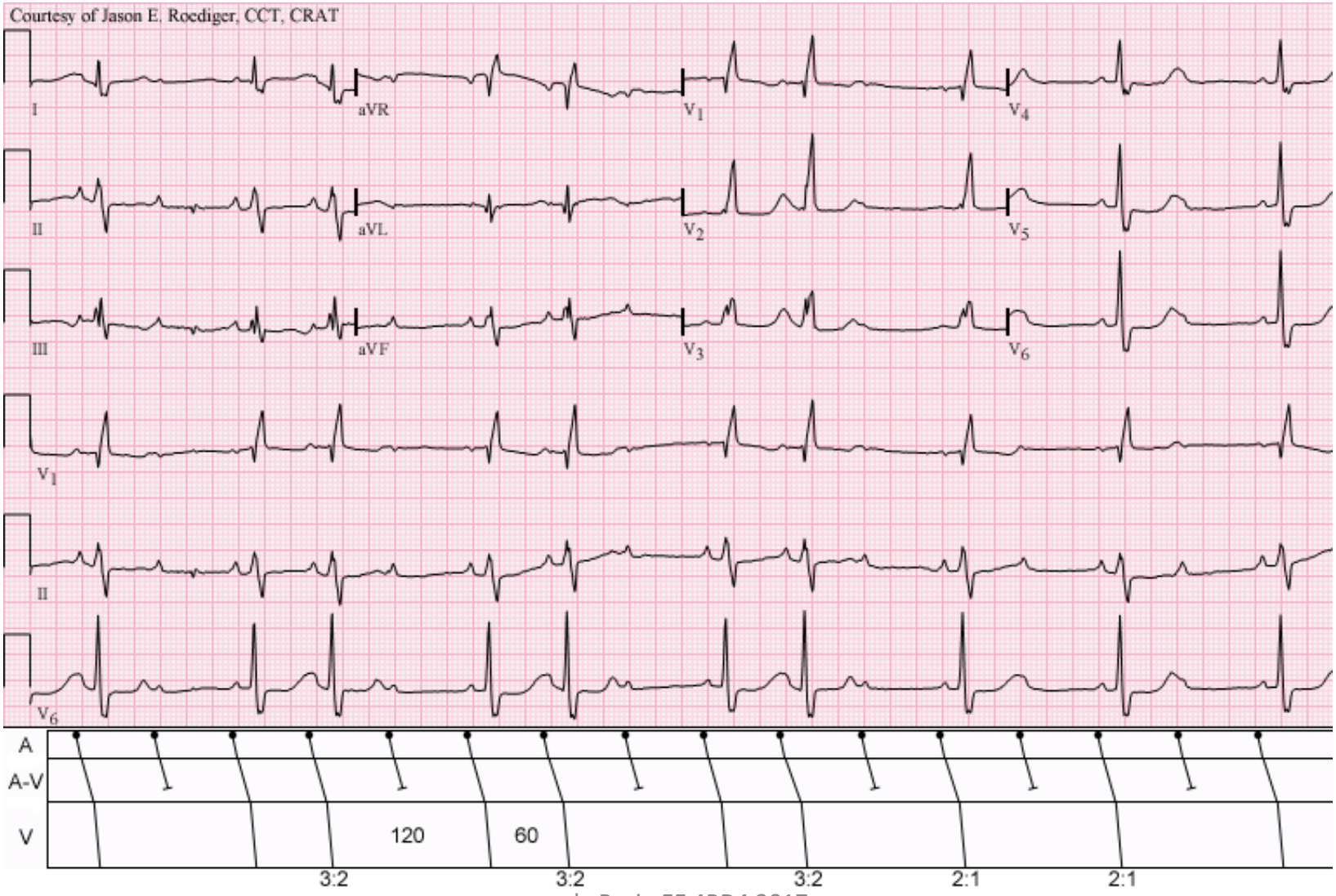
Type I Heart Block



AV-Block

- 2nd degree
  - Some atrial signals fail to pass through the AV node or Bundle of His.
  - Will require a pacemaker if this occurs frequently

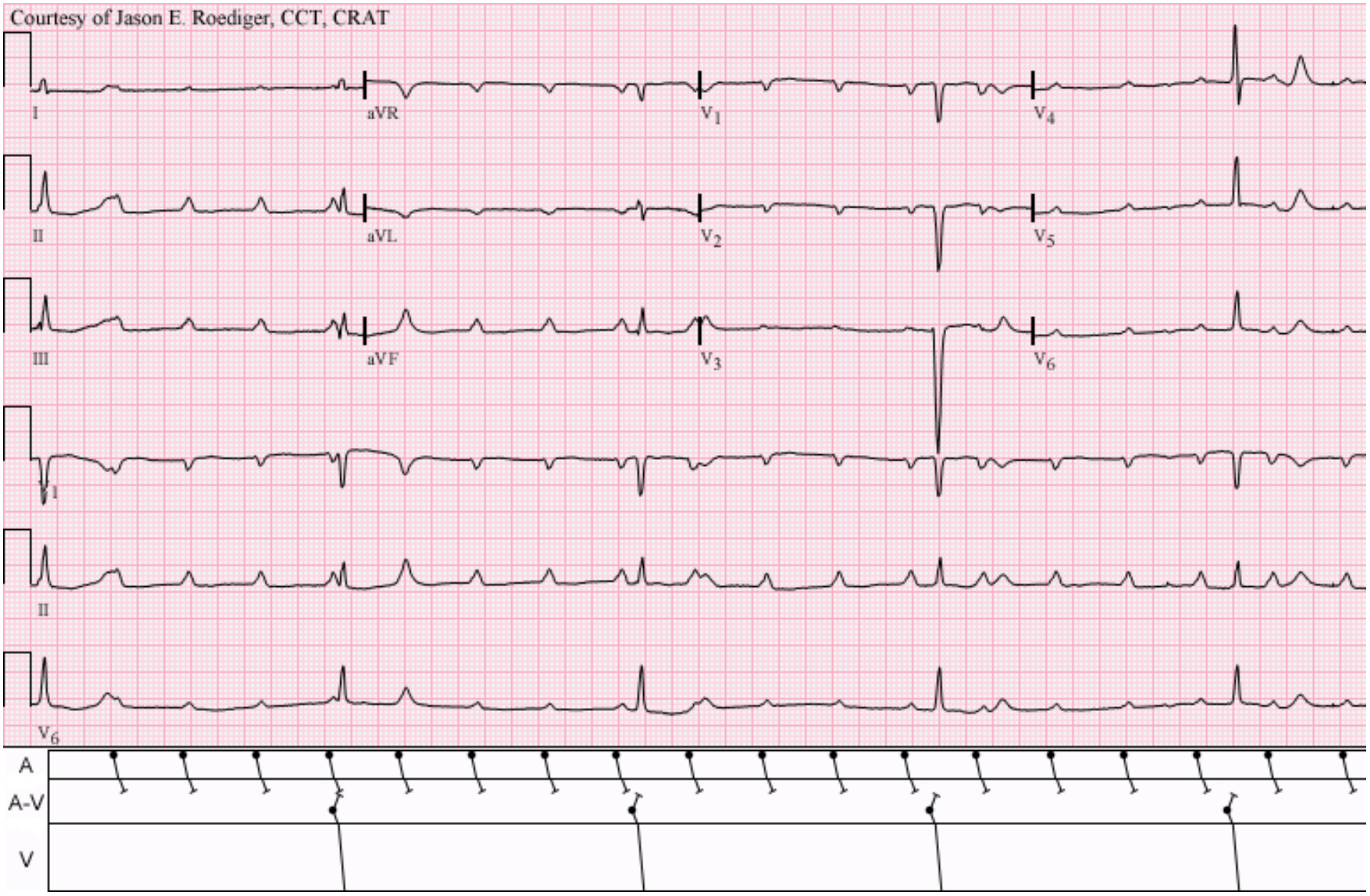
Type 2 Heart Block



AV-Block

- 3rd degree
  - No atrial signals pass through the AV node.
  - The ventricular contraction is initiated by autorythmical cells.
  - Requires a pacemaker

Type 3 Heart Block



History

- 1774 Aldini electrically resuscitated a 3 year old child
- Over next 2 centuries scientists experimented with electrical cardiac stimulation cardiac
- First electrostatic charges and later a-c and d-c currents
- 1932 Alfred Hyman developed the first device to stimulate the heart electronically. Delivered 3 mA pulses directly to heart using needle electrodes
- Coined the term *pacemaker*
- 1947 Beck reported a successful cardiac defibrillation
- 1952 Paul Zoll reported a closed-chest external electrical cardiac pacemaker using surface electrodes, 2 ms pulses, 100-200 mA
- Caused pain and burns

History (cont'd)

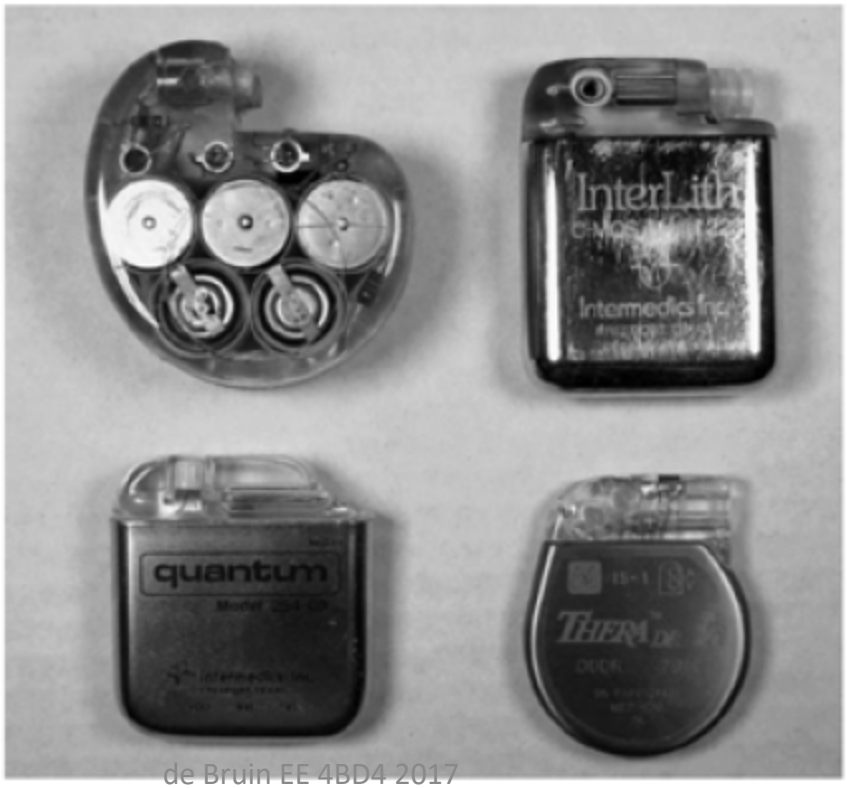
- 1958 – Ake Senning (physician) implanted the first pacemaker in a human.
- Developed by Rune Elmqvist.
- 2V amplitude pulses with 2ms duration.
- The batteries were charged through EM induction.
- First unit worked for few hours. Second unit worked for 6 weeks.

History (cont'd)

- Feb. 2nd 1960 first long-term human implant. Uruguay, Orestes Fiandra and Roberto Rubio.
- Developed also by Elmqvist
- Battery charge over RF link
- One night charging session provided enough energy for one month.
- The unit worked for nine and a half months until the patient died from sepsis caused by an infection.

History (cont'd)

- 1960 Chardack and Greatbach implanted a pacemaker
- Examples:



First Type of Pacemaker Developed

complete heart block only

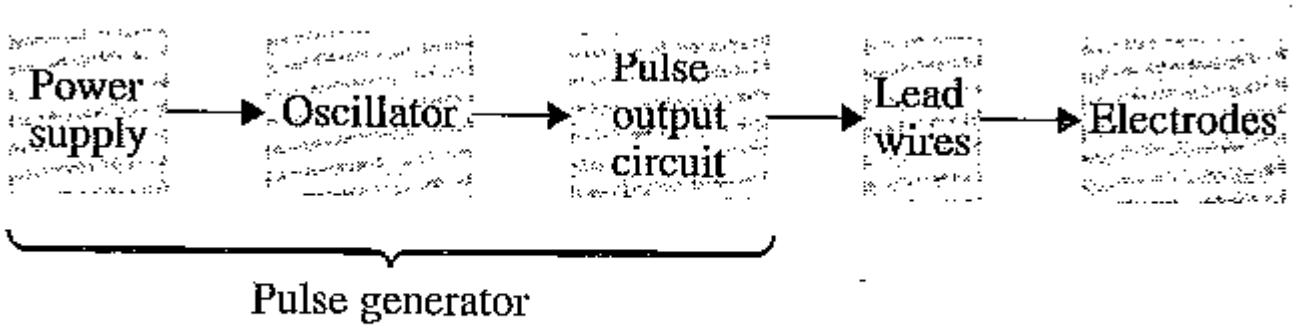
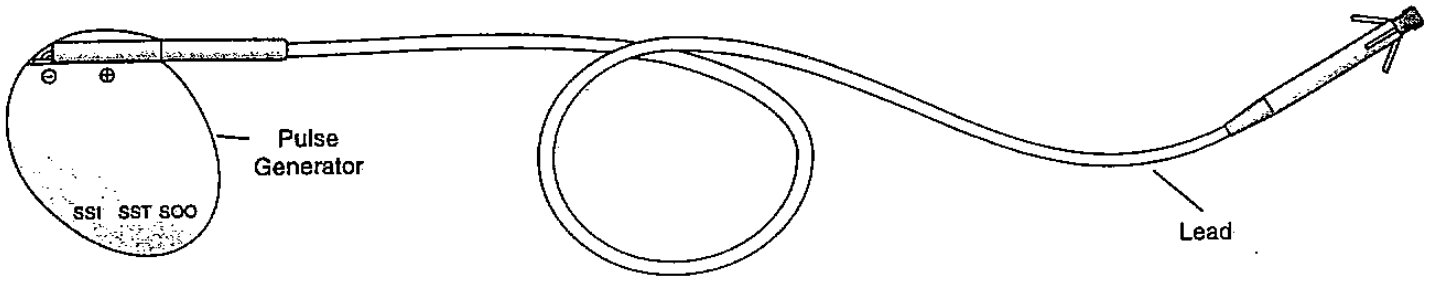


Figure 13.1 Block diagram of an asynchronous cardiac pacemaker



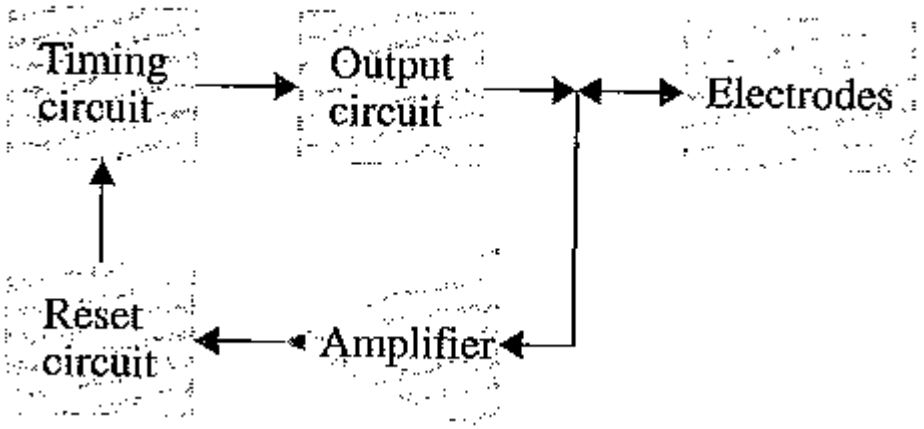
Pacemaker Specifications

- Power supply: lithium type (iodide) long life 5 -10 years (early batteries 2 years max)
- Oscillator: (fixed rate) set at 70 – 90 beats/min
- Output circuit: Constant voltage 5.0 to 5.5, 500 – 600 µs duration; constant current 8 – 10 mA, 1.0 – 1.2 ms
- Lead wires: inter-wound helical coils spring-wire alloy (fatigue resistant) in silicone rubber or polyurethane cylinder
- Electrodes: unipolar or bipolar (unipolar return electrode on case) platinum alloys such as platinum iridium (biocompatible and inert)

Demand Inhibit (synchronous)

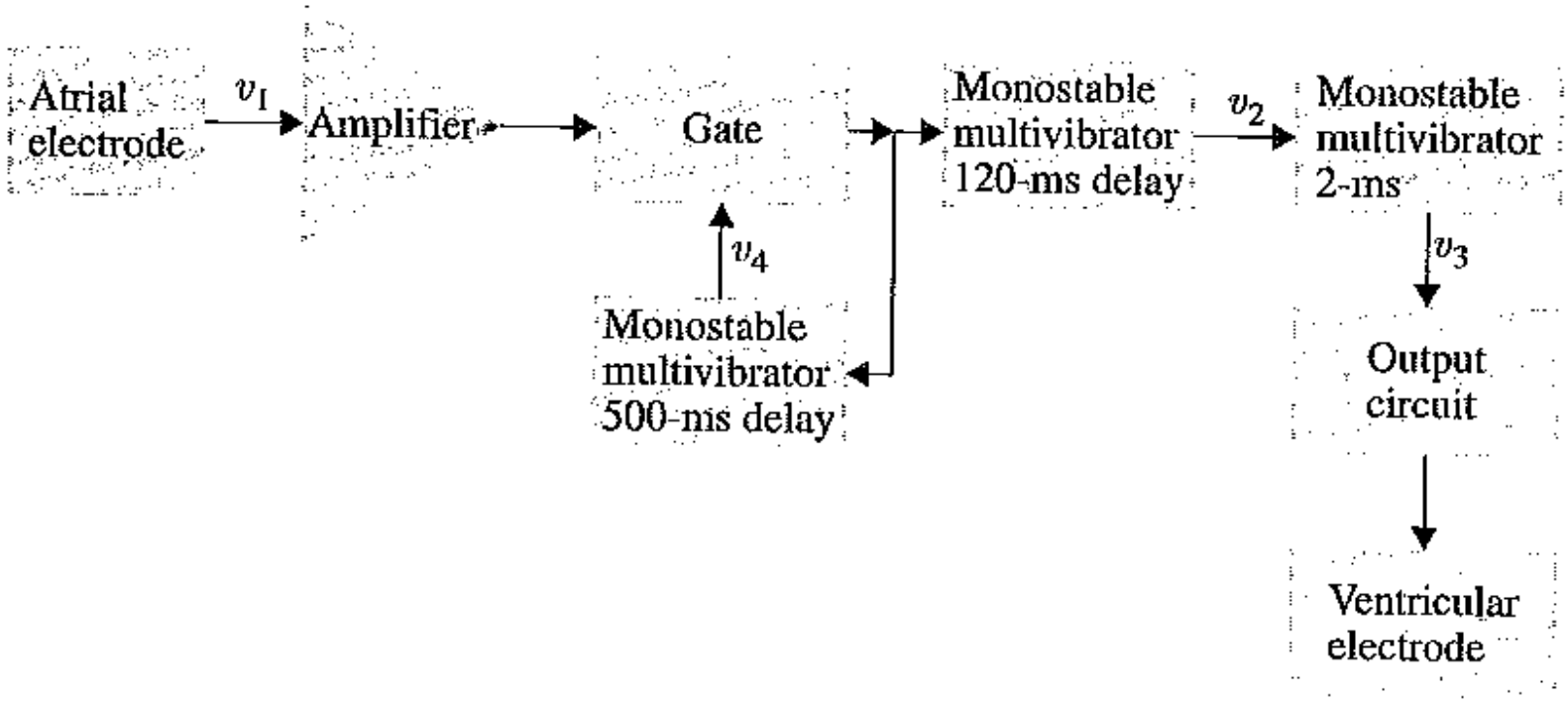
incomplete heart block

- Most current single lead types (avoids stimulating during naturally occurring T-wave to avoid sending heart into fibrillation)
- Saves energy since pulse sent out only when needed
- Stimulating electrode senses QRS and resets timer
- Rest of circuit same as asynchronous



Atrial Synchronous

- Assumes SA node functional
- 120 ms delay allows ventricles to fill during atrial contraction



Activity or Demand Responsive Pacemakers

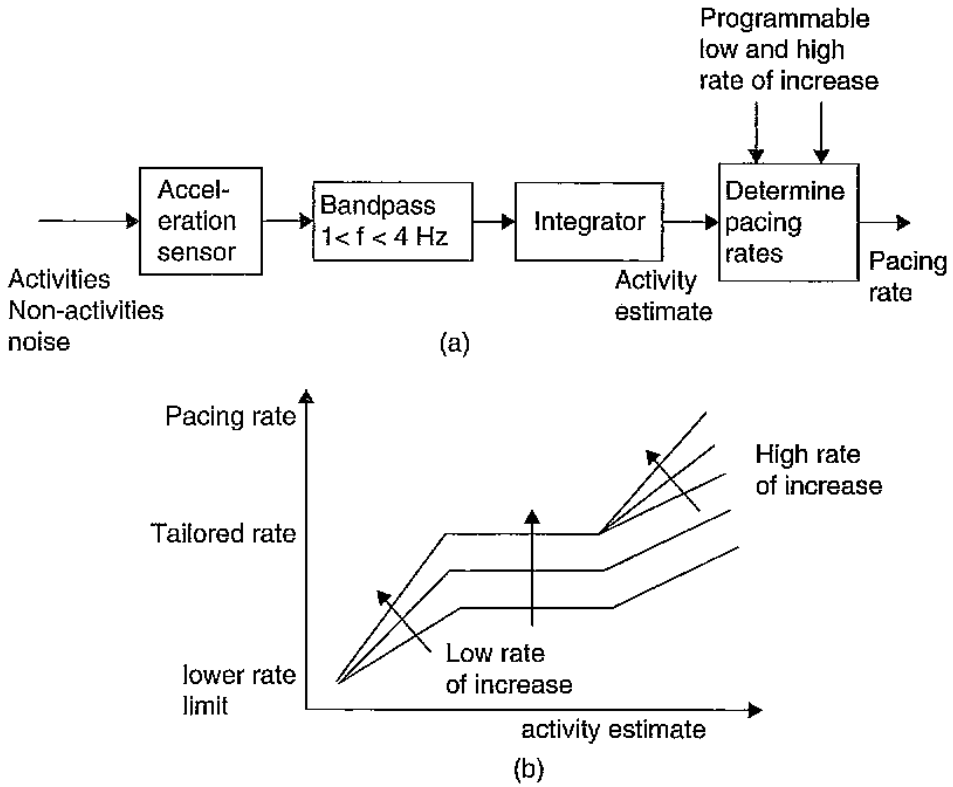


Figure 13.5 (a) The signal from an acceleration sensor within the rate-responsive pacemaker is bandpass filtered to minimize noise, then rectified and low-pass filtered to yield the activity estimate. (b) The physician selects a programmable curve that has a more sensitive acceleration and/or pacing-rate relationship during low and high levels of activity, with a less sensitive intermediate slope to maintain stability during ordinary workloads. [From Webster (1995).].

Temporary External Pacemakres

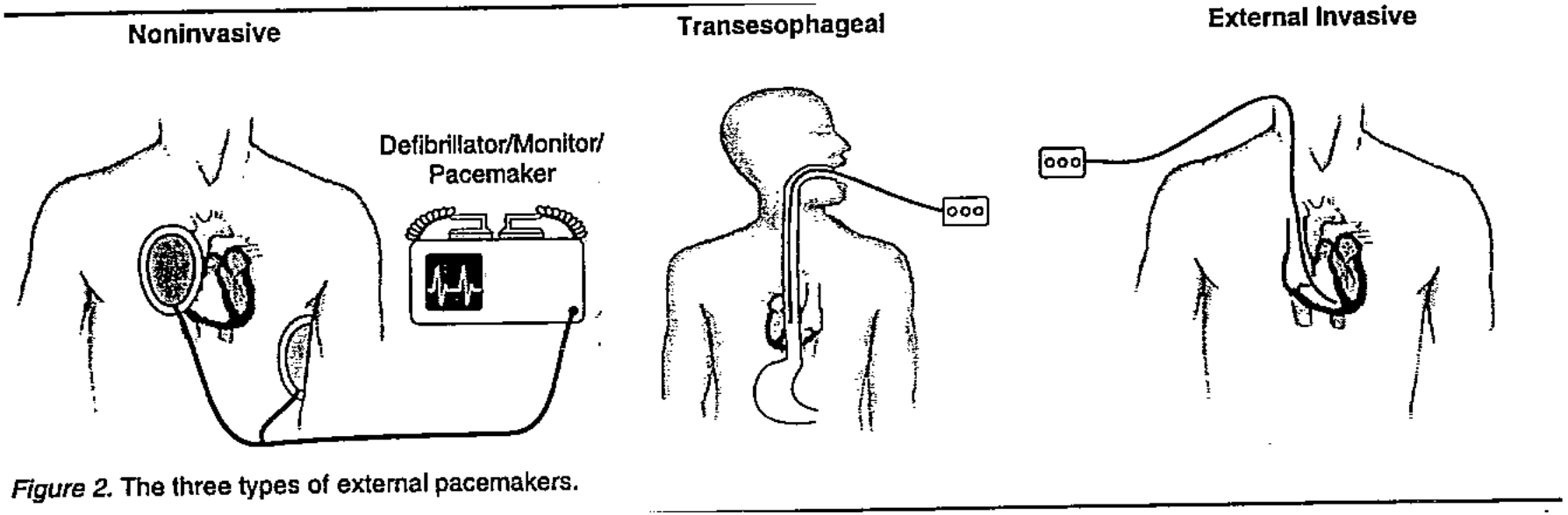


Figure 2. The three types of external pacemakers.

Lead Placements

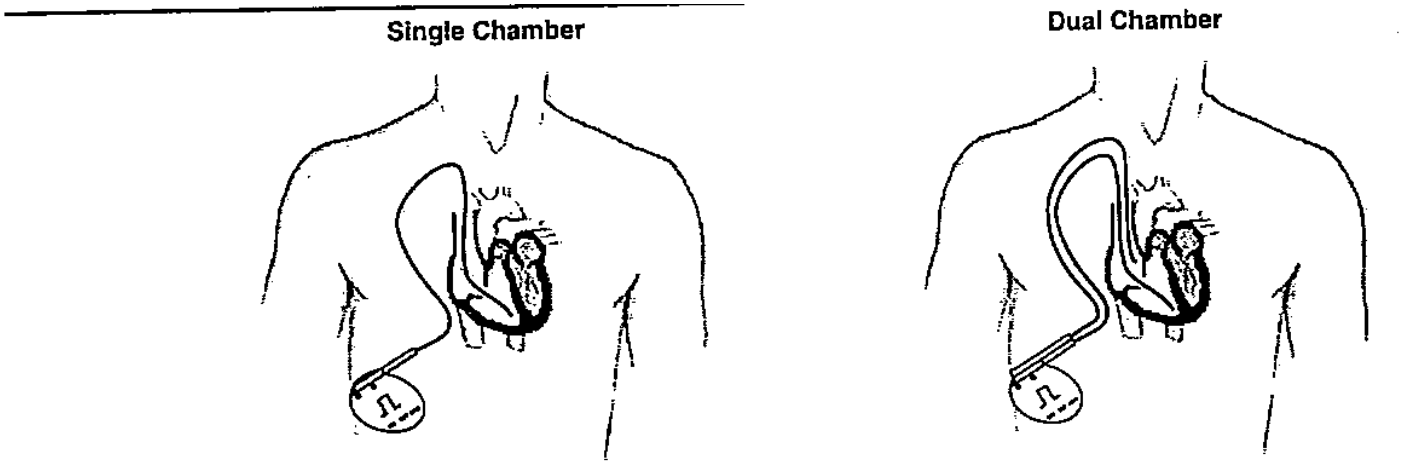


Figure 3. Single-chamber and dual-chamber pacemakers.

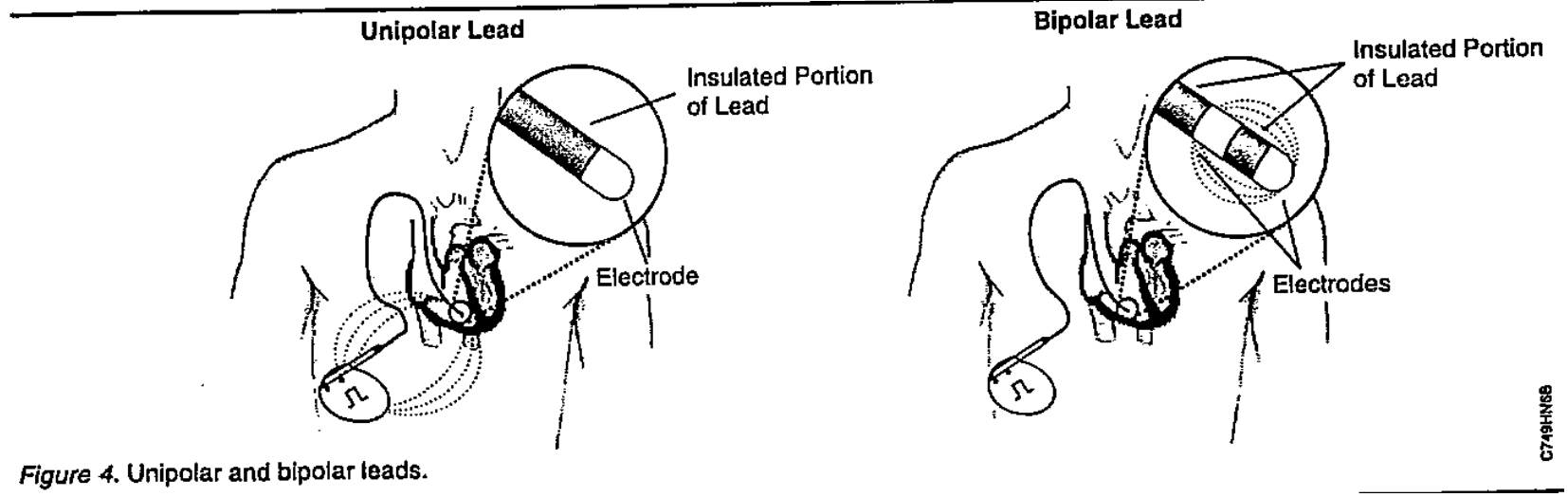


Figure 4. Unipolar and bipolar leads.