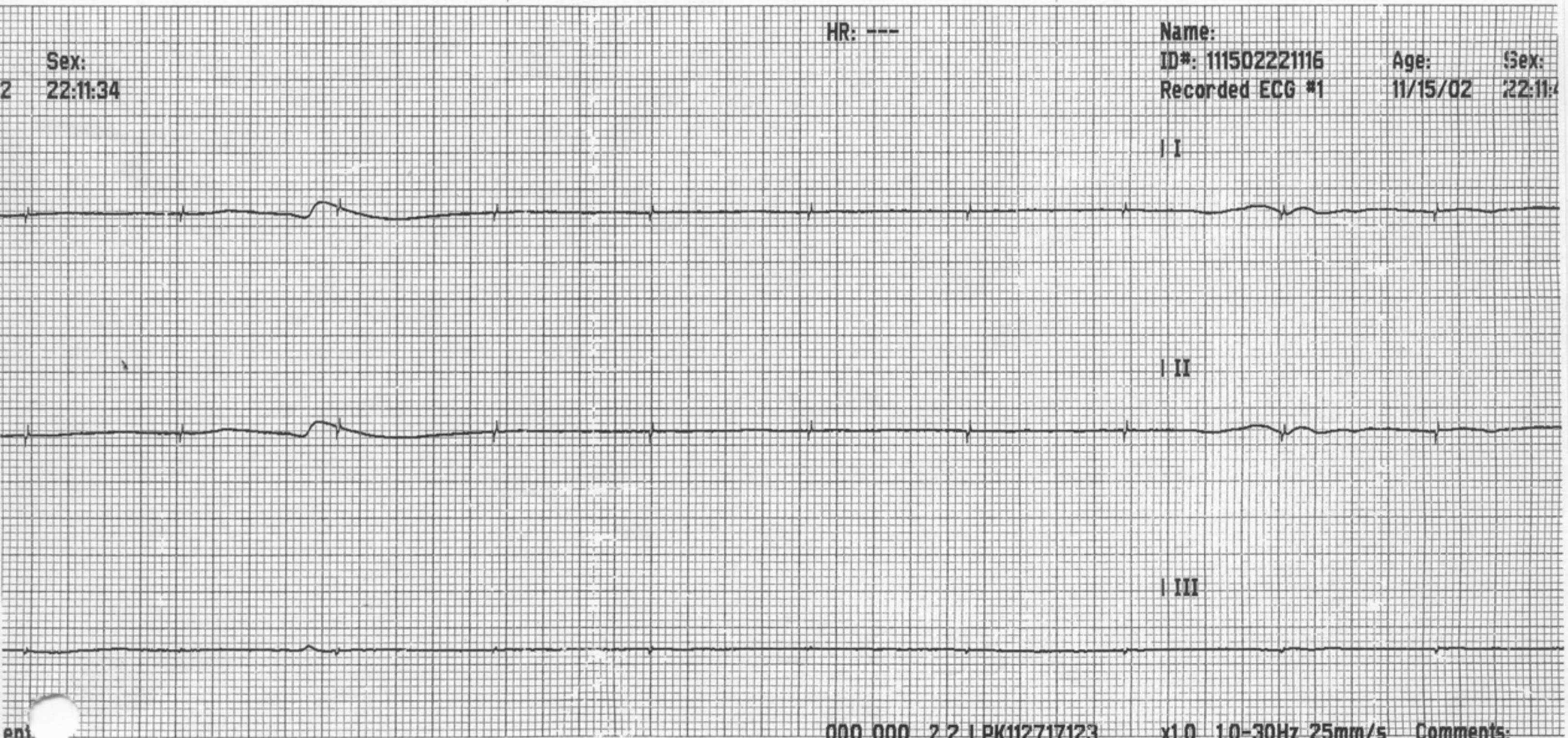
HR: ---
Name:
ID#: 111502221116
Recorded ECG #1
Age:
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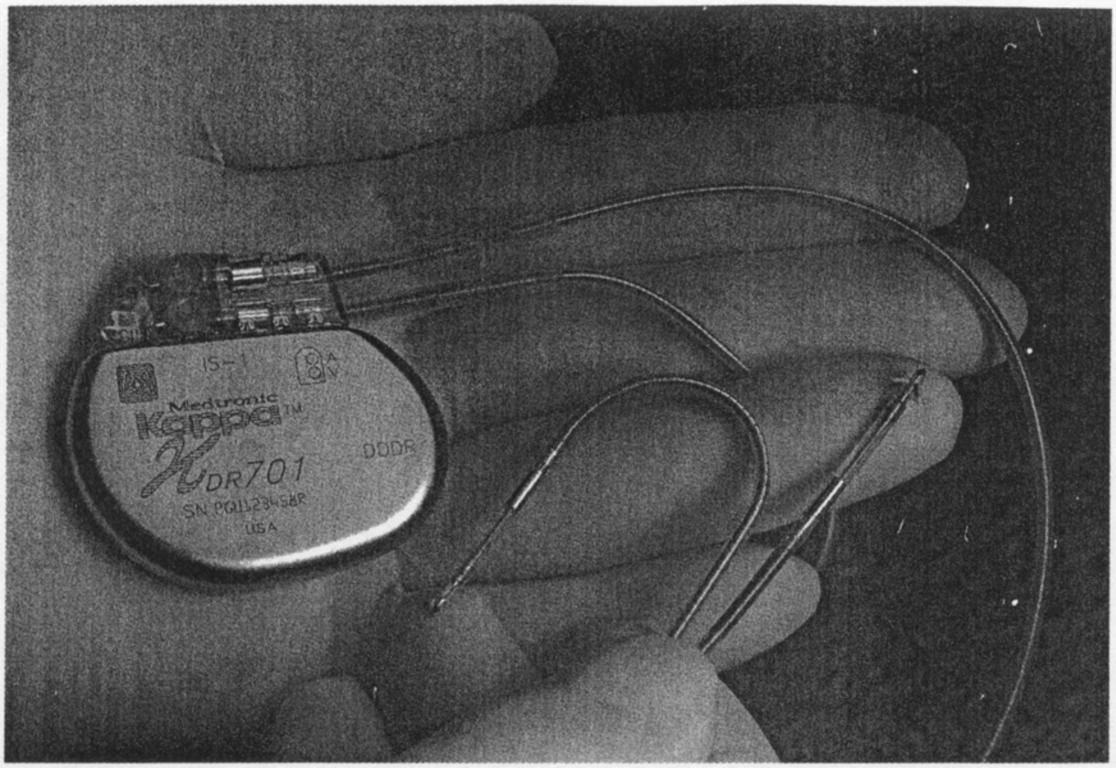

Figure 19–1 This dual-chambered pacemaker has an oblong shaped generator battery attached to two silicone insulated leads (wires). One end of the leads has barbs designed to be embedded into the ventricular heart muscle to prevent lead dislodgment. (Courtesy of Medtronic Inc.)

While most pacemakers are used to treat symptomatic bradycardias, some of the newer devices also have defibrillation and anti-tachycardia features. (Figure 19–3). The latest generation of pacemakers involve **dual-chamber devices** that are smaller and able to pace the atria as well as the ventricles. While older devices had limited commands that required the parameters to be determined *before* insertion, current devices have variable functions that can be reprogrammed as often as needed *after* insertion. For instance, newer pacemakers are capable of adjusting their discharge rate to meet the body's changing metabolic needs, such as, increasing when muscle activity is sensed during physical activity (Figure 19–4). Despite these advanced features, pacemakers remain relatively straight forward devices that are reliable and easy to troubleshoot.

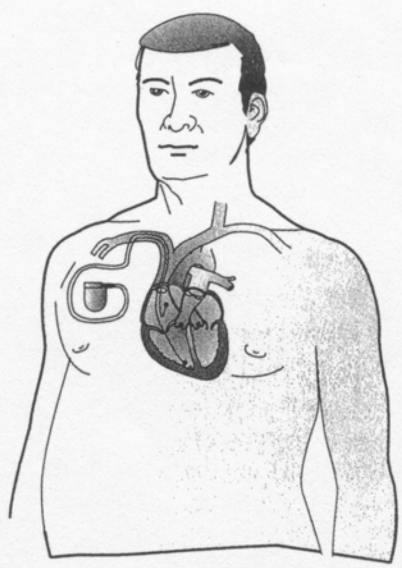

Figure 19–2 Dual-chamber pacemaker leads in place in the atrium and ventricle enable the pacemaker to simultaneously sense and pace both chambers. (Reproduced with permission from Lewis KM, Handal KA. Sensible ECG Analysis. Albany, NY: Delmar Publishers; 2000: 189.)

Pacemakers must be able to sense the patient's own natural beats in order to avoid competition between the device and the sinus node. Two terms that are used to describe the body's natural beats are **native beats** and **intrinsic cardiac activity** to distinguish them from an

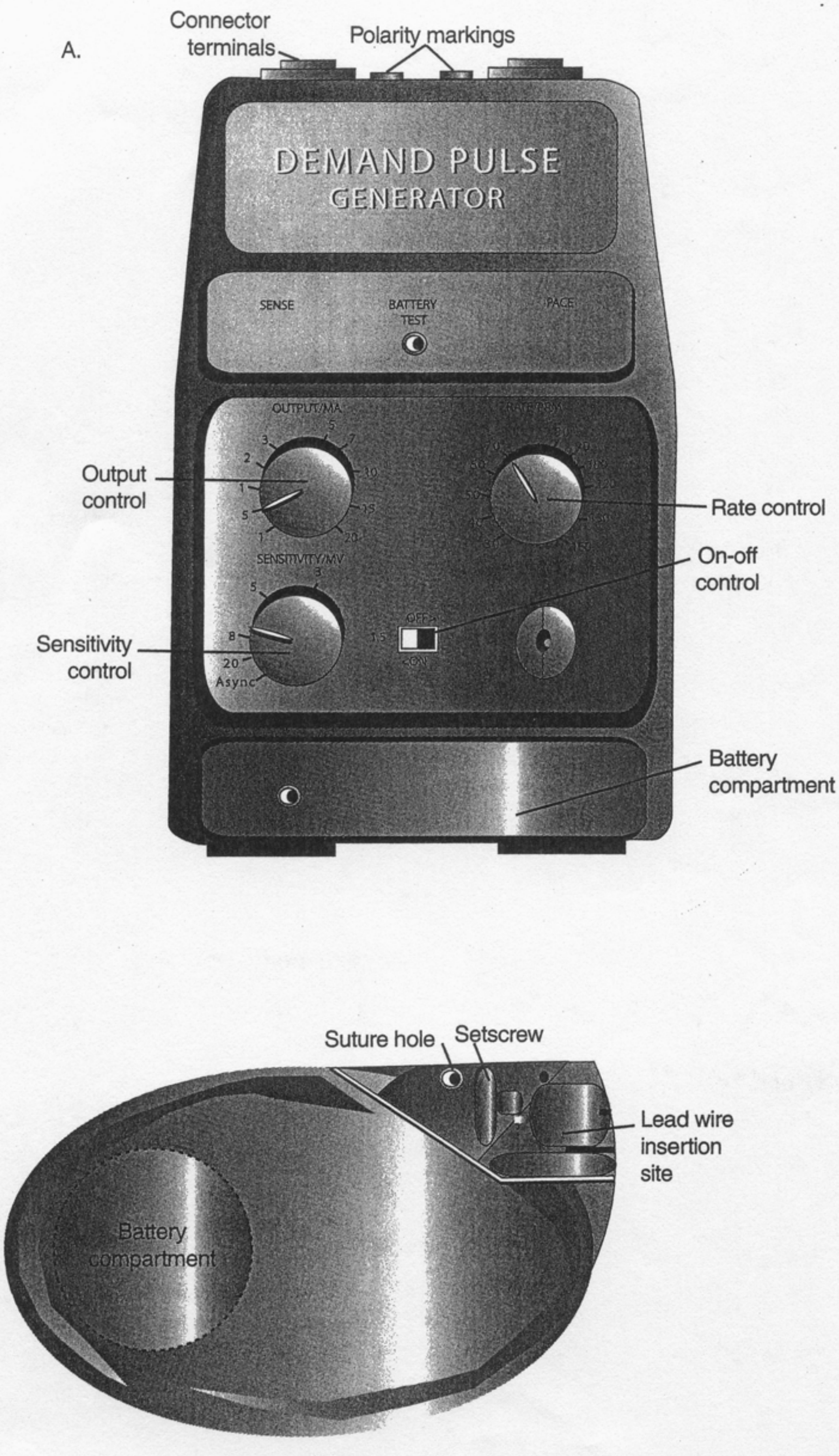

Figure 19-5 (A) A temporary pulse generator that is not implanted in the patient. The exrenal pulse generator is secured to the patient's body. Controls on the face allow the operator to adjust the settings. (B) Permanent generator that is implanted inside the patient's chest, and initial settings are programmed before insertion. The settings can be adjusted after implantation by using a programming device that is held over the patient.

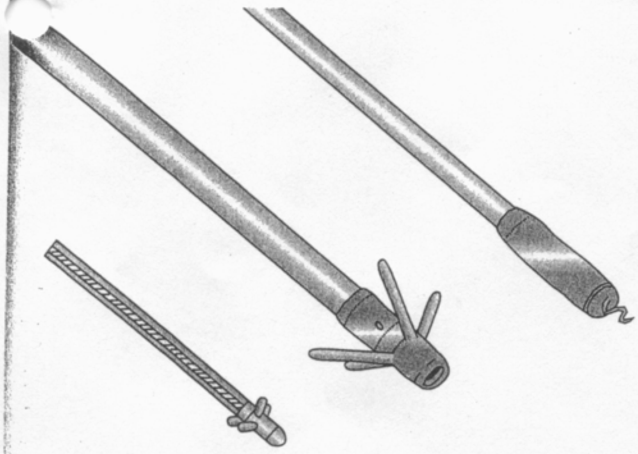

Figure 19-6 Transvenous electrode tips are designed to securely anchor the ends to the myocardium.

plex followed by a distorted QRS complex having a left bundle branch block shape (Figure 19–11). Since dual-chamber pacemakers stimulate both the atria and the ventricles, the ECG shows an atrial spike followed by a P wave, as well as, a ventricular spike associated with a wide QRS complex a short time later (Figure 19–11).

Pacing Threshold

The pacing threshold is the minimum amount of energy output needed to cause consistent cardiac capture.

Table 19-2 Pacemaker Properties

- **Discharging/ Firing:** Pulse generator discharges at a set rate per minute.
- **Output Pulse:** Electrical pulse intended to stimulate the myocardium and the energy level is expressed in voltage.
- **Sensing:** Pacemaker detects natural cardiac (electrical) activity.
- **Capturing/ Depolarization:** Pulse-generated impulse causes a cardiac depolarization or "captures" the heart.
- **Inhibition:** Pulse generator is inhibited when intrinsic cardiac activity is sensed.
- **Programmability:** Pacemaker functions can be adjusted noninvasively after insertion.
- **Sensing Threshold:** Minimal amount of energy needed to ensure consistent myocardial depolarization.

Programmability

In the past, pacemaker functions could only be set prior to insertion. Pacemakers are now fully programmable after implantation using noninvasive methods.

Sensing and Inhibition

Pacemakers must be able to sense intrinsic cardiac activity in order to prevent competition with native cardiac activity. When the pacemaker senses a native beat it will be inhibited. When a patient with a pacemaker has a natural heart rate that is faster than the programmed paced rate, any artificial pacemaker activity will not occur because the pacemaker has been inhibited (Figure 19–12).

ECG Interpretation Tip *The ECG tracing of an artificial pacemaker that fails to sense will show pacemaker spikes that are superimposed on the intrinsic P-QRS-T complexes. A pacemaker that fails to discharge due to oversensing will be inhibited by ECG artifact and pacemaker spikes will not occur where expected.*

Pacemaker Types

There are several basic types of pacemakers, some of which can be implanted internally, or applied externally on the chest wall, and can be used on an emergent, temporary, or permanent basis.

Internal Versus External Pacemakers

Internal and external pacing refers to the location of the pacing electrodes relative to the patient's chest wall. External pacemakers are the easiest and quickest way to pace during an emergency. For **transcutaneous pacing**, the pacing energy is applied to the chest wall using large adhesive electrodes, typically placed in an anterior-posterior position (Figure 19–13). This is also referred to as **transthoracic or external pacing**. Emergent external pacing is intended to temporarily stabilize the patient's rhythm until a more dependable device can be used. External pacing is the treatment of choice for symptomatic bradycardia.

Internal pacing electrodes are attached directly to the heart via wires that are advanced or "floated" into the right ventricle via large central veins, such as the subclavian. Internal electrodes can be permanently attached to an internally placed pulse generator or connected to a temporary external pacemaker that is securely attached to the patient.

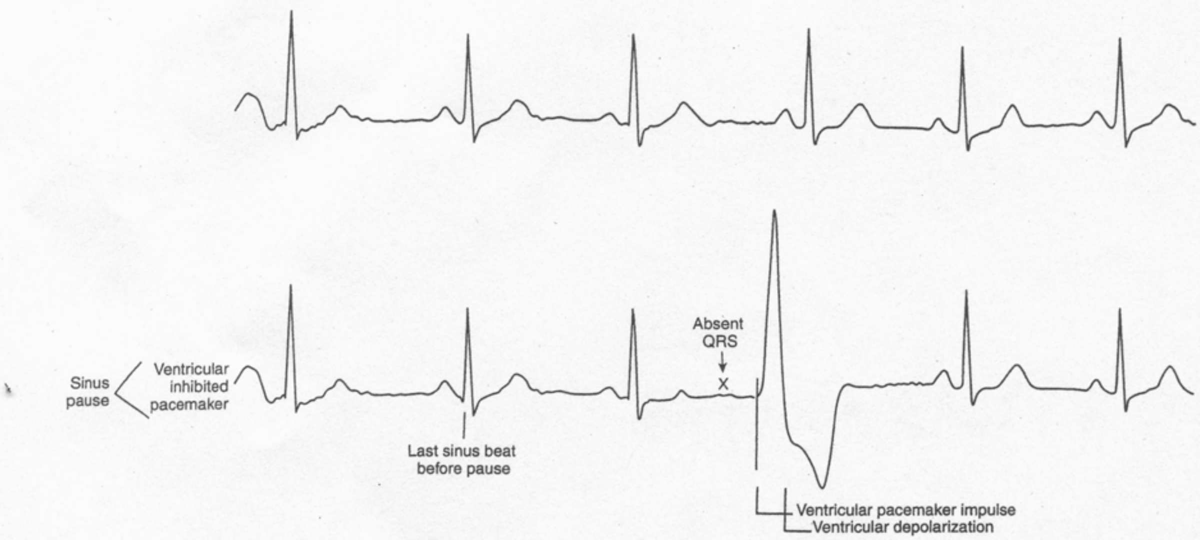

Figure 19–7 A normal functioning ventricular inhibited pacemaker is shown. (A) shows NSR; (B) shows a sinus pause.

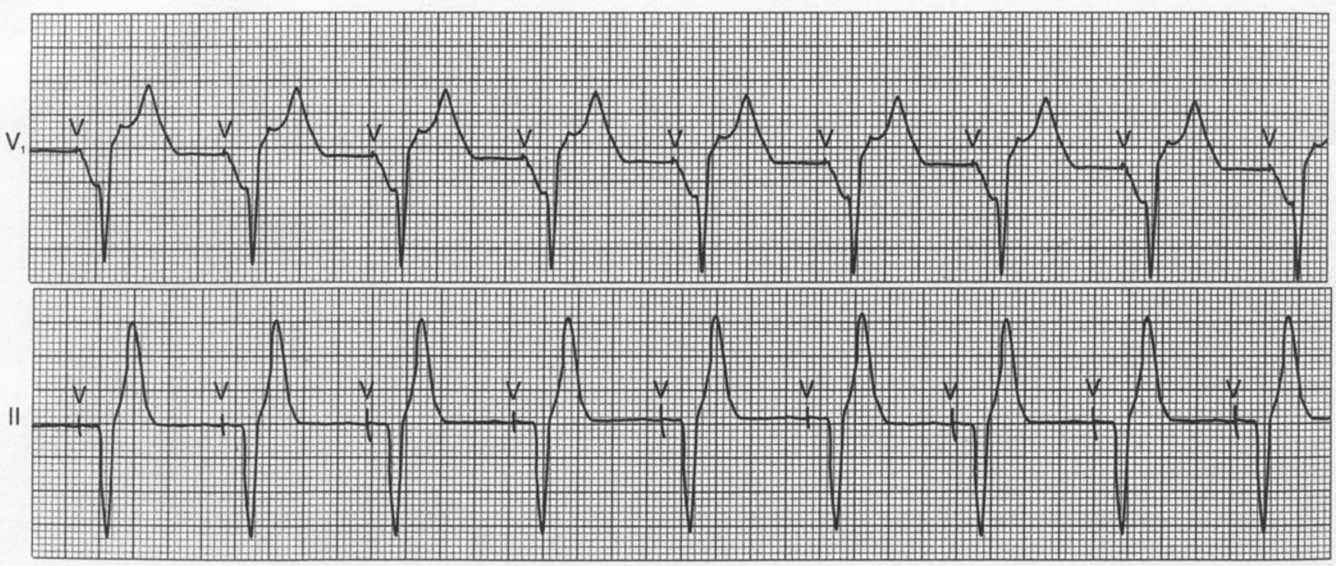

Figure 19–8 Normal ventricular capture. Ventricular spikes, which are labeled V, precede wide QRS complexes in the two ECG leads. No intrinsic rhythm is present and the pacemaker is set at a rate of 60 impulse/minute, which corresponds to a one second interval between beats. If an intrinsic complex is not sensed a pacing spike will occur after a one second escape interval.

Permanent Versus Temporary Devices

Pacemakers can be used permanently or for short-term emergent therapy, as in transient cases of advanced AV heart block. Temporary pacemakers may either be an external type, such as the transthoracic pacer, or transvenously inserted. Transthoracic external pacers are only employed for a few hours until a more stable pacing method can be accomplished. The transvenous route for emergent pacing can be used for several days

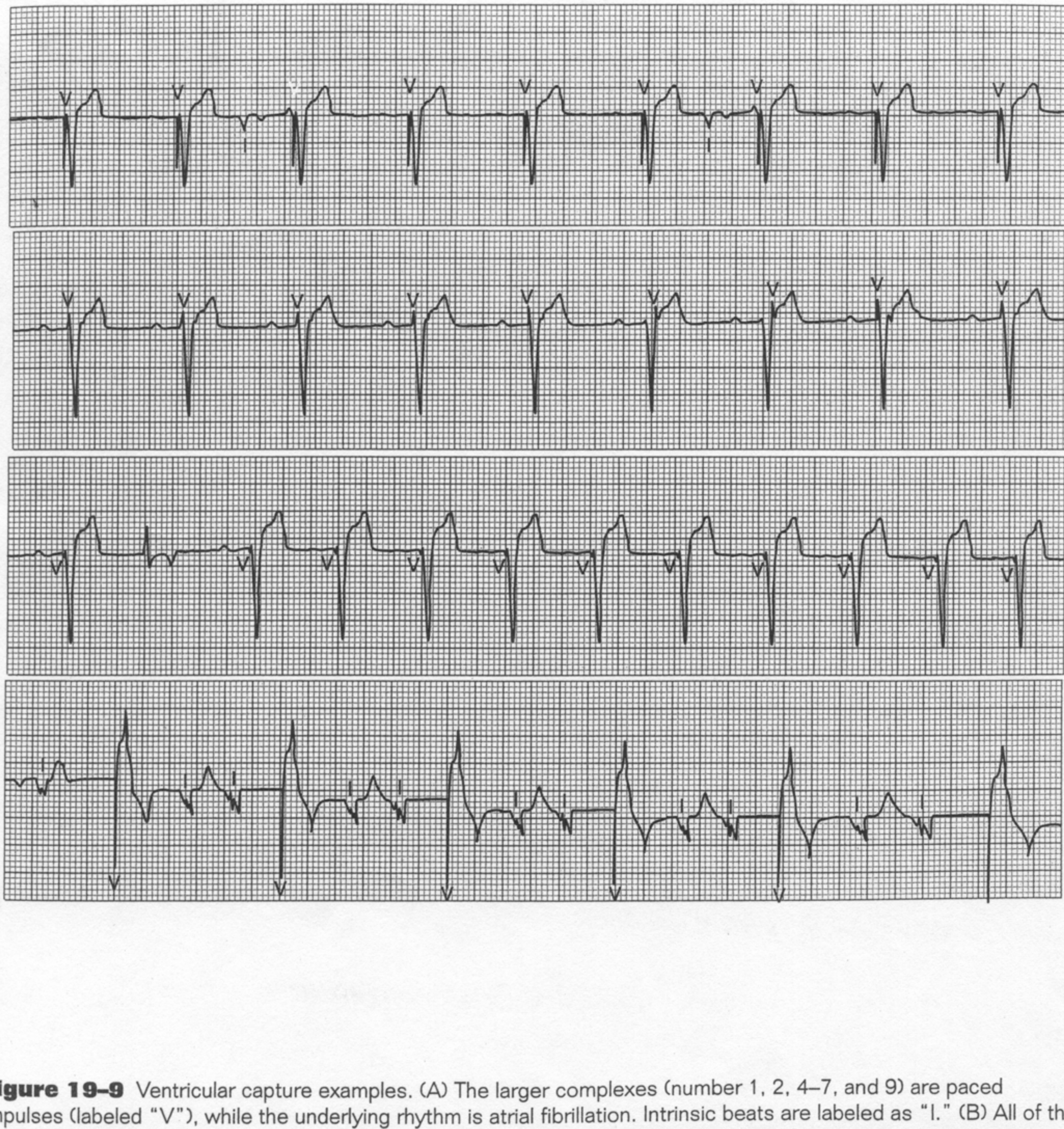

Figure 19–9 Ventricular capture examples. (A) The larger complexes (number 1, 2, 4–7, and 9) are paced impulses (labeled "V"), while the underlying rhythm is atrial fibrillation. Intrinsic beats are labeled as "I." (B) All of the beats are pacemaker complexes. The underlying rhythm is complete AV heart block. (C) All beats except for the second beat are pacemaker complexes. The underlying rhythm cannot be assessed because most of the tracing shows pacing function. (D) Beats number 2, 5, and 8 are pacer complexes. The underlying rhythm is a bundle branch block.

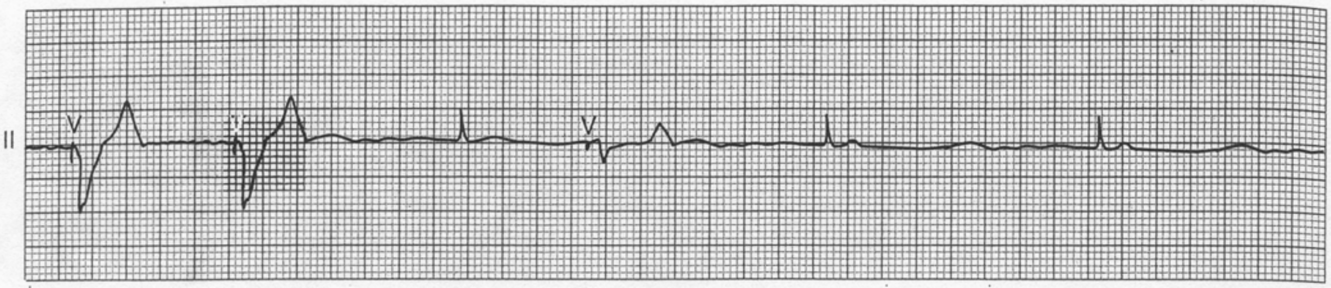

Figure 19–10 Normal ventricular sensing with pacemaker-related bundle branch block shapes. The underlying rhythm is atrial fibrillation. The artificial pacemaker rate is set at 50 bpm and has an escape interval of 1.2 seconds, which can be determined by evaluating the first two complexes labeled as V. The third complex is narrow and inhibits the artificial pacemaker. The 4th complex demonstrates a ventricular spike ("V") with a wide QRS complex. The last two beats occur following a period that is clearly less than the escape interval and inhibits the pacemaker.

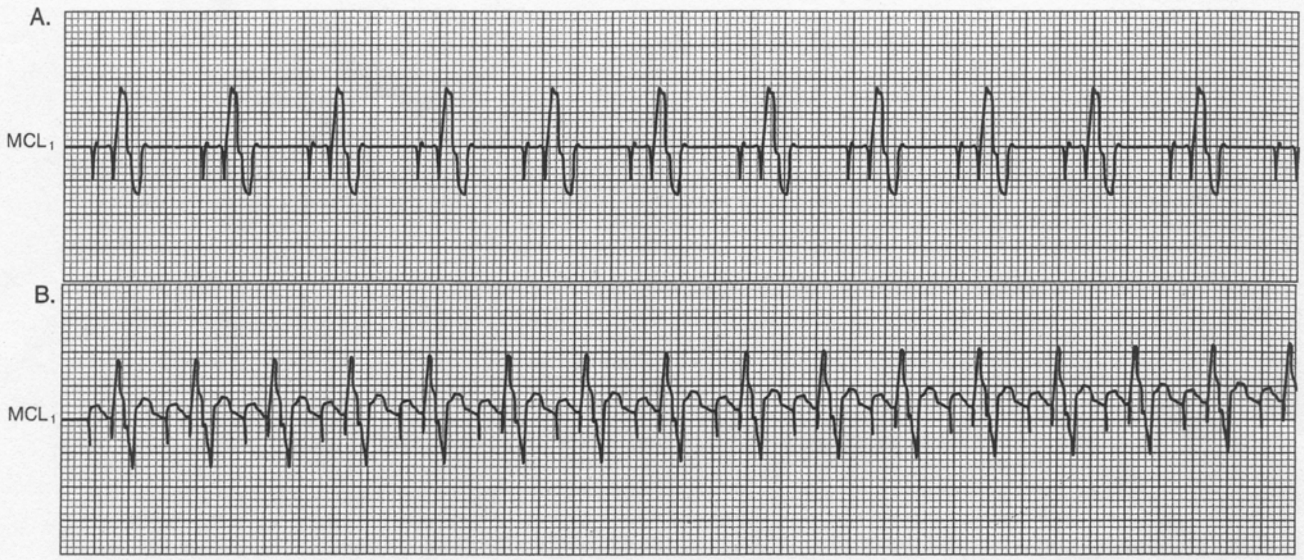

Figure 19–11 AV sequential pacing with a dual-chamber pacemaker. There are two pacemaker spikes for each cardiac complex. (A) The first impulse spike is followed by a P wave, while the second spike stimulates a QRS-T complex. (B) AV sequential pacemaker in which both atrial and ventricular pacer spikes are associated with P waves and QRS complexes, respectively.

until the need for permanent pacing is determined. In some patients, when the heart block or bradycardia subsides, the pacemaker can be discontinued.

Permanent pacemakers are used to treat chronic conditions, such as a slow heart rate caused by sick sinus syndrome. Permanent pacemaker insertion requires a brief surgical procedure, which is accomplished using local anesthesia, during which the pulse-generator is inserted into the subcutaneous tissue of the upper chest. The leads are transvenously threaded into place within the right ventricle (Figure 19–14).

Single Versus Dual Chamber Pacing

Pacemakers can stimulate either the ventricles, the atria, or the atria and ventricles, known as single- or dual-chamber devices, respectively. Most **single-chamber pacemakers** pace the right ventricle although if AV conduction is normal but the sinus node is defective, an atrial pacemaker can be used (Figure 19–15). Until recently, most pacemakers were single-chamber devices but because of clear advantages in certain groups of patients, more dual-chamber pacemakers are now being implanted.

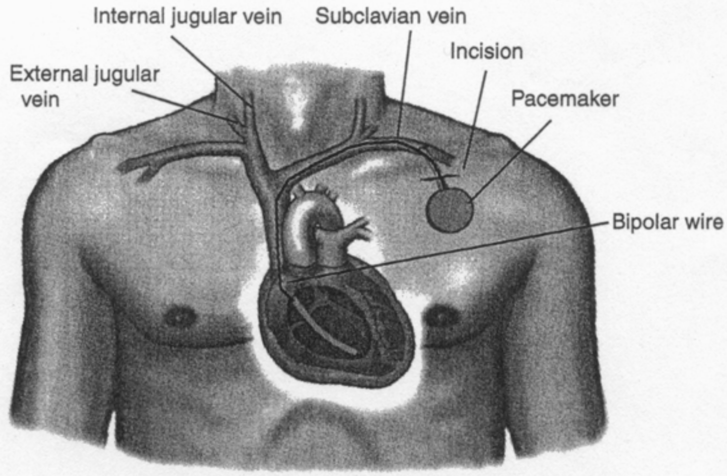

Figure 19–14 Permanently implanted pacemaker. The pulse generator is implanted in the subcutaneous tissue of the right or left anterior upper chest area just below the clavicle. The typical scar and pacemaker bulge can be easily detected.

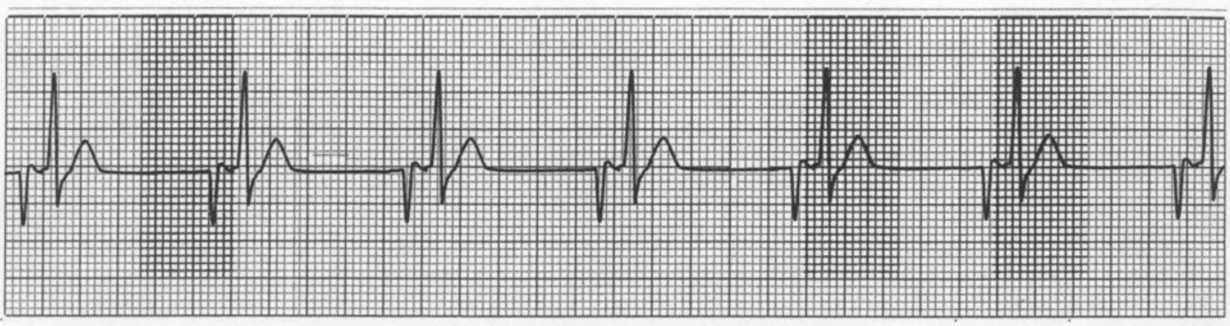

Figure 19–15 Atrial pacing with normal A-V conduction. An atrial pacemaker stimulates the atria if intrinsic P waves are not sensed within the programmed period (for example, one second when the rate is set at 60/minute).

chamber devices since atrial contraction precedes ventricular stimulation and the ventricles fill completely before contraction. The increased sophistication of dual-chamber pacemakers causes a greater battery drain and a shorter battery life.

Dual-chamber pacemakers have one lead in the atrium and another in the ventricle (Figure 19–2). In dual-chamber systems, when a P-wave is sensed a ventricular pulse is triggered if an associated QRS is not detected within a 0.2 second interval. This is an effective way of maintaining normal atrial-ventricular coordination, especially when the sinus node is functioning normally and can regulate the heart rate, such as during complete heart block. Dual-chamber pacemakers are especially suited for younger and active individuals who benefit from a higher cardiac output and the ability to quickly change cardiac output.

When stable sinus activity is present, a dual-chamber pacemaker is often used because the sensed P wave can be used to trigger the ventricular impulse (Figure 19–16). Dual-chamber pacemakers allow the sinus node to continue to set the cardiac rate and be responsive to changing conditions requiring different heart rates. The patient still has the ability to increase the sinus discharge as more cardiac output is needed and the pacer will trigger the ventricles to "keep pace" with the atria.

PACEMAKER PACING RATES AND INTERVALS

The pacing rate is the number of times per minute the pacemaker is set to discharge if there is no sensed cardiac activity. The **pacing rate** is also referred to as the backup or demand rate and is analogous to how the body's own escape pacemakers function. For example, if the pacemaker is set to discharge at 60 impulses/minute, the ECG will show a pacemaker spike every