Pacemakers

Sotiris Papaspyros 2009

Contents

- History.
- Indications.
- Physiological conduction pathway.
- Basic pacemaker parameters.
- Pacemaker setup.
- Common scenarios in cardiac surgery.

Definition

- An electronic device which generates and transmits an electrical signal to the atria, ventricles or both.

- Temporary
- Permanent
- Single chamber
- Two chamber (sequential)

History

- 1889 J A McWilliam reported in the British Medical Journal of his experiments
- 1926 Albert Hyman the first true external artificial pacemaker.[
- 1928 anaesthetist Mark Lidwell devised a device which "ran on alternating current and required a needle to be inserted into the patient's ventricle".
- 1950 An external pacemaker was designed and built by the Canadian electrical engineer John Hopps based upon observations by cardio-thoracic surgeon Wilfred Bigelow at Toronto General Hospital .
- 1957 engineer Earl Bakken of Minneapolis, Minnesota, produced the first wearable external pacemaker for a patient of Dr. C. Walton Lillehei.
- 1958 The first implantation into a human at the Karolinska University Hospital in Solna, Sweden,
- 1960 following extensive animal testing, implantable pacemakers constructed by the American Wilson Greatbatch entered use in humans mercury battery as the energy source

Pre 1957 console cardiac pacemaker





1st pacemaker 1957

arl Elmer Bakken, Founded Medtronic




The Saturday
Evening
POST

2006 external pacing box

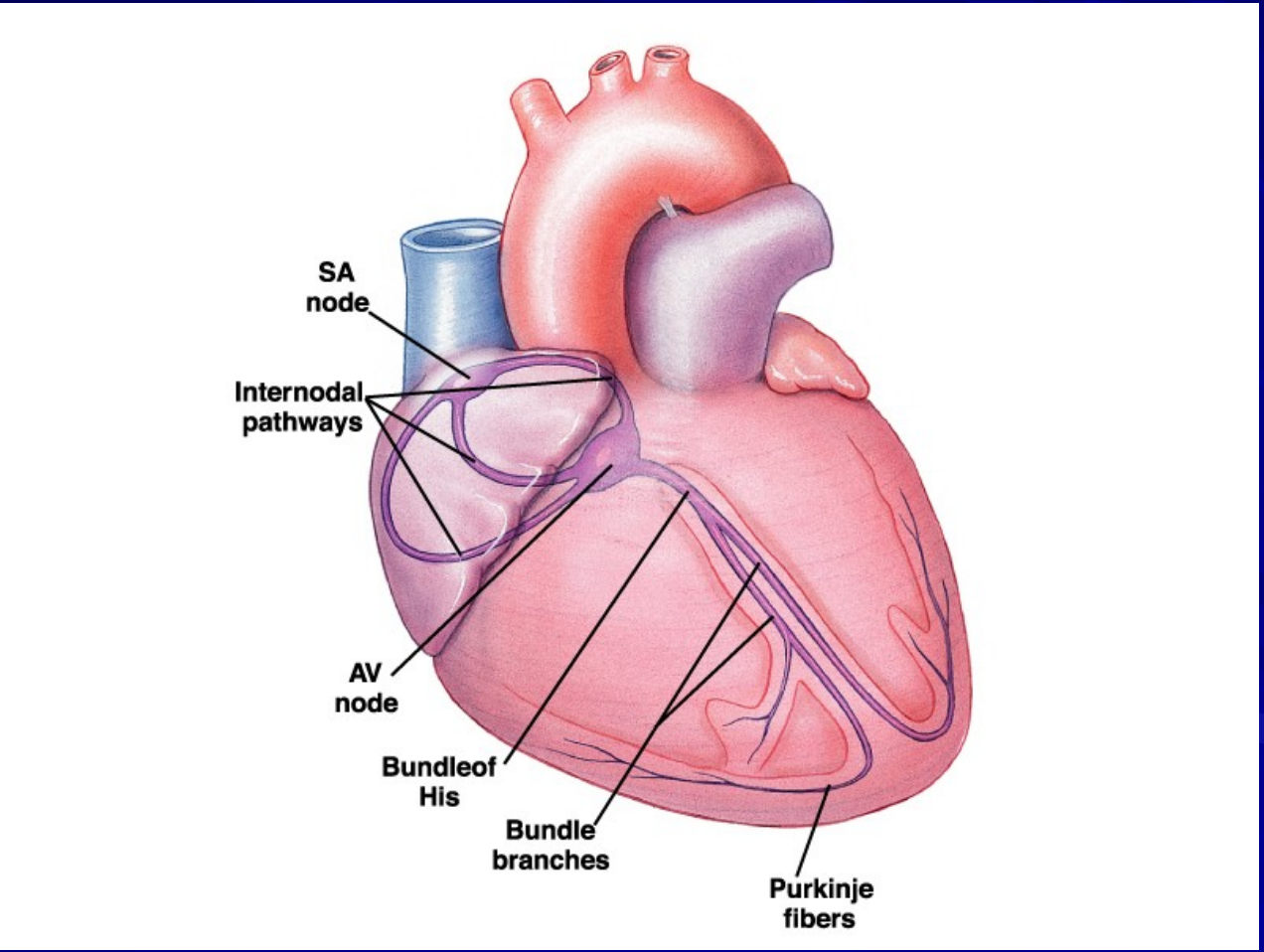


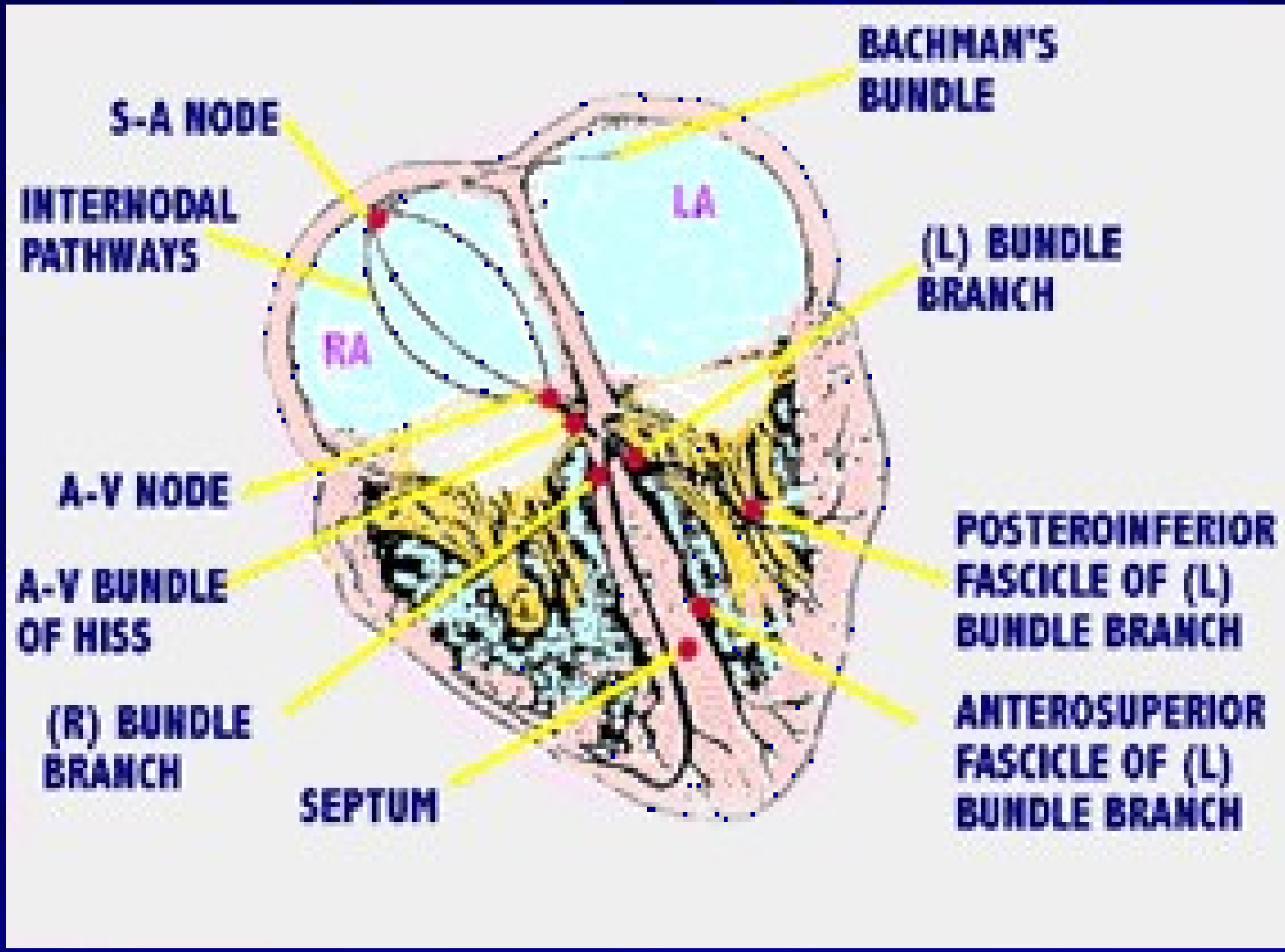


Indications for pacing

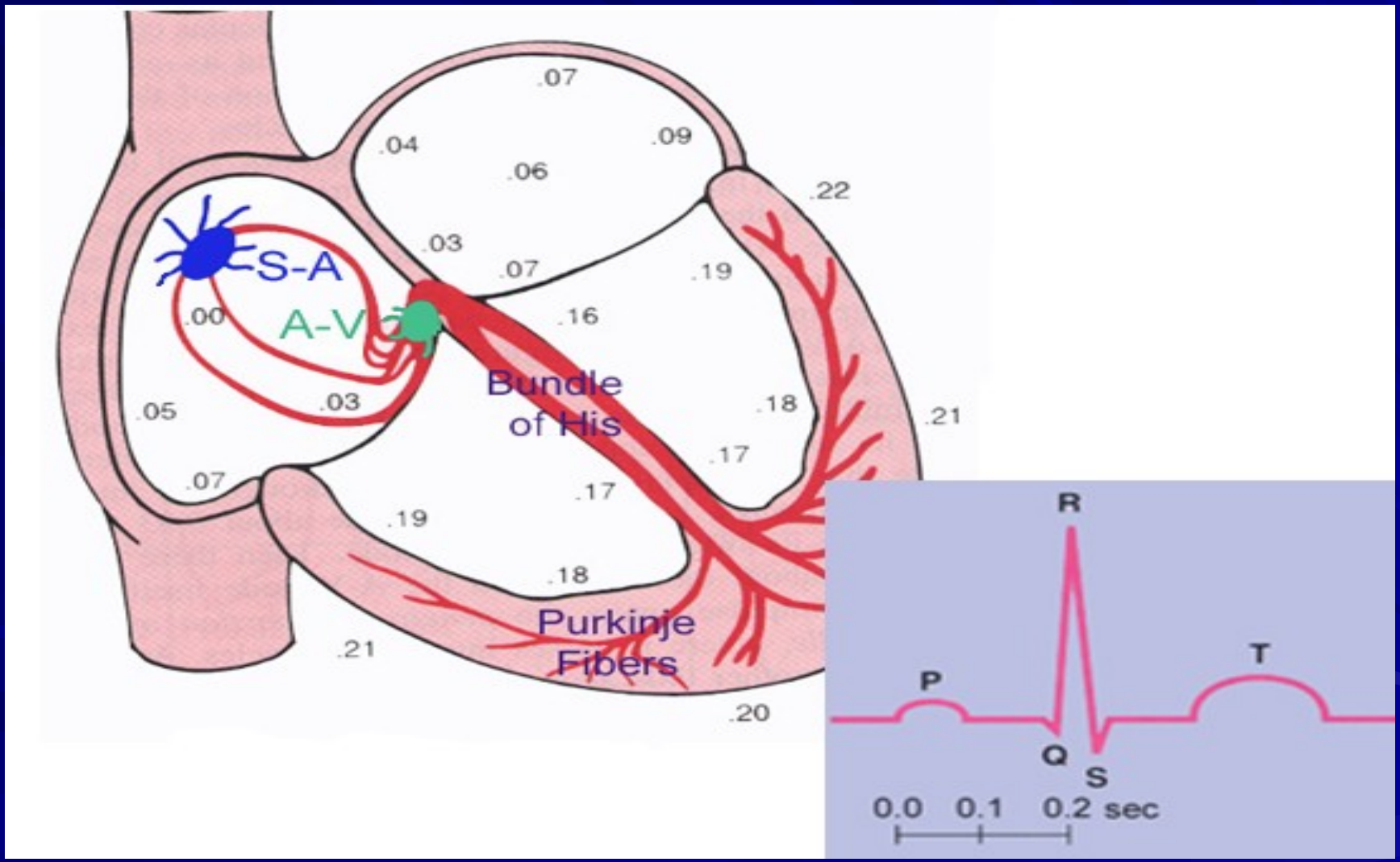
- Atrial pacing
  - Sinus bradycardia or desire to increase sinus rate to a higher level
  - Junctional bradycardia.
  - Suppression of atrial and ventricular ectopics: set at a rate slightly faster than the sinus mechanism.
  - Slow junctional rhythm.
  - Supraventricular tachycardias and flutter - Overdrive pacing:Rapid atrial pacing can interrupt a reentrant circuit and convert it to sinus rhythm or AF, which may terminate spontaneously.
- Ventricular
  - Slow ventricular response to AF/Flutter
  - Failure of atrial pacing to maintain heart rate
  - Ventricular Tachycardia - overdrive pacing
- AV pacing
  - Complete heart block
  - First and second-degree heart block if ventricular rate is slow to achieve 1:1 conduction
  - Sequential AV pacing is innefective during AF/flutter

Conduction pathways

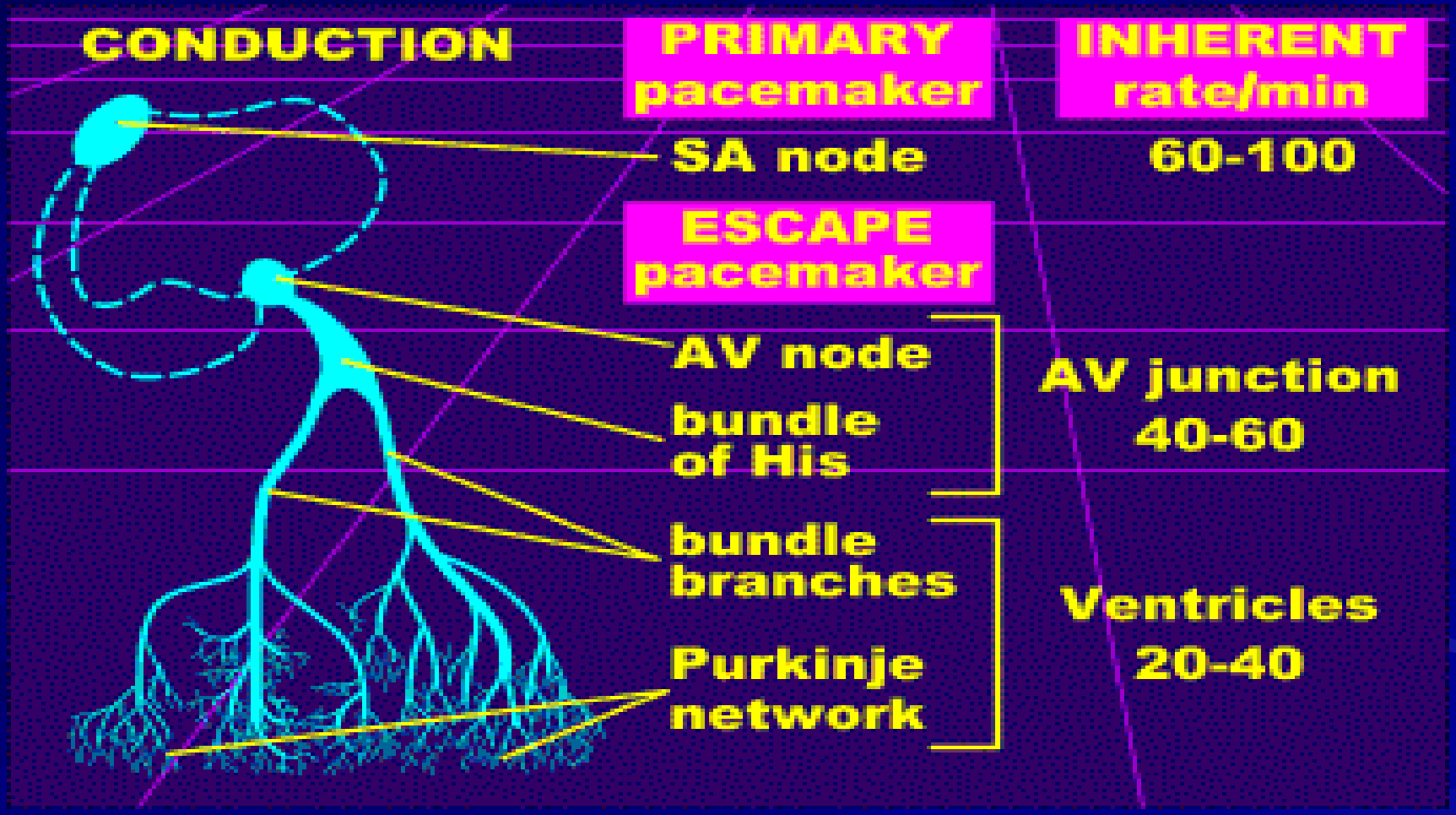



BACHMAN'S BUNDLE
S-A NODE
INTERNODAL PATHWAYS
LA
(L) BUNDLE BRANCH
RA
A-V NODE
POSTEROINFERIOR FASCICLE OF (L) BUNDLE BRANCH
A-V BUNDLE OF HISS
(R) BUNDLE BRANCH
ANTEROSUPERIOR FASCICLE OF (L) BUNDLE BRANCH
SEPTUM

Conduction velocities



Inherent rates

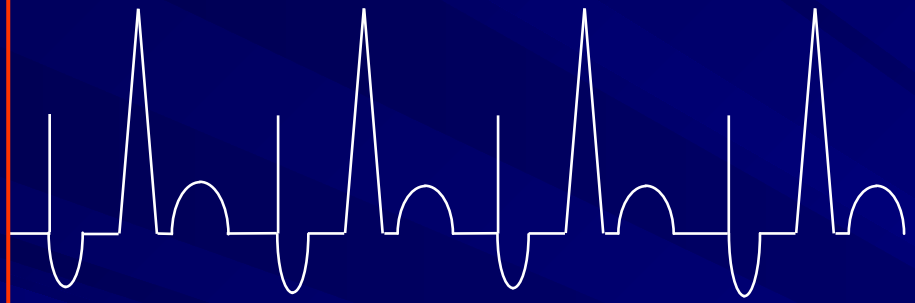


Capture

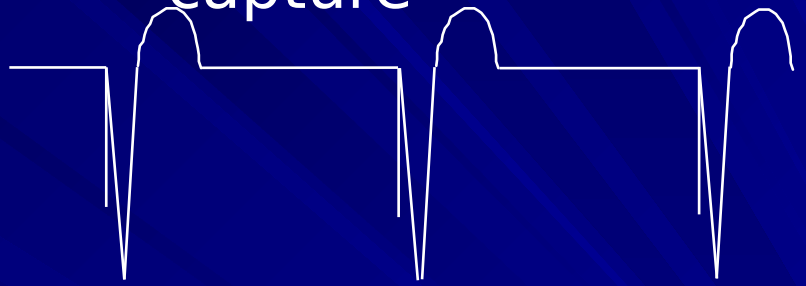
The depolarization and resultant contraction of the Atria or Ventricles in response to an electrical stimulus emitted by a pacemaker.

One-to-one capture occurs when each electrical stimulus causes a corresponding depolarization and resultant cardiac contraction.

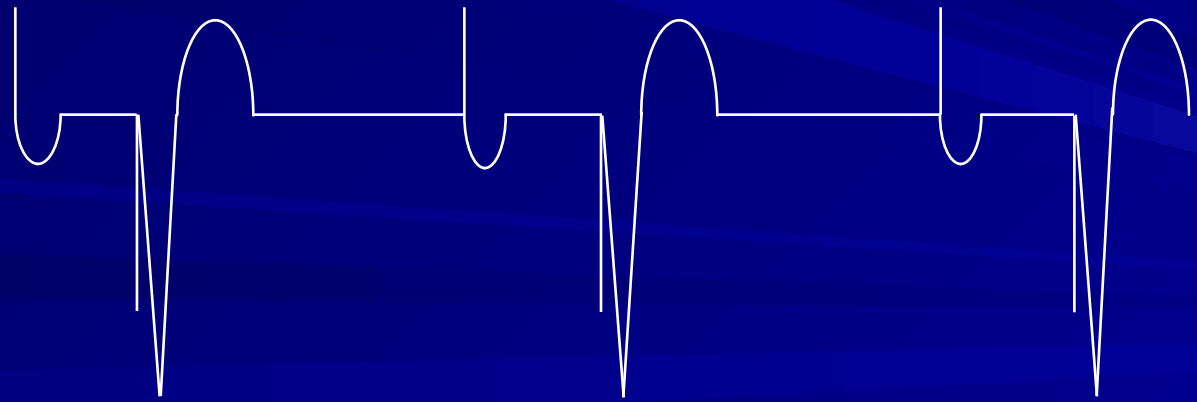
Atrial Capture



Ventricular capture



Atrial + Ventricular Capture



Threshold

- Stimulation Threshold - The minimum amount of electrical energy that consistently produces a depolarisation and resultant contraction.
  - Can be expressed in terms of amplitude (milliamperes or volts), pulse duration (milliseconds), charge (microcoulombs), or energy (microjoules).

What affects threshold

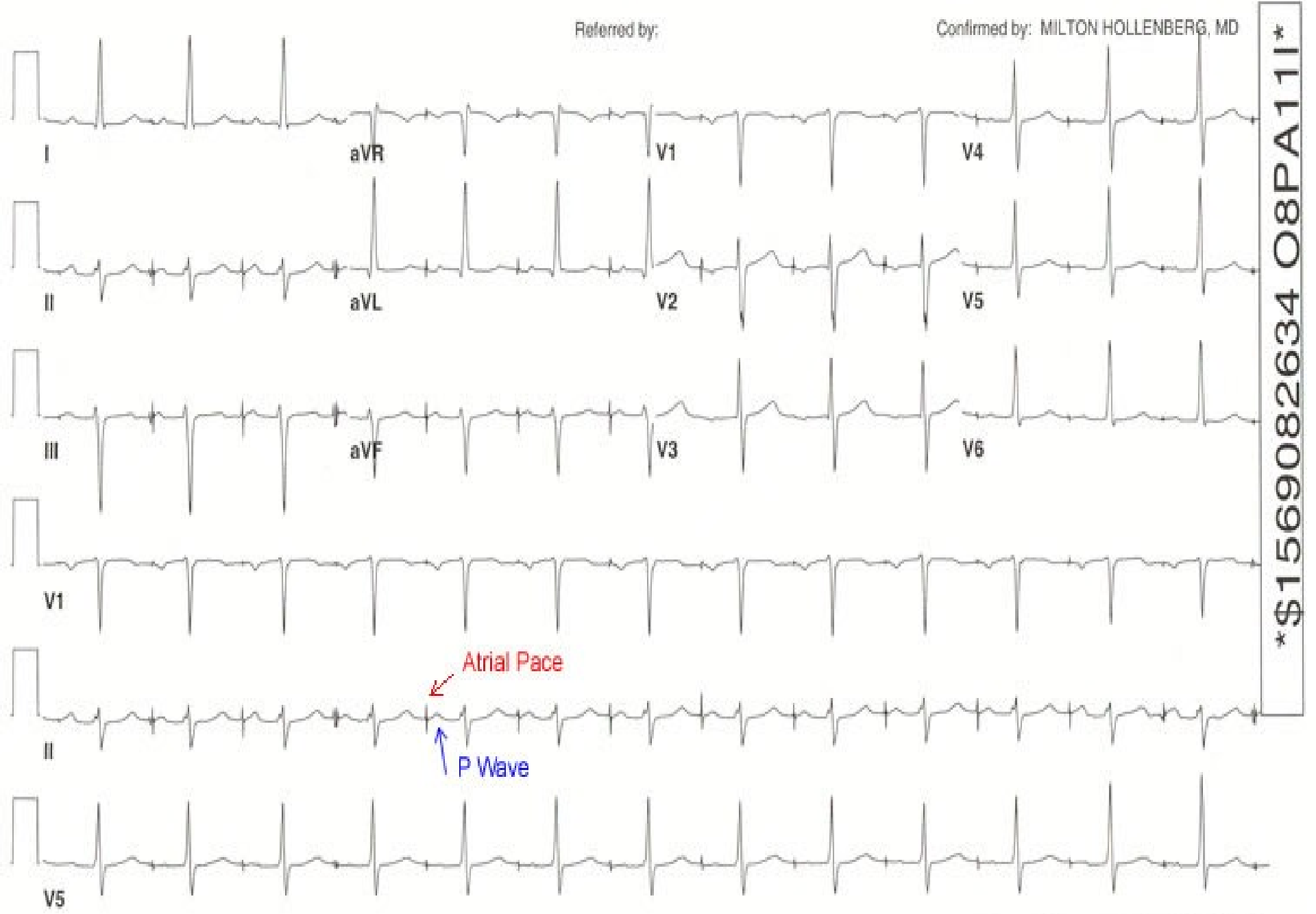
- Increase:
  - Bretyllium, sotalol, possibly lidocaine, B blockers, procainamide, quinidine, verapamil
  - Hyperkalemia, acidosis/alkalosis, hypoxemia, cardioversion/defibrillation
- Decreases:
  - Atropine, catecholamines, glucocorticoids, myxedema, hyperglycemia
- No proven effect- amiodarone, anesthetics

Sensing

- Definition: The ability of the pacemaker to sense an intrinsic electrical signal. Sensing is dependent upon the amplitude and frequency of the signal.

- The sensitivity setting of the pacemaker indicates the minimum intracardiac signal required by the pacemaker to initiate the pacemaker response (inhibited or triggered).

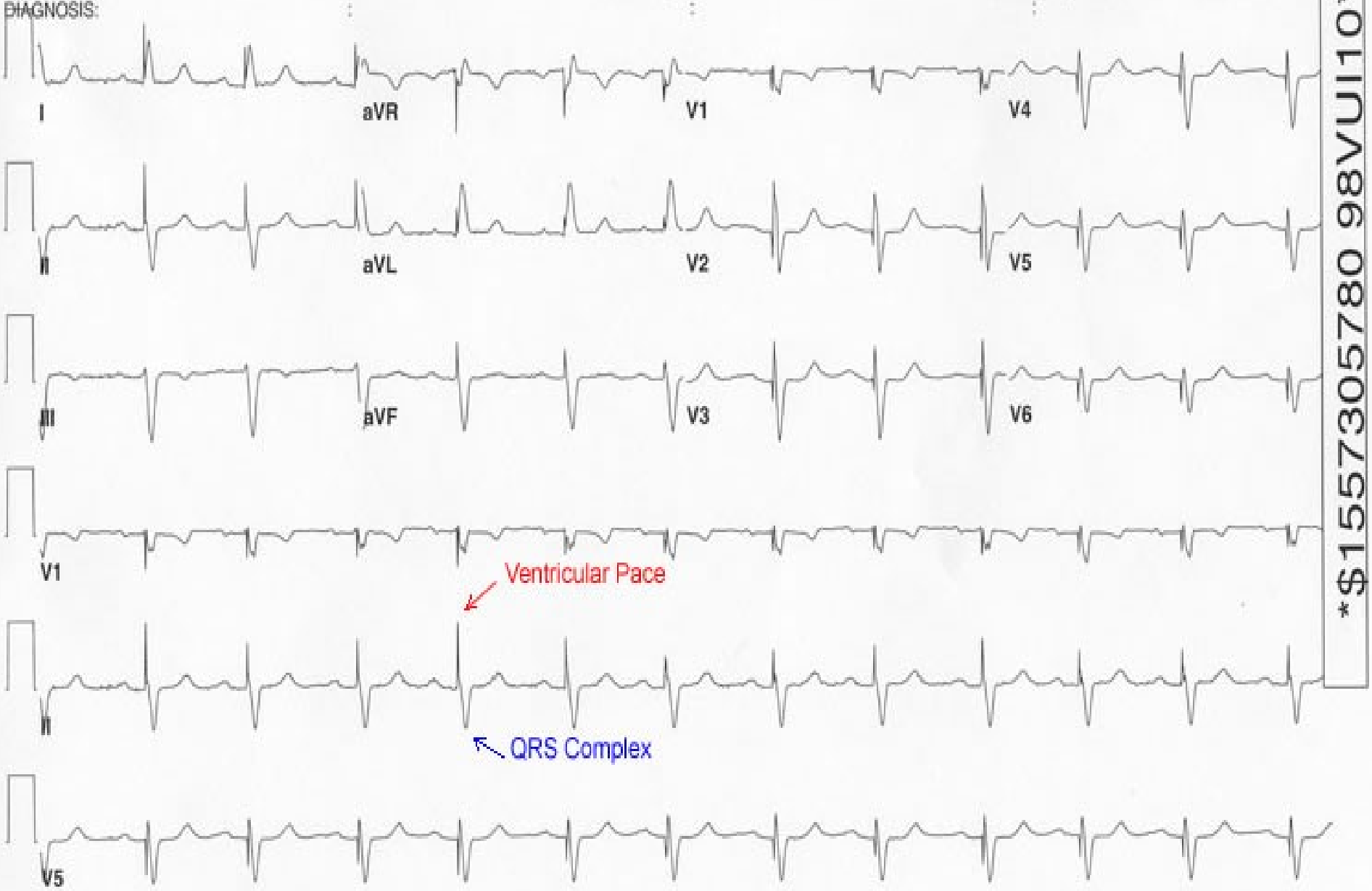
I	II	III	IV	V
Chamber paced	Chamber sensed	Response to Sensation	Extra Options	Cardioverting Options
A= atrium	A= atrium	T= triggers*	P= programmable	P= pacing
V= ventricle	V= ventricle	I= inhibits**	M=multiprogrammable	S= shocking
D= dual (A+V)	D= dual (A+V)	D= dual (T+I)	C= communicating	D= dual (P+S)
	O= none	O= none	R=rate adaptation O= none	O= none


Referred by:
Confirmed by: MILTON HOLLENBERG, MD
$1569082634 O8PA111
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
Atrial Pace
II
P Wave
V5
25mm/s 10mm/mV 150Hz 005B 12SL250 CID: 15
EID:69 EDT: 06:42 25-OCT-2000 ORDER:

Referred by:

Confirmed by: PAUL SIMPSON, MD

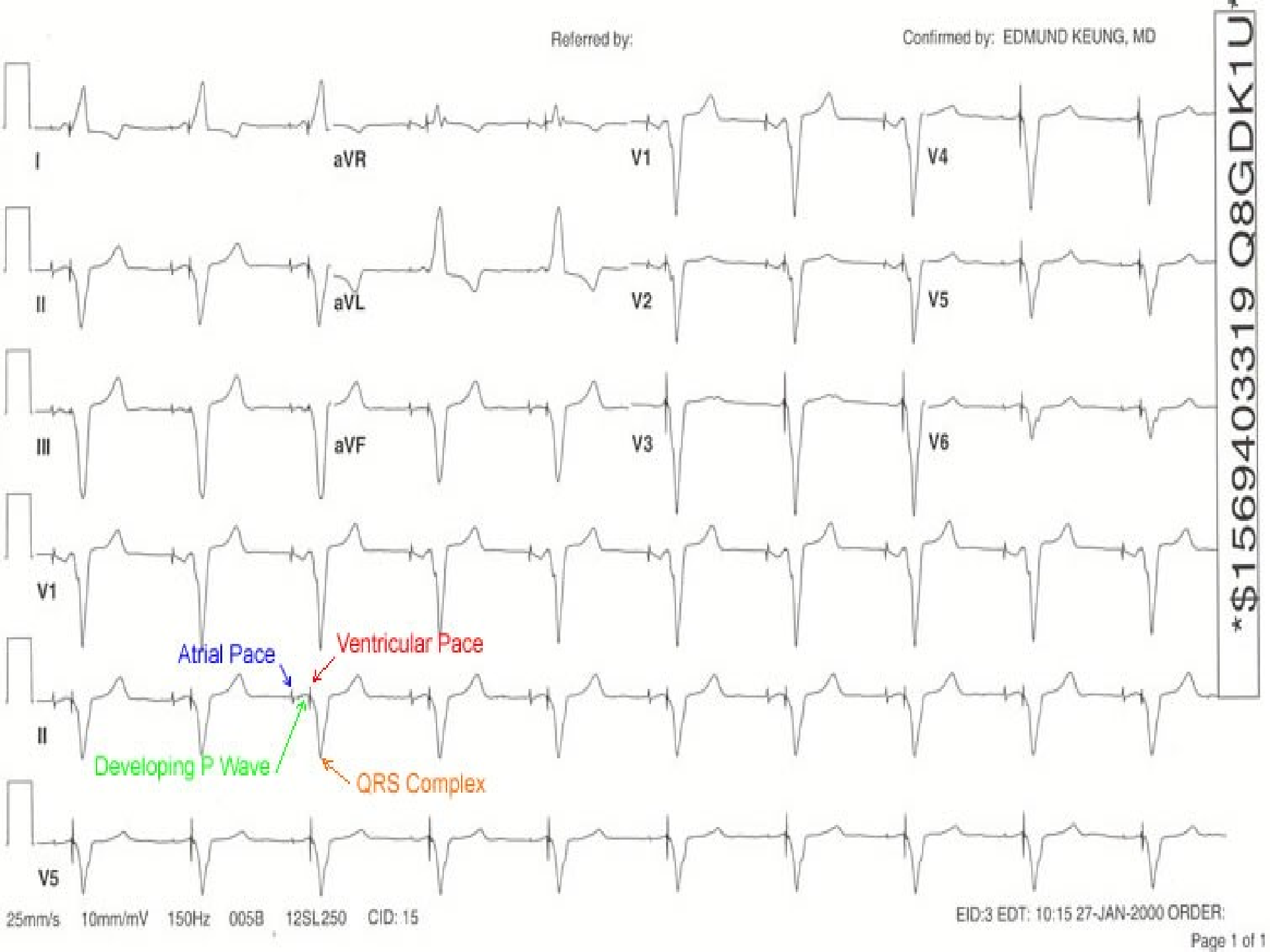
DIAGNOSIS:



$155730578098VU10

25mm/s 10mm/mV 150Hz 005B 12SL250 CID: 33

EID:3 EDT: 10:57 11-APR-2001 ORDER:


Referred by:
Confirmed by: EDMUND KEUNG, MD
$1569403319 Q8GDK1U
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
V1
Atrial Pace
Ventricular Pace
II
Developing P Wave
QRS Complex
V5
25mm/s 10mm/mV 150Hz 005B 12SL250 CID: 15
EID:3 EDT: 10:15 27-JAN-2000 ORDER:
Page 1 of 1

Pacemaker setup

1. Rate
2. AV delay
3. Mode (On-Off switch)
4. Adjust atrial sensitivity
5. Adjust atrial threshold
6. Repeat for ventricles

Adjust sensitivity

1. Set pacemaker rate < patient's rate.
2. Set threshold to zero.
3. Start with lowest sensitivity and increase until green light stops flashing and orange light starts flashing.
4. Set sensitivity lower than the detected point.

Adjust threshold

1. Sensitivity adjusted.
2. Set pacemaker rate > patient's rate.
3. Start with low threshold and increase until you see capturing on the monitor (patient's rate changes to the pacemaker rate).
4. Set the threshold 1.5mV higher (safety margin).

Common scenarios

- Bradycardia
- Asystole

- Atrial Fibrillation with slow ventricular response

Potential problems with epicardial pacing wires.

- Failure to function
  - Check connections, change lead, change pacemaker
  - Increase output
  - Reverse polarity
  - Unipolarise pacemaker
  - Use chronotrope
  - Transvenous pacing wire
- Change in threshold
- Competition with patient's rhythm (ectopics), switch off
- Oversensing (AF), change to V V I mode
- Mediastinal bleeding
- Inability to remove wires.

Questions ?


DIFF. A INDIFF.
INDIFF. V DIFF.
BAT.-INDICATOR
RATE
ppm
MODE
AV DEL.
ms
ATRIUM
SENS. STIM.
mV V
SENSE
PACE
VENTRICLE
SENS. STIM.
mV V
SENSE
PACE
EDP 30/S
BIFOCAL
BIOTRONIK
WARD 4