13 Temporary Pacing

Indications

Patients with significant intracardiac conduction defects who are symptomatic with dizziness or syncope due to bradycardia should have a temporary pacemaker (TPM) inserted if the defect is thought to be reversible, or if when deemed irreversible, permanent pacemaker implantation cannot be done immediately. After acute myocardial infarction (MI) (see Fig. 3.1) or cardiac surgery, evidence of new or extensive intracardiac conduction defect, prolonged sinus arrest or asystole requires a TPM. Those with "at risk" conduction defects require a TPM prior to general anesthesia as do patients with certain drug overdosage associated with severe bradycardia, for example, digoxin toxicity, β-blocker, or verapamil overdosage.

Temporary pacing is also indicated during interventional procedures such as percutaneous coronary rotational atherectomy to a dominant right or left circumflex coronary artery and for AV node ablation (unless a permanent pacemaker is present) since both may be associated with profound bradycardia or heart block (see Fig. 3.9). A TPM is indicated for patients with hypertrophic obstructive cardiomyopathy who are undergoing alcohol septal ablation, as this procedure

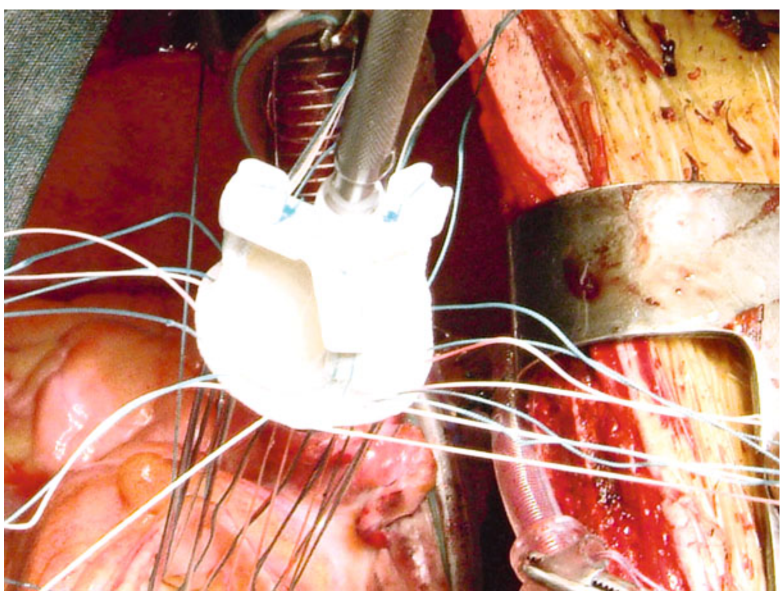

Fig. 13.1 Temporary epicardial pacing is not infrequently required after certain types of open heart surgery such as aortic valve replacement shown here

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Fig. 13.2 Epicardial pacing leads exit the chest wound and are attached to the connecting cable which in turn is connected to the temporary pacing box

may be associated with AV block (see Fig. 3.8). Temporary epicardial pacing may be necessary after cardiac surgery, especially after surgery close to the AV node or bundle of His (Figs. 13.1 and 13.2). TPMs are also used in electrophysiological studies (see Fig. 3.12) and for overdrive pacing in patients with ventricular tachycardia (see Fig. 3.11).

Patients with infrequent bradycardias should not routinely receive a TPM while awaiting permanent pacemaker implantation.

The clinical and electrocardiographic indications for TPM are shown in Tables 13.1–13.4.

AV Block in Acute MI

Complete AV Block

In anterior MI, complete AV block usually is a result of septal infarction and requires temporary pacing. In inferior MI, complete AV block most often occurs as a result of right coronary artery occlusion with loss of the AV nodal artery, and temporary pacing is necessary (Fig. 13.3).

Table 13.1 Clinical indications for temporary pacing

Dizziness or syncope due to chronic disease of the conducting tissue (if permanent pacing is not immediately possible)
Hemodynamics compromised by bradycardia
Bradycardia-induced ventricular arrhythmias
Intracardiac conduction defects after acute myocardial infarction (see Table 13.2)
Prior to general anesthesia in patients "at risk" of 2° or 3° AV block (see Table 13.3)
Prior to rotational coronary atherectomy in a dominant right or left circumflex coronary artery
Post-cardiac surgery (see Table 13.4)
Termination of refractory tachyarrhythmias, e.g., ventricular tachycardia
During electrophysiological studies, e.g., initiation/termination of arrhythmias
During AV node ablation
Drug toxicity, e.g., digoxin, B-blockers causing symptomatic, severe or life-threatening bradycardia

Second-Degree AV Block

Mobitz Type I (Wenckebach), where there is a progressive increase in the PR interval eventually leading to complete failure of a P wave to conduct and produce a QRS complex is usually due to decremental conduction at AV node level. In acute inferior MI, it usually does not require temporary pacing unless the bradycardia causes adverse clinically significant hemodynamic effects. It may respond to IV atropine (1 mg). In anterior MI, this type of AV block may be more sinister and patients should be temporary paced.

Mobitz Type II AV block is evident by a fixed PR interval with sudden failure of conduction of the atrial impulse (P wave). It frequently occurs in the presence of a wide QRS perhaps because it is commonly associated with more distal fascicular disease. It requires temporary pacing in both inferior and anterior MIs as complete AV block often follows (Fig. 13.4).

Table 13.2 ECG indications for temporary pacing in acute myocardial infarction

Alternating RBBB/LBBB
Long PR + new RBBB + LAFB
New RBBB + LPFB
Long PR + LBBB
RBBB + new LPFB
Wenckebach (Mobitz type I) 2° AV Block in anterior MI (in inferior MI if bradycardia poorly tolerated)
Mobitz type II 2° AV block in anterior MI and in inferior MI if heart rate <40 beats/min or associated with hypotension or ventricular tachyarrhythmia
Complete AV block
Symptomatic junctional bradycardia[a]
Symptomatic sinus arrest (>3 s or if hemodynamically affected)[a]
Severe symptomatic sinus bradycardia[a]
Asystole

[a]If unresponsive to atropine

Table 13.3 ECG indications for temporary pacing prior to general anesthesia for noncardiac surgery

Alternating RBBB/LBBB
Long PR + new RBBB + LAFB
New RBBB + LPFB
Long PR + LBBB
RBBB + new LPFB
Wenckebach (Mobitz type I) 2° AV block
Mobitz type II 2° AV block
Complete AV block
Sick sinus syndrome – severe sinus bradycardia/sinus arrest

First-Degree AV Block

Although approximately 40% of patients with first-degree AV block may eventually develop higher degrees of AV block, patients with first-degree heart block do not require temporary pacing.

Table 13.4 Types of cardiac surgery which are more likely to be associated with the need for temporary pacing

Aortic valve replacement for calcific aortic stenosis (with calcium extending into the septum)
Aortic valve surgery/interventricular septal abscess drainage/repair in infective endocarditis
Tricuspid valve surgery/Ebstein's anomaly repair
Repair of AV canal defects
Ostium primum atrial septal defect repair
Surgical repair of corrected transposition/AV discordance defect
Myomectomy for hypertrophic obstructive cardiomyopathy

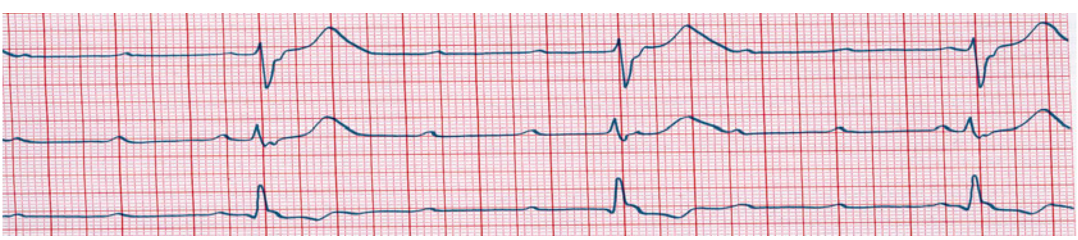

Fig. 13.3 Complete heart block

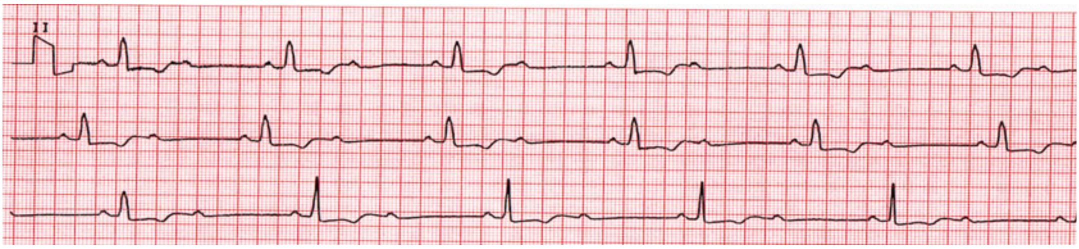

Fig. 13.4 Mobitz type II AV block

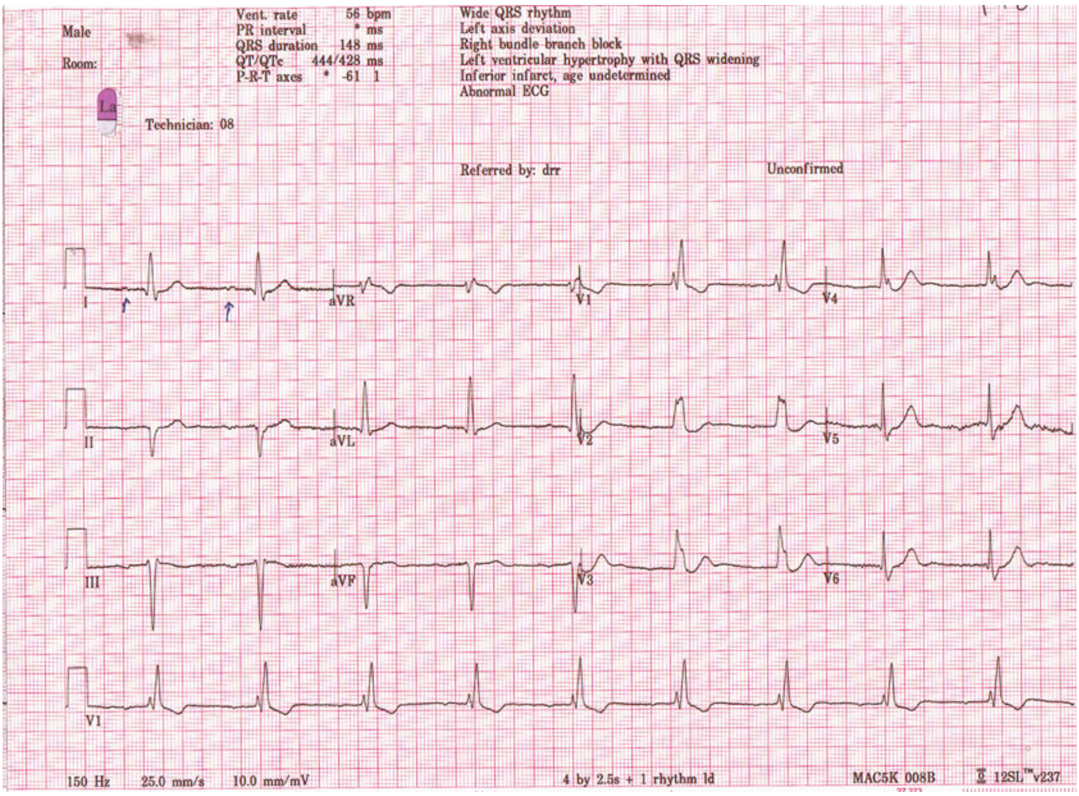

Fig. 13.5 Trifascicular block manifested by 1° heart block, right bundle branch block and left axis deviation

Bundle Branch Block

Patients with trifascicular disease or so-called nonadjacent bifascicular disease complicating acute MI should receive temporary pacing.

Trifascicular disease (Fig. 13.5) includes alternating RBBB/LBBB, long PR + new RBBB + LAFB, long PR and new RBBB + LPFB, and long PR + LBBB.

Nonadjacent bifascicular disease includes RBBB + new LPFB. If LBBB + long PR develops in acute anteroseptal MI, the LBBB is assumed to represent LAFB + LPFB, although a His-bundle study would need to be done to confirm this. RBBB + LAFB (left axis deviation) is not uncommon after acute anterior MI as these two fascicles are in the anterior portion of the septum. A long PR in this situation should indicate the need for pacing.

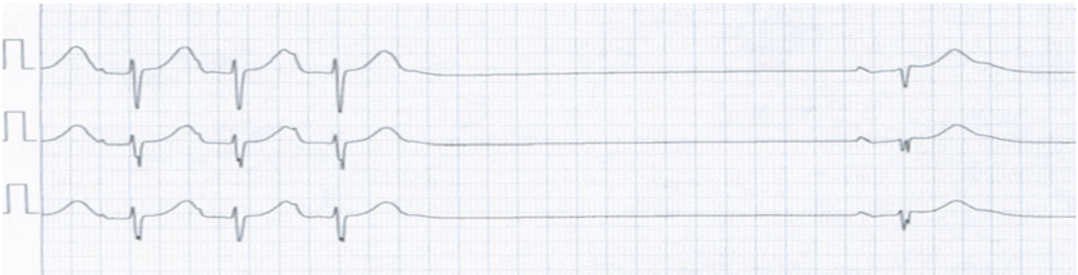

Fig. 13.6 Wenckebach 2° AV block in conjunction with prolonged sinus arrest

Sino-Atrial Disease

Marked sinus bradycardia or sinus arrest may occur after acute MI, most commonly inferior MI. Since this is likely to be vagotonically mediated, it usually responds to IV atropine. Only if unresponsive to atropine or poorly tolerated should temporary pacing be considered (Fig. 13.6).

Prior to General Anesthesia

ECG abnormalities as listed in Table 13.3 should indicate the possible need for prophylactic pacing prior to general anesthesia, especially if there is evidence of any recent deterioration such as a lengthening PR or the development of new LAFB. Holter ECG monitoring should be considered prior to surgery to identify those possibly at higher risk. As a minimum, ECG monitoring, IV access, and an external transcutaneous pacing facility should be available in theater if patients are thought to be at risk of developing severe bradycardia or higher degrees of AV block during general anesthesia. If a strong indication for permanent pacing exists and the surgery is not urgent, permanent pacemaker should occur first and the procedure requiring general anesthesia postponed.

During or After Cardiac Surgery

Temporary epicardial pacing may be required in cardiac surgery adjacent to the AV node and bundle of His. Such surgery includes aortic valve replacement for calcific aortic stenosis, particularly when the calcium extends into the interventricular septum, aortic valve replacement in infective endocarditis especially when infection has caused septal abscess formation – when permanent pacing is indicated (see Fig. 3.3), tricuspid valve surgery and Ebstein's anomaly, repair of AV canal defects and ostium primum ASD and closure of a VSD in corrected transposition or of the ventricular component of a complete AV canal defect.

Techniques

Temporary pacing may be performed transcutaneously by the application of external pacing electrodes to the chest wall or by insertion of pacing electrodes transvenously. The latter may be inserted using a femoral, subclavicular, supraclavicular, internal jugular, or antecubital approach. When pacing is necessary in a patient who has received thrombolytic therapy for acute MI, a TPM should be placed via the femoral, brachial, or internal jugular route – sites that are compressible. During cardiac surgery, temporary pacing can be established by direct attachment of special pacing wires to the epicardium – so-called epicardial pacing.

Transesophageal ventricular pacing, developed in 1969, has been abandoned because of its relative ineffectiveness compared to modern transthoracic, transcutaneous pacing. Transesophageal atrial pacing is more reliable than transesophageal ventricular pacing but is now rarely used and has been replaced by transvenous atrial pacing (see below).

A review of temporary cardiac pacing was presented by McCann in 2007. He concluded that

Fig. 13.7 Lifepak 20 (Medtronic Inc.) is both a defibrillator and external pacemaker

cardiologists who implant TPMs have lower complication rates and higher success rates than non-specialists, that the internal jugular vein (R > L) followed by the subclavian (L > R) and then femoral vein were the most preferred route of access, and that antibiotics and ultrasound probes should be contemplated for all temporary wire insertions. The commonest complications were sepsis, followed by incorrect placement of the wire causing failure to pace, arrhythmias, myocardial and lung perforation. Training in the skills required to insert transvenous TPMs is essential before accepting the responsibility for this potentially hazardous procedure.

External, Transthoracic Pacing

Modern transcutaneous, transthoracic pacemakers function in demand mode and have a maximum output in the region of 150 mA (Fig. 13.7). Appropriate pacing electrodes (some which can act as defibrillator pads) are required (Figs. 13.8 and 13.9), which are linked via a cable to a special connector which is then inserted into the external pacing device (Fig. 13.10). One electrode pad is placed on the front of the chest and a second on the back over the right or left scapula (Figs. 13.11–13.14), although anterior and lateral placement is also effective. The arterial pulse should be monitored for effective pacing as the ECG may not show pacing spikes. Transthoracic pacing causes chest wall muscle twitching, which is painful and usually requires sedation.

This form of pacing should be considered only as an emergency or rescue treatment and a more stable and reliable transvenous pacemaker should be placed as soon as possible

Transvenous Pacing

General Requirements

Written consent from the patient should be obtained after due explanation of the risks and benefits of the procedure – preferably in the presence of their next of kin, although this may be impractical in a serious or life-saving situation. The procedure should ideally be performed in a sterile theater dedicated to such procedures and specially designed for the use of X-ray fluoroscopy. Cardiac catheter laboratories are often used for insertion but are at best clean areas rather than sterile environments. A TPM may be inserted in a coronary care unit when a "cath-lab" is not available on site. However, the patient must be on a "screening bed" and a mobile C-arm image intensifier must be readily available (see Figs. 7.1 and 7.4).

Fig. 13.8 Quik-Combo™ (Medtronic) external pacing/defibrillator adhesive pads

Fig. 13.10 Pacing cable attached to the Lifepak 20 (*arrow*)

Fig. 13.9 Quik-Combo™ pads removed from sealed packet

Fig. 13.11 One pad is placed over the precordium

Fig. 13.12 The second pad is placed on the back

Fig. 13.13 Connecting cable inserted into the fitting attached to the disposable pads

A specially trained coronary intensive care nurse or cath-lab nurse is required, as is a radiographer who is familiar with X-ray fluoroscopy and who can set up and operate a portable fluoroscope or cath-lab X-ray screening equipment. The operator should be trained in the technique and be able to operate independently, possess a certificate confirming his/her ability to use the X-ray equipment, and ideally be able to perform advanced life support procedures if necessary.

The operator must scrub carefully with antiseptic, and put on a sterile gown, face-mask, and gloves to perform this aseptic procedure (Fig. 13.15). A wide area of skin around the intended puncture site should be cleaned with an antiseptic solution of povidone iodine and/or chlorhexidine (Fig. 13.16) and the area covered with sterile drapes before administering the local anesthesia (Fig. 13.17).

During insertion of the TPM, the heart rhythm must be monitored and equipment for external pacing and resuscitation should be available.

Methods

Temporary ventricular pacing is performed by introducing a pacing lead into a systemic vein and advancing it, with the help of X-ray fluoroscopy, to the apex of the right ventricle.

Fig. 13.14 Cable attached to the Lifepak 20

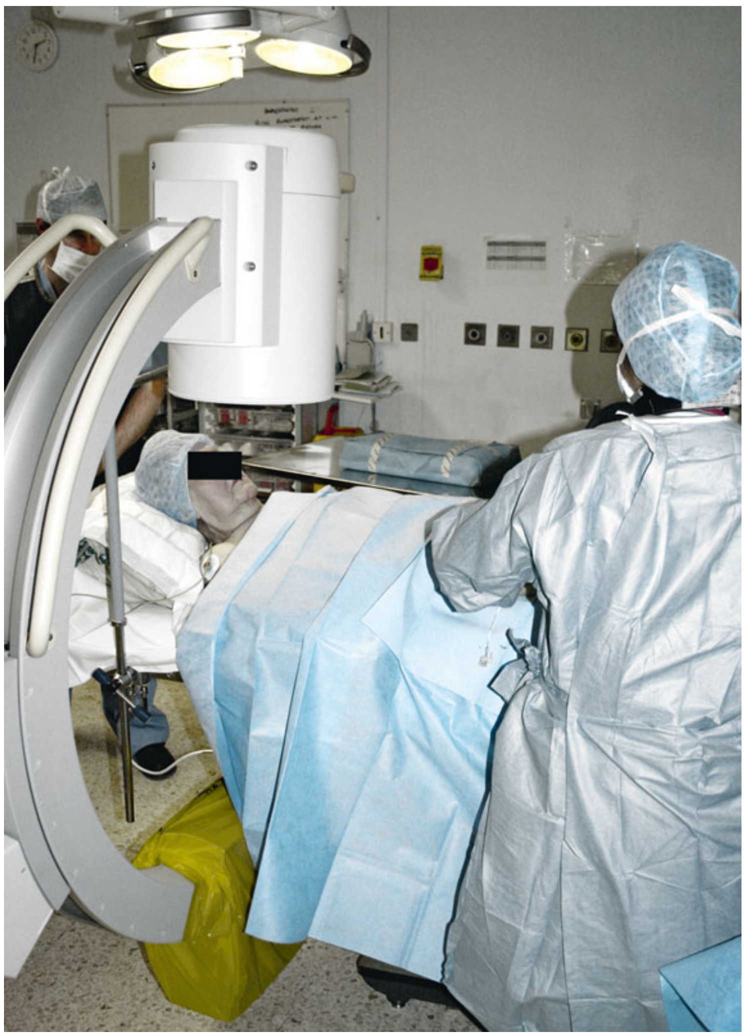

Fig. 13.15 The operator should be in a sterile gown and gloves and wear mask and hat

Fig. 13.16 The skin over the insertion site (inguinal region for femoral vein insertion) is cleaned with chlorhexidine antiseptic solution

Fig. 13.17 The site is covered with a sterile drape with a purpose-designed window

Techniques for reaching the right ventricular apex with the lead tip are described below, but once positioned (Fig. 13.18) the lead is connected

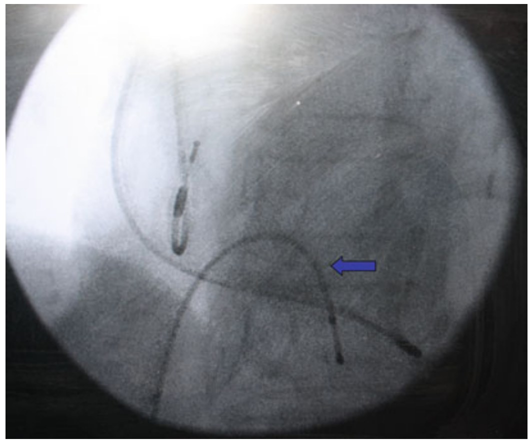

Fig. 13.18 Fluoroscopic image showing a temporary pacemaker in the right ventricular apex (*arrow*) from the femoral vein. Permanent RA and RV leads are present in this pacemaker-dependent patient undergoing a box-change procedure

to an external pulse generator (Fig. 13.19) whose pulse rate and energy output can be adjusted. Several approaches are used and are described below. Generally, access via the right internal jugular vein is least hazardous but the complications of carotid artery puncture may be serious and the lead position is often uncomfortable for the patient.

Temporary atrial pacing is performed by introducing a J-shaped atrial lead (Fig. 13.20) into a systemic vein (not femoral vein) and advancing it, with the aid of X-ray fluoroscopy, to the right atrium. The preformed J-shaped lead is pulled up into the right atrial appendage and then sutured to the skin at the skin puncture site (see below). Atrial temporary pacing leads are frequently unstable and capture/pacing of the atrium is then lost. However, an active fixation temporary lead is available for placement in the atrium which should offer more reliable atrial sensing/pacing for as long as is necessary (see below).

Temporary Pacing Leads

Extruded polyurethane bipolar pacing catheters with stainless steel electrodes are most commonly used in catheter laboratories and coronary care units for temporary pacing (Fig. 13.21). TC

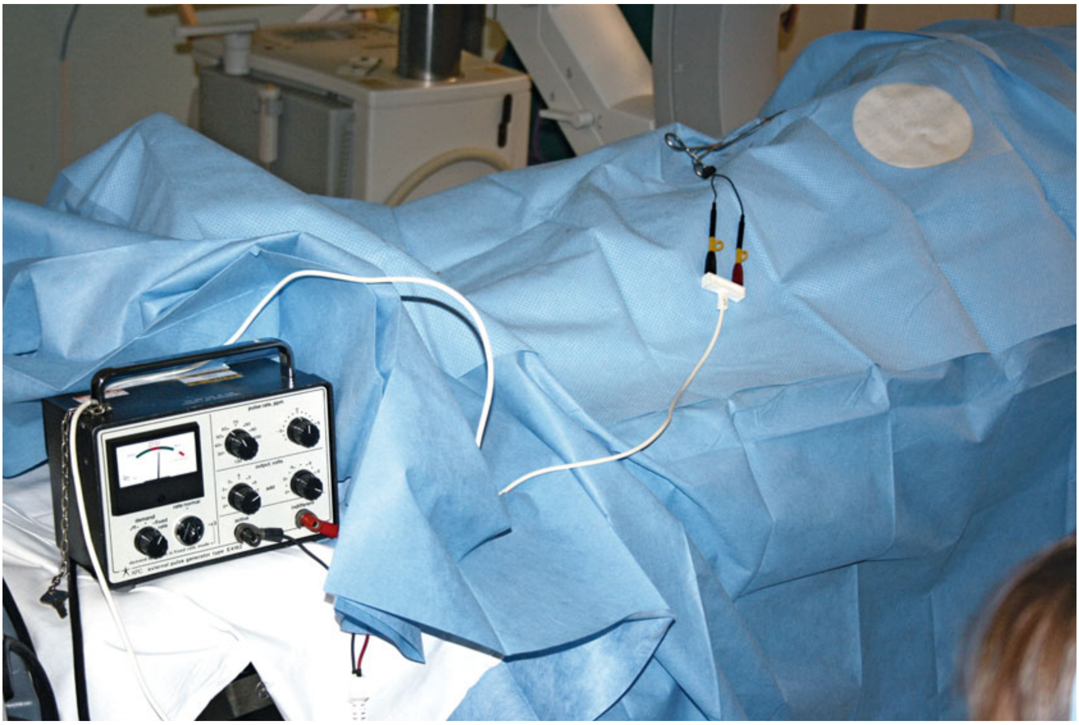

Fig. 13.19 The bipolar temporary electrode's pins are connected to the cable which is then attached to the temporary pacing box

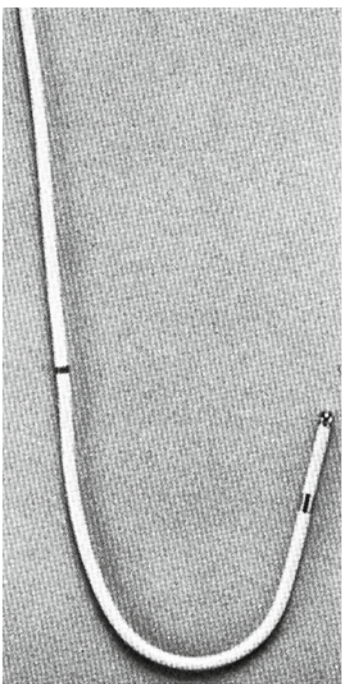

Fig. 13.20 Temporary bipolar "J" lead for positioning in the RA appendage

is the current bipolar temporary pacing catheter from Biotronik. It is easily visible on fluoroscopy due to its coaxial shaft design. Its standard 2 mm adapter pins allow direct connection to all common external pacemakers and EP devices. High-quality NBIH and Goetz catheters with platinum electrodes are also available in 4–7F sizes. The Bard temporary pacing catheter is available in 6F, 7F, and 8F sizes and the catheter is shown in Figs. 13.22 and 13.23.

Balloon flow-assisted catheters (Fig. 13.24) are available for use when fluoroscopy is not immediately available and more specialist designs have specific uses. The Zucker® catheter is ideal for right heart bipolar pacing, intracardiac ECG sampling, and infusion. The Myler® catheter is suited for pulmonary artery pressure monitoring and sampling while pacing the right ventricle and the Gorlin® catheter for coronary sinus sampling while simultaneously pacing the right atrium. A CVP/pacing lumen electrode catheter is ideal for pressure monitoring and sampling from the vena cava or right atrium while simultaneously pacing the right ven-

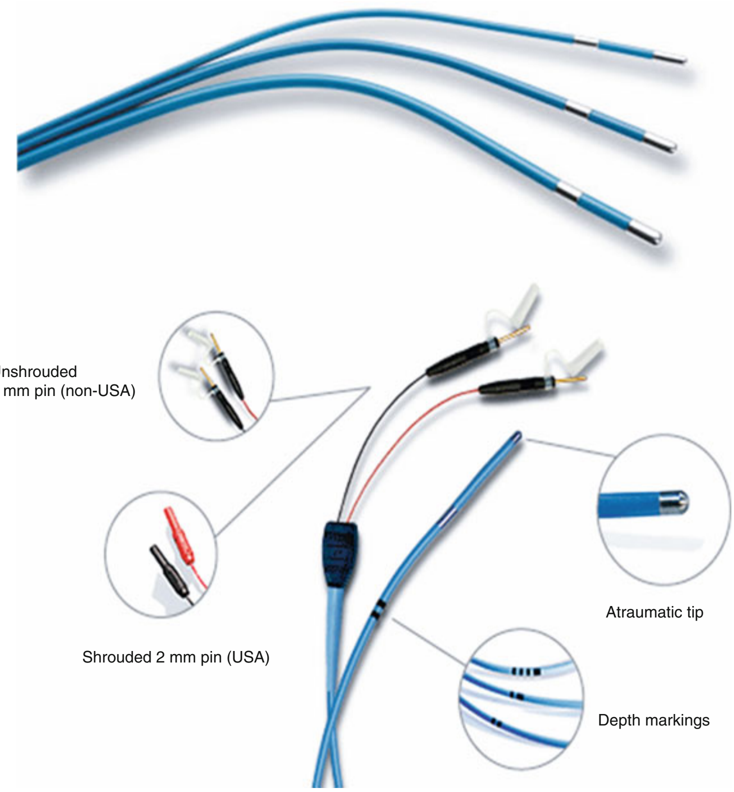

Fig. 13.21 *Upper*: Three bipolar temporary ventricular leads from Biotronik Ltd. *Lower*: *TB* is a 110 cm long bipolar temporary pacing lead available as 4F, 5F or 6F diameter, straight or preformed "J" version (Courtesy of Oscor® Inc., Palm Harbor, FL, USA)

Fig. 13.22 6F bipolar temporary pacing lead from Bard is presented in a well-labeled sterile package

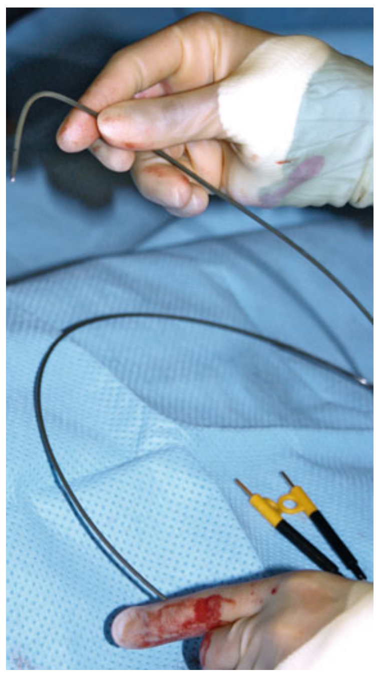

Fig. 13.23 6F bipolar temporary pacing lead from Bard. The distal tip is gently curved which aids placement into the RV apex from the femoral route. The proximal connector pins are also shown

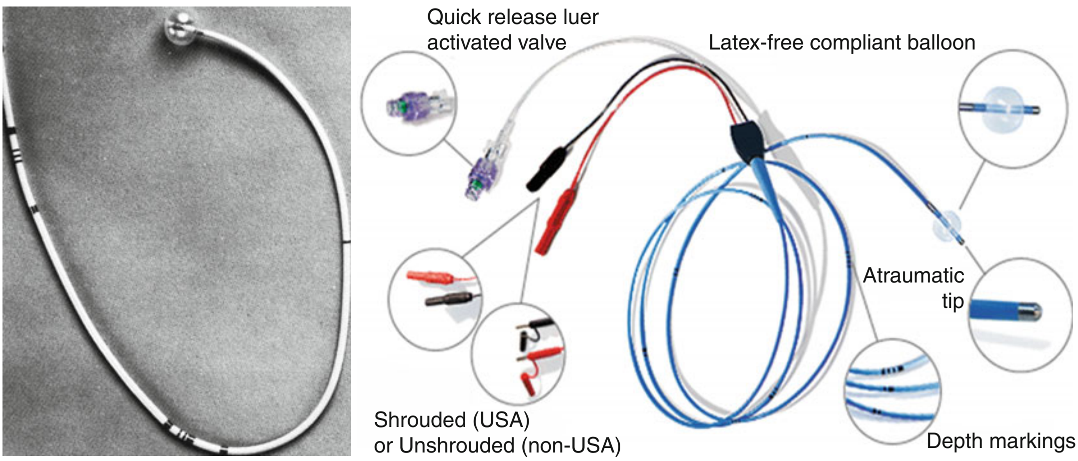

Fig. 13.24 *Top*: The floatation pacing lead has an inflatable distal balloon which helps delivery of the distal tip into the pulmonary artery and hence positioning of the bipolar leads in the RV. *bottom*: *The Helios*™ temporary pacing lead is a 5F latex-free radiopaque bipolar temporary pacing lead (110 cm long) with 8 mm balloon (Courtesy of Oscor® Inc., Palm Harbor, FL, USA)

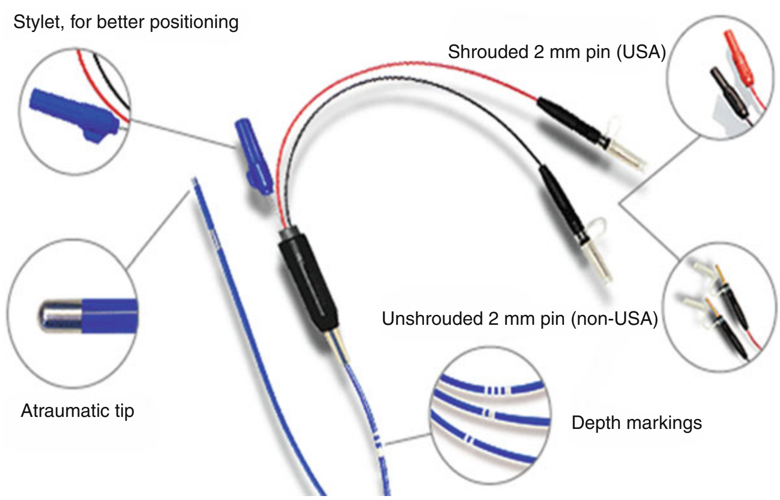

Fig. 13.25 *The TAU* 110 cm long bipolar electrode catheters (4–6F) are designed for EP studies – suitable for recording intracardiac signals and temporary pacing. The catheters have an inner lumen through which a stylet may be inserted in order to help placement within the right heart (Courtesy of Oscor Inc., Palm Harbor, FL, USA)

tricular apex. The *TAU* 110 cm long bipolar leads (4–6F) are designed for EP studies – suitable for recording intracardiac signals and temporary pacing (Oscor® Inc.). The leads have an inner lumen through which a stylet may be inserted in order to help placement within the right heart (Fig. 13.25).

V-Pace™ (APC Cardiovascular, Ltd.) are also bipolar temporary pacing leads for use in the right ventricle. They are 110 cm long, are available in 4–7F size, and the electrodes are 1 cm apart. The coaxial design, incorporating stainless steel conductors along the length of the catheter, ensures maximum strength and precise torque control. The smooth polyurethane surface reduces the risk of thrombosis and offers excellent biocompatibility.

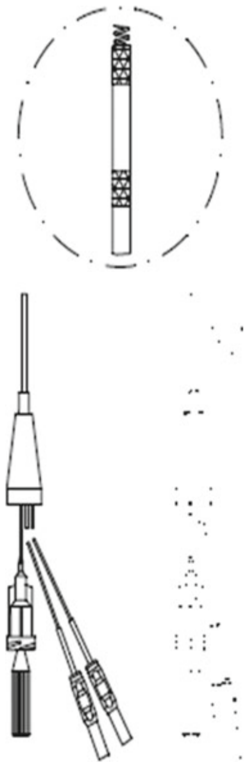

Fig. 13.26 The VascoStim Screw 2/6F screw-in temporary pacing lead (VascoMed®)

Fig. 13.27 Temporary pacing box from APC Medical

The VascoStim bipolar semi-floating pacing leads (VascoMed) are available in 4–6F diameters and in a straight, curved, or J-shape. A temporary screw-in lead is also available (VascoStim Screw 2/6F) (Fig. 13.26).

External Pulse Generators for Temporary Pacing

The external pulse generator allows adjustment of pacing output (voltage ± current), pulse width, pacing rate, mode and sensitivity to intrinsic activity (Figs. 13.27 and 13.28). Dual-chamber generators will offer adjustment of AV delay, PVARP, and MTR depending on stimulation rate (Figs. 13.28, 13.29, and 13.56) and a three-chamber temporary pacing generator for biventricular pacing is also available from Osypka (Fig. 13.30). The Oscor® PACE 203 H from Osypka provides easy measurement of P/R wave amplitude and optional AUTOSENSE function that automatically tracks P/R wave peak amplitudes and adjusts atrial and ventricular sensitivities accordingly. Most are now small enough to allow the patient to be ambulant, although atrial lead stability is the limiting factor in this regard. Generally, however, patients should be confined to bed when a temporary pacing lead is in situ. The generator's batteries should be checked daily (a 9 V alkaline battery provides approximately 5 days of continuous operation in the PACE 203 H) and care should be taken to avoid dropping the device and inadvertently pulling the lead out of position. Some generators allow high rate pacing – using a "x3" key, to allow for overdrive pacing of ventricular tachyarrhythmias (Fig. 13.31) or up to 1,000 ppm for rapid atrial pacing (e.g., PACE 203 H).

Techniques of TPM Insertion

It is important to be familiar with the venous anatomy (Fig. 13.32).

Internal Jugular Vein Puncture

The right internal jugular vein (IJV) is preferred to the left. Injury to the thoracic duct is avoided. The patient is tilted 15° head down and the head turned toward the opposite side. The landmarks are first identified. The IJV lies lateral to the carotid artery. The sternocleidomastoid muscle (SCM) overlies the IJV in the lower half of the neck. The apex of the triangle where the clavicular and sternal heads of the SCM meet is identified

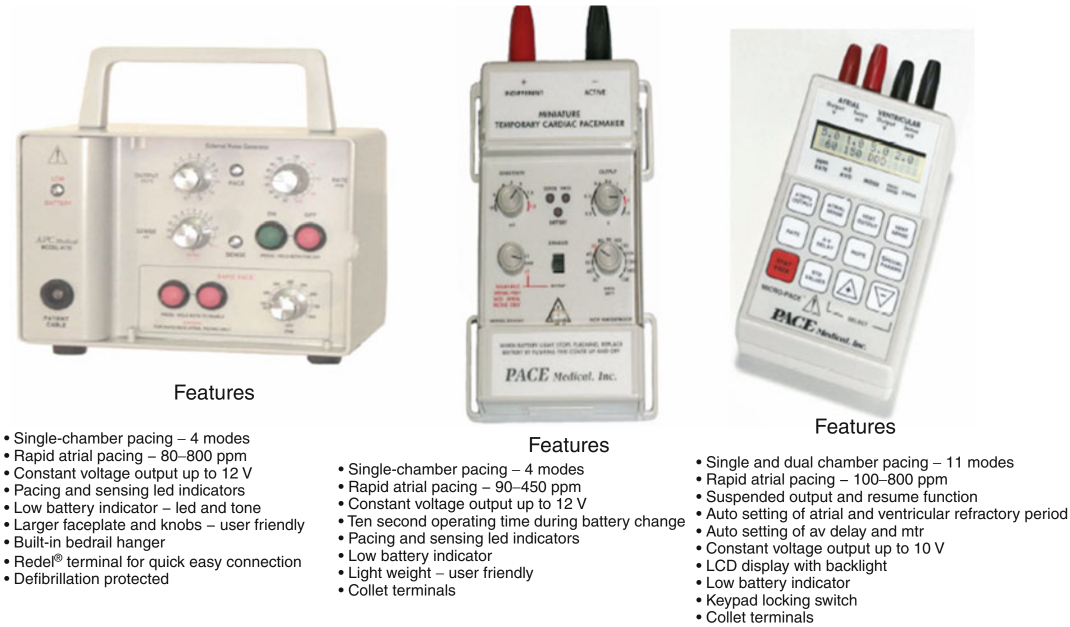

Fig. 13.28 Current temporary pacing devices available from APC Medical. *Left*: Bedside™ single-chamber pulse generator; *center*: Miniature™ single-chamber external pulse generator; *right*: MicroPace™ dual-chamber external pulse generator

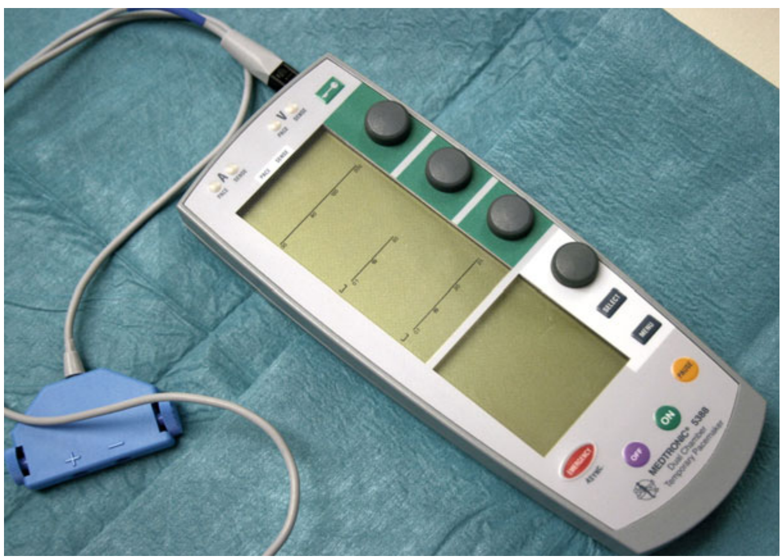

Fig. 13.29 Dual-chamber temporary pacemaker (Medtronic Inc.)

and local anesthetic should be infiltrated into this area. "Scouting" for the IJV with an 18 gauge needle is sometimes helpful and ultrasound-guided access of the IJV is to be recommended. An introducer needle is then inserted at a 45° angle pointing toward the ipsilateral nipple of the patient. As the needle is advanced, aspiration on the syringe should yield venous blood on entering the IJV. Keeping a finger on the carotid artery ensures that the puncture/needle direction is always lateral to the artery (Fig. 13.33). Once the needle is within the IJV lumen, a guidewire and

Fig. 13.30 PACE 300 three-chamber temporary pacemaker (Osypka) has a large range of features including AUTO SENSE for automatically tracking P/R wave peak amplitudes and adjusting atrial and ventricular sensitivities. An optional function automatically adjusts the settings for AV delay, PVARP and MTR depending on selected stimulation rate. A wide range of pacing modes are available

Fig. 13.31 This temporary pacing box from APC cardiovascular has a key to enable X3 pacing for overdrive pacing

introducer/sheath can be inserted over the wire and the sheath then sutured to the skin. The pacing lead can then be introduced through the sheath and positioned in the right ventricle and/or right atrium using fluoroscopy.

Subclavian Vein Puncture

This provides a suitable route of access to the venous system. It is quick, infection and lead displacement are unusual, and in experienced hands complications are rare. However, if permanent pacing is going to be required, then it is generally accepted to use the internal jugular, antecubital,

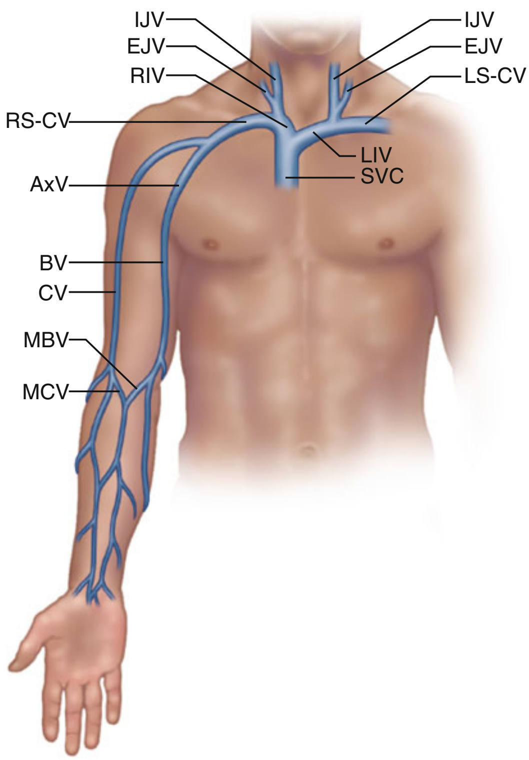

Fig. 13.32 Venous anatomy of the upper limb/upper mediastinum relevant to pacing. *MCV* median cephalic vein, *MBV* median basilic vein, *BV* basilic vein, *CV* cephalic vein, *AxV* axillary vein, *RS-CV* right subclavian vein, *RIV* right innominate vein, *LIV* left innominate vein, *LS-CV* left subclavian vein, *EJV* external jugular vein, *IJV* internal jugular vein, *SVC* superior vena cava

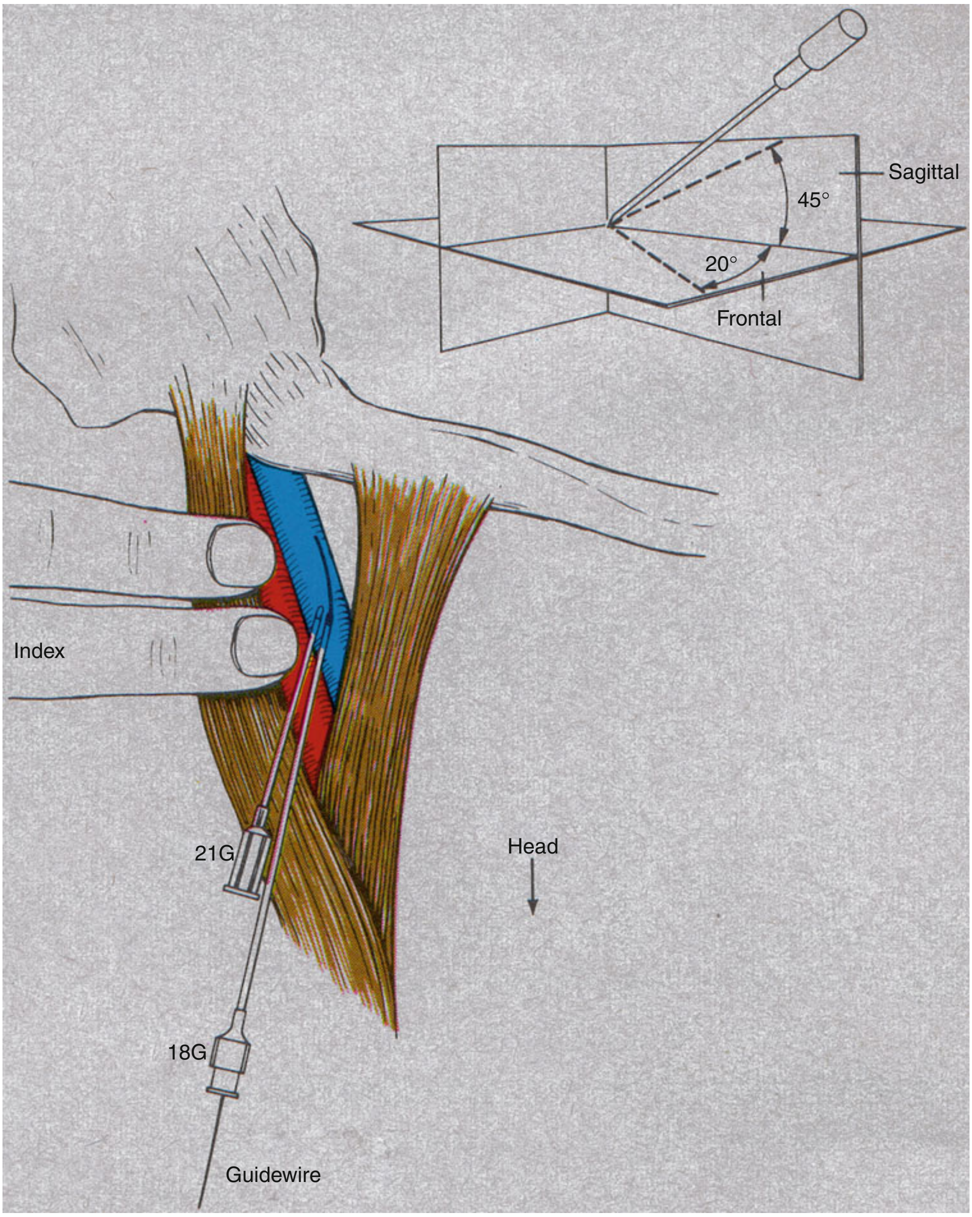

Fig. 13.33 Landmarks for puncture of internal jugular vein

or femoral vein so as to leave the subclavian veins available for permanent lead placement.

The subclavian vein runs behind the medial third of the clavicle and can be punctured using either supra- or infraclavicular approaches. The left subclavian venous approach is easier than the right, because of the straighter run into the superior vena cava (SVC). The technique of subclavian vein puncture and lead insertion is shown in Chap. 7.

The patient lies flat or in a slightly head-down position. A tiltable table is preferable so that the legs can be raised to improve venous return and distend the subclavian vein if the patient is hypovolemic (Fig. 13.34). Alternatively, intravenous fluid can be given prior to puncturing the vein. A needle is introduced through a 0.5 cm skin incision just below the inferior border of the clavicle and just lateral to the mid-clavicular point

Fig. 13.34 Head-down tilt on the pacing table may be helpful for avoiding air-embolism during temporary pacemaker insertion from the subclavian/jugular veins

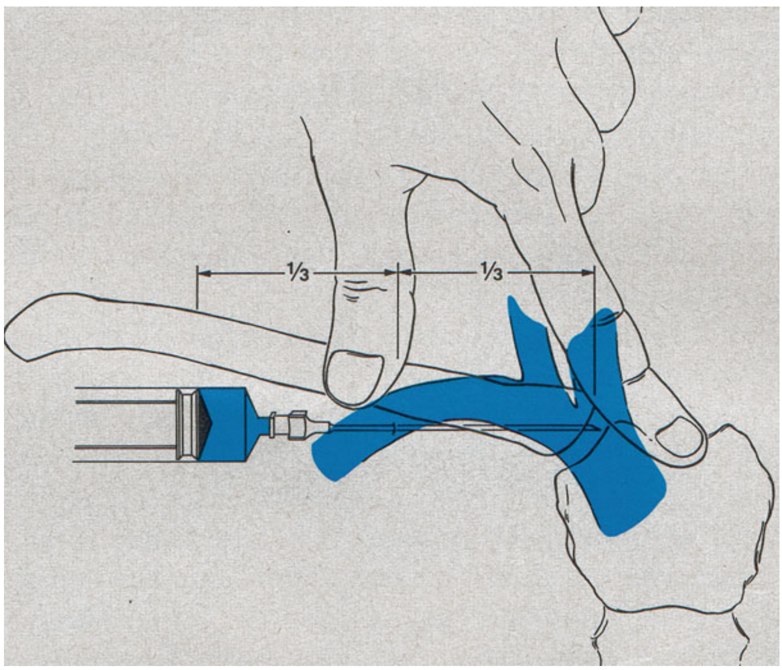

Fig. 13.35 Landmarks for subclavian vein puncture

and is directed toward the suprasternal notch so it passes immediately behind the posterior surface of the clavicle (Fig. 13.35). Feeling the undersurface of the clavicle with the needle tip during entry helps to keep it superficial and avoid subclavian artery puncture and pneumothorax (see Chap. 7).

When the subclavian vein is entered, venous blood will be easily aspirated from this large vein. The syringe is removed (taking care not to move the needle) and a soft-tipped J-shaped guidewire is then inserted through the needle and into the subclavian vein and advanced through the left brachiocephalic vein into the SVC. The needle is then

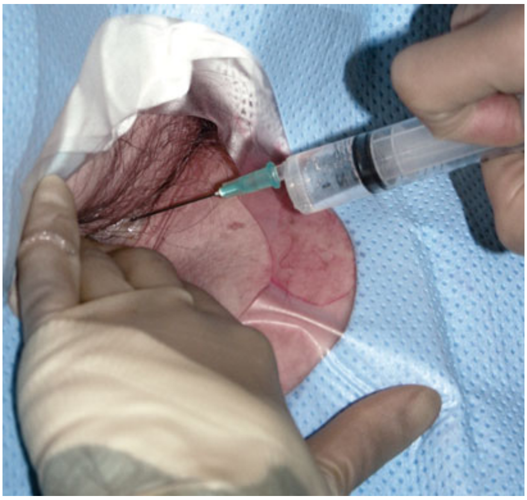

Fig. 13.36 Local anesthetic being administered in region of femoral vein

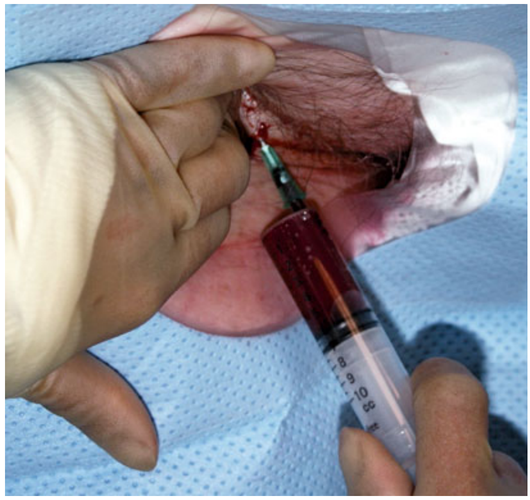

Fig. 13.37 Blood aspiration from the femoral vein

removed and a sheath within which there is a tapered vessel dilator is passed over the wire into the vein. Care must be taken to ensure that the guidewire always extends outside of the sheath during its insertion in order to avoid losing the guidewire within the venous system. The guidewire and dilator are then removed, leaving the sheath in situ, and the pacing lead is then passed through the sheath along the same route to the SVC and right atrium. Ensuring a head-down position during insertion and blood flow out of the needle and sheath during insertion of the guidewire and pacing lead, respectively, should prevent air embolism from occurring. An alternative approach should be considered if the patient has received thrombolytic therapy, is anticoagulated, or if the contralateral subclavian vein has been used and permanent pacing is likely to be required.

Femoral Vein Puncture

This is perhaps the easiest and quickest venous access route for establishing temporary pacing. Using a similar needle/sheath technique to that described above and local anesthesia, entry into the femoral vein is usually easy, the femoral vein being located just medial to the femoral artery pulse (Figs. 13.36–13.41). A splittable sheath can also be used. The lead is then inserted into the sheath (Fig. 13.42), passed up the external and

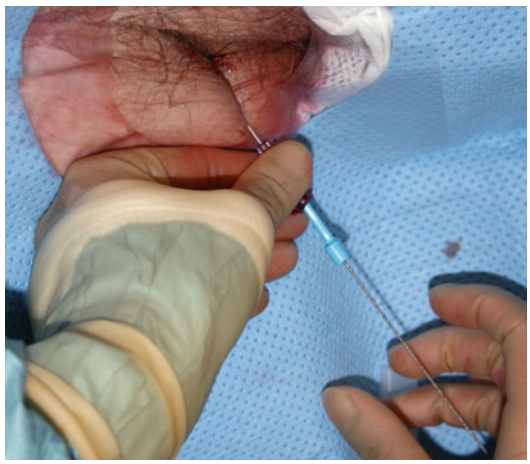

Fig. 13.38 Insertion of the guidewire

common iliac veins and into the inferior vena cava and then into the right atrium using X-ray fluoroscopy. Most leads are slightly curved and advancing the lead across the tricuspid valve into the RV apex usually requires little manipulation (see Fig. 13.18). Figure 13.43 shows a diagrammatic representation of this usually simple maneuver. Unfortunately lead stability is not as good as when inserted via the subclavian vein, and infection and venous thrombosis are slightly greater risks. It should be reserved for short-term emergency pacing such as post-cardiac arrest/collapse complicated or caused by complete heart block,

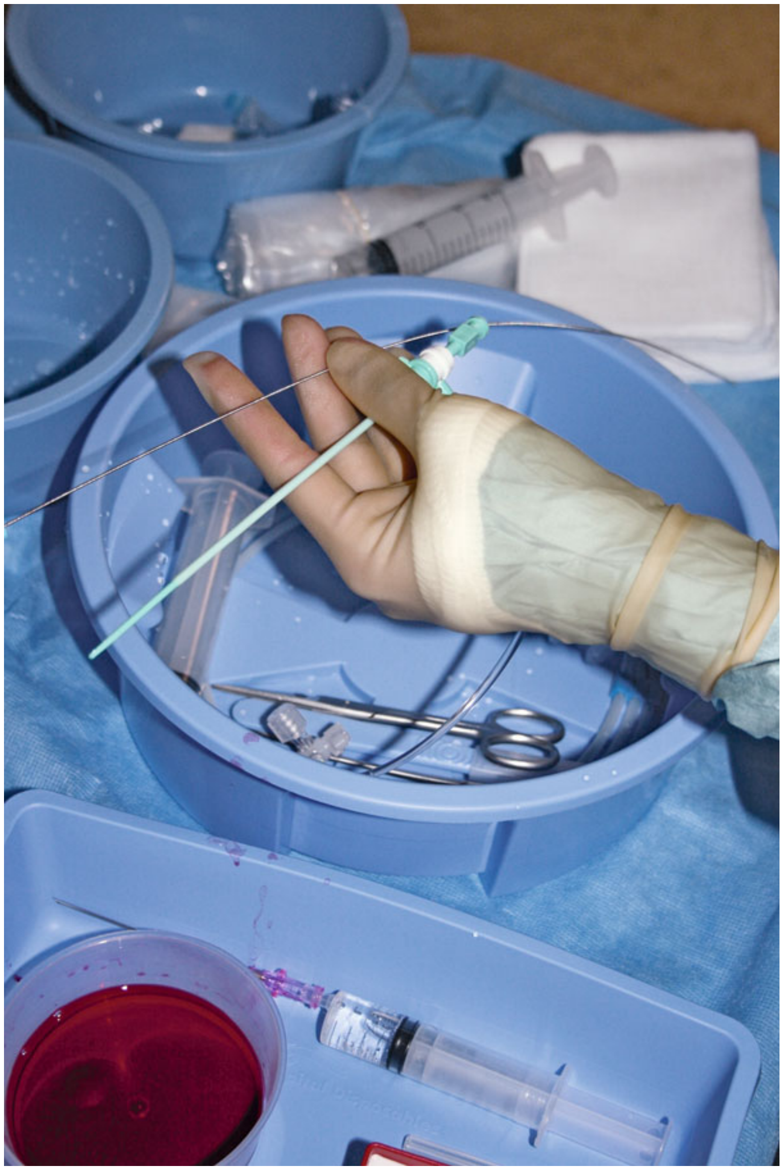

Fig. 13.39 Setting up the introducer sheath

severe bradycardia, sinus arrest, or asystole. Once established, a subclavian pacemaker can then be inserted more leisurely and then the femorally placed lead removed. Electrophysiologists use the femoral route for inserting one or more temporary pacing leads during EP studies (see Fig. 3.12) and when temporary pacing cover is required during a generator change in a pacemaker-dependent patient.

Antecubital Vein Puncture

This route may be chosen if the patient has received thrombolytic therapy or is anticoagulated. A medially placed vein should be used such as the median basilic vein. Although enticing, laterally placed veins do not provide easy entry into the SVC. Like the femorally placed leads, lead stability is relatively poor and phlebitis and infection are not uncommon.

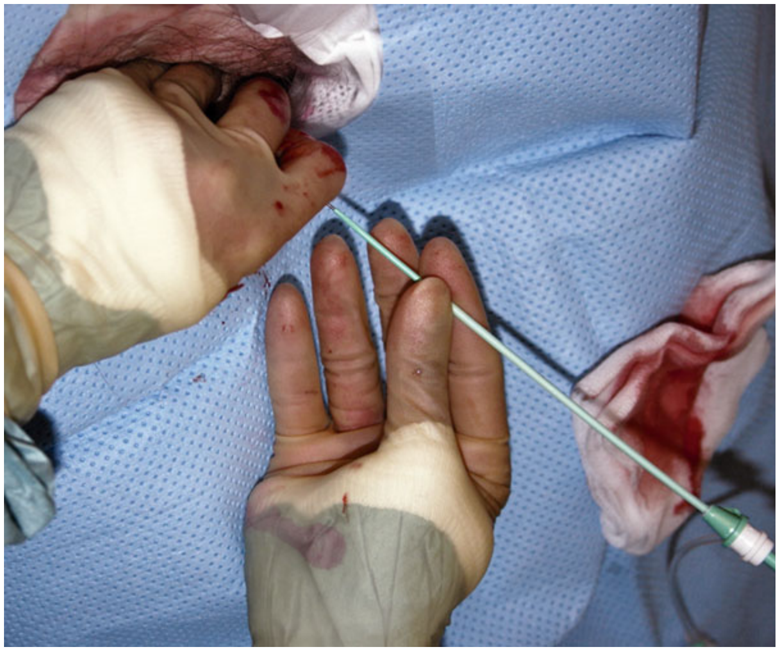

Fig. 13.40 Inserting the introducer sheath over the guidewire

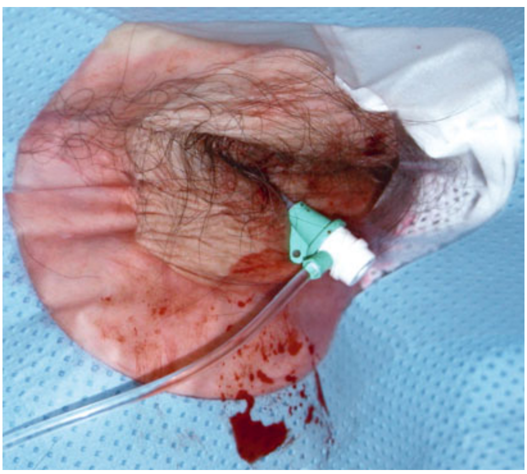

Fig. 13.41 Introducer sheath fully inserted into the femoral vein

Fig. 13.42 Inserting the temporary pacemaker lead into the sheath

Positioning of the Lead

From the Antecubital, Subclavian, or Jugular Vein

After placing the pacing lead into the venous system, the lead is advanced into the SVC and into the right atrium. There should be no resistance during advancement. If obstruction is felt, the lead should be withdrawn slightly, rotated and then advanced again under fluoroscopy. Occasionally congenitally abnormal anatomy may be encountered such as a left-sided SVC, when the course of the lead should raise this possibility (Fig. 13.44). Contrast injection can usually show the operator unusual anatomy or

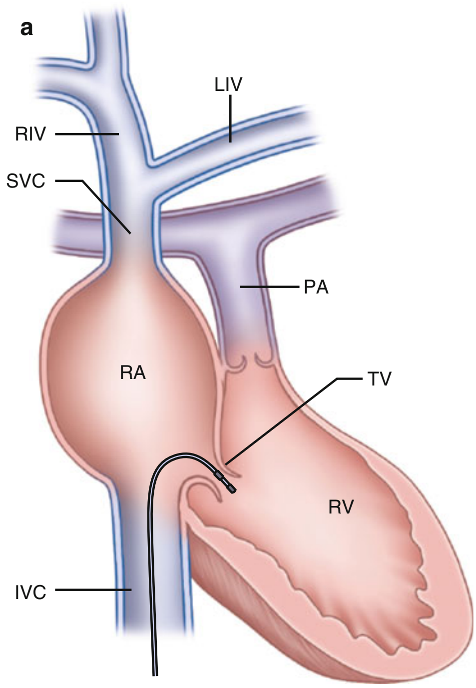

Fig. 13.43 (**a**) From the femoral vein, a temporary pacing lead is simply advanced up the IVC and into the RA using fluoroscopy. A gentle pre-shaped curve on the lead helps to point the tip across the tricuspid valve. (**b**) The lead tip can be simply advanced across the valve and into the RV apex (*arrow*) *RIV* Right Innominate Vein; *LIV* Left Innominate Vein; *SVC* Superior Vena Cava; *RA* Right Atrium; *TV* Tricuspid Valve; *IVC* Inferior Vena Cava; *RV* Right Ventricle; *PA* Pulmonary Artery

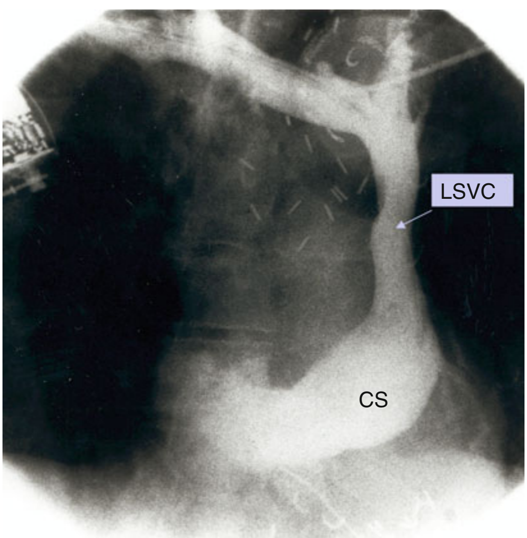

Fig. 13.44 Unusual route taken by pacemaker lead via a left-sided SVC is confirmed by injection of contrast agent *CS* Coronary Sinus; *LSVC* Left Superior Vena Cava

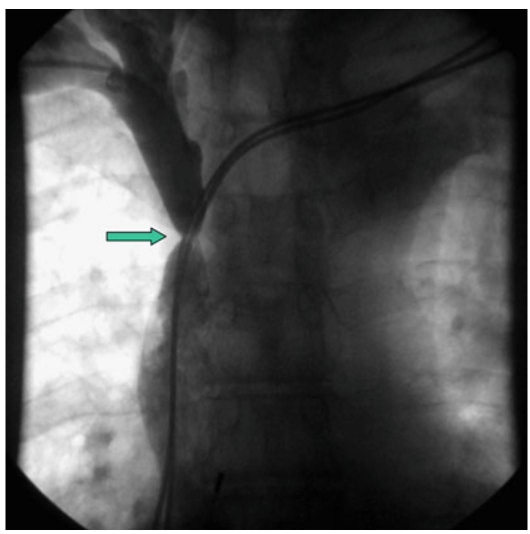

Fig. 13.45 Contrast injection can identify areas of obstruction in the great veins resulting from fibrosis associated with chronically implanted permanent leads (*arrow*)

venous obstructions that can sometimes occur in patients who have had several pacing leads placed in the subclavian vein or SVC (Figs. 13.45 and 13.46).

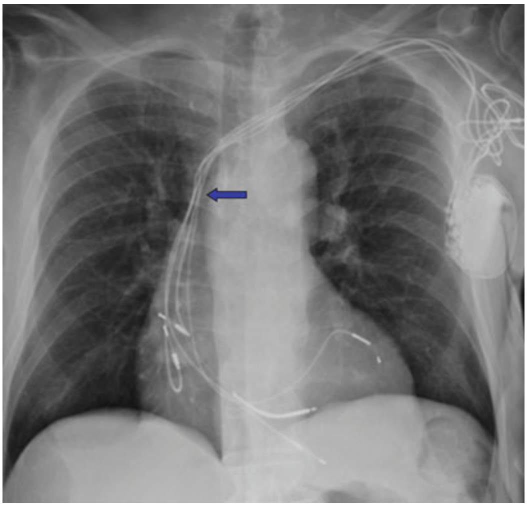

Fig. 13.46 Multiple leads in the SVC (current and redundant) are more likely to result in fibrosis and obstruction of the SVC (*arrow*)

Once within the right atrium, a loop should be formed by pushing the lead tip against the atrial wall while simultaneously advancing the lead (Fig. 13.47). The lead may then cross the tricuspid valve (TV) or this can be achieved by twisting the lead in order to rotate the loop toward and across the TV. Otherwise slight advancement or withdrawal should allow the lead to cross the TV into the RV. It can then be gently advanced and slightly rotated into the RV apex. Further slight withdrawal and advancement may be necessary to position the lead tip in an optimal position with a low pacing threshold. Alternatively if the lead is advanced up into the pulmonary artery, which confirms entry into the RV, the lead must then be withdrawn into the body of the RV and then rotated and advanced into the RV apex. Fluoroscopy in anteroposterior view shows the lead tip pointing toward the RV apex with a gentle downwards curve (see Fig. 13.18).

Ventricular ectopic beats commonly occur on entering the RV and nonsustained ventricular tachycardia less commonly.

As indicated above, during lead positioning it is often useful to cross the TV and advance the lead into the right ventricular outflow tract before withdrawing it and rotating the tip downwards into the RV apex. Placement of the lead into the coronary sinus looks similar to placement in the RV outflow tract when screening in the PA projection. Correct placement can be confirmed by fluoroscopy in the left anterior oblique or left lateral view. If in the coronary sinus, the lead will usually point posteriorly, whereas in the RV outflow tract or apex the lead tip will point anteriorly (Fig. 13.48).

From the Femoral Vein

The lead is advanced up the inferior vena cava into the right atrium. The "C"-shaped distal section of most temporary pacing leads makes it quick and easy to advance across the tricuspid valve into the RV apex. Slight rotation of the pacing lead may be necessary to cross the tricuspid valve (see Fig. 13.43).

Initiating Pacing

Once a stable pacing lead position is obtained, the proximal and distal poles of the lead should be connected to the external pacemaker (Figs. 13.49–13.51). The proximal pole should be connected to the pacemaker's anode (+ve) (red) and the distal pole to the cathode (−ve) (black), respectively. If the poles are inadvertently reversed, the pacing threshold will be significantly higher.

The minimum voltage necessary for pacing stimuli to capture or pace the ventricle consistently, the pacing threshold should then be measured by the technician (Fig. 13.52). Starting at 3 V, the pacemaker amplitude or output is decreased by 0.1 V progressively until the pacing spike ceases to produce a QRS complex (Fig. 13.53). This is the pacing threshold and generally it should be less than 1 V with a pulse duration of 1 ms. Usually, the output is set at 2 V (or double the threshold) above the pacing threshold. The stability of the pacing lead is tested by observing the paced ECG during deep inspiration or coughing. It is usually worth looking at the lead by fluoroscopy during the deep inspiration to ensure the correct amount of "slack" is present in the right atrium. Figures 13.54 and 13.55 respectively show the ECG before and after right ventricular pacing.

If pacing output needs to exceed 5 V or 10 mA, repositioning should be considered.

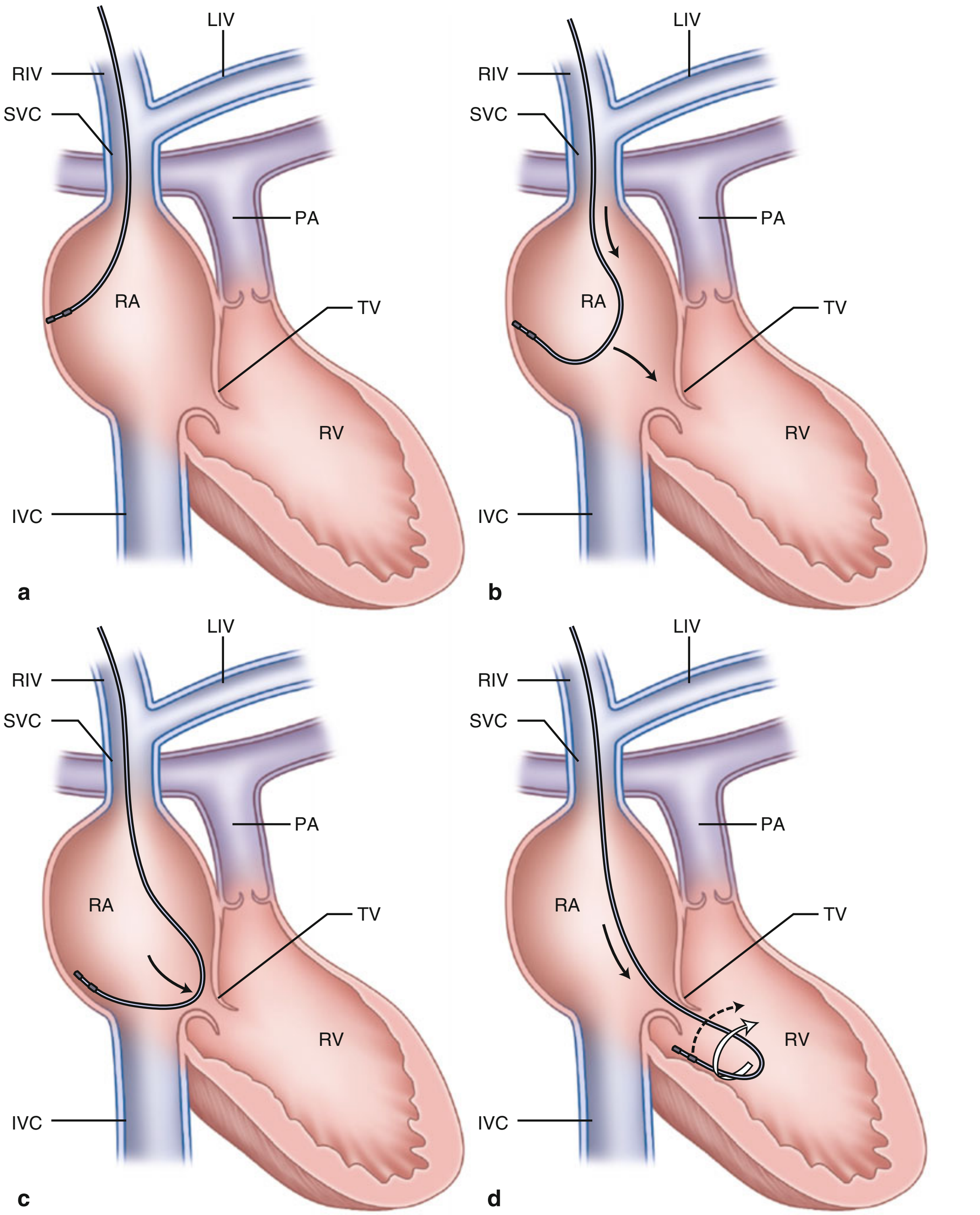

Fig. 13.47 Placement of a temporary pacing lead into the RV apex from the internal jugular, subclavian or axillary veins (**a**). Once into the SVC, the lead tip should be pushed gently against the RA free wall in order to form a "C-curve" (**b**). (**c**) Further advancement will prolapse the lead across the tricuspid valve (TV) and into the RV. (**d**) Once across the TV, the lead can be rotated in order to turn the bipolar tip to point and be advanced upwards toward the RVOT. (**e**) With the tip of the electrode pointing toward the RVOT, the lead can then be straightened by gentle withdrawal (**f**) and then advanced toward the RV apex (**g**). (**h**) Some slack should be left in the RA to allow for straightening with inspiration and the tip should ideally point slightly downwards and anteriorly *RIV* Right Innominate Vein; *LIV* Left Innominate Vein; *SVC* Superior Vena Cava; *RA* Right Atrium; *TV* Tricuspid Valve; *IVC* Inferior Vena Cava; *RV* Right Ventricle; *PA* Pulmonary Artery

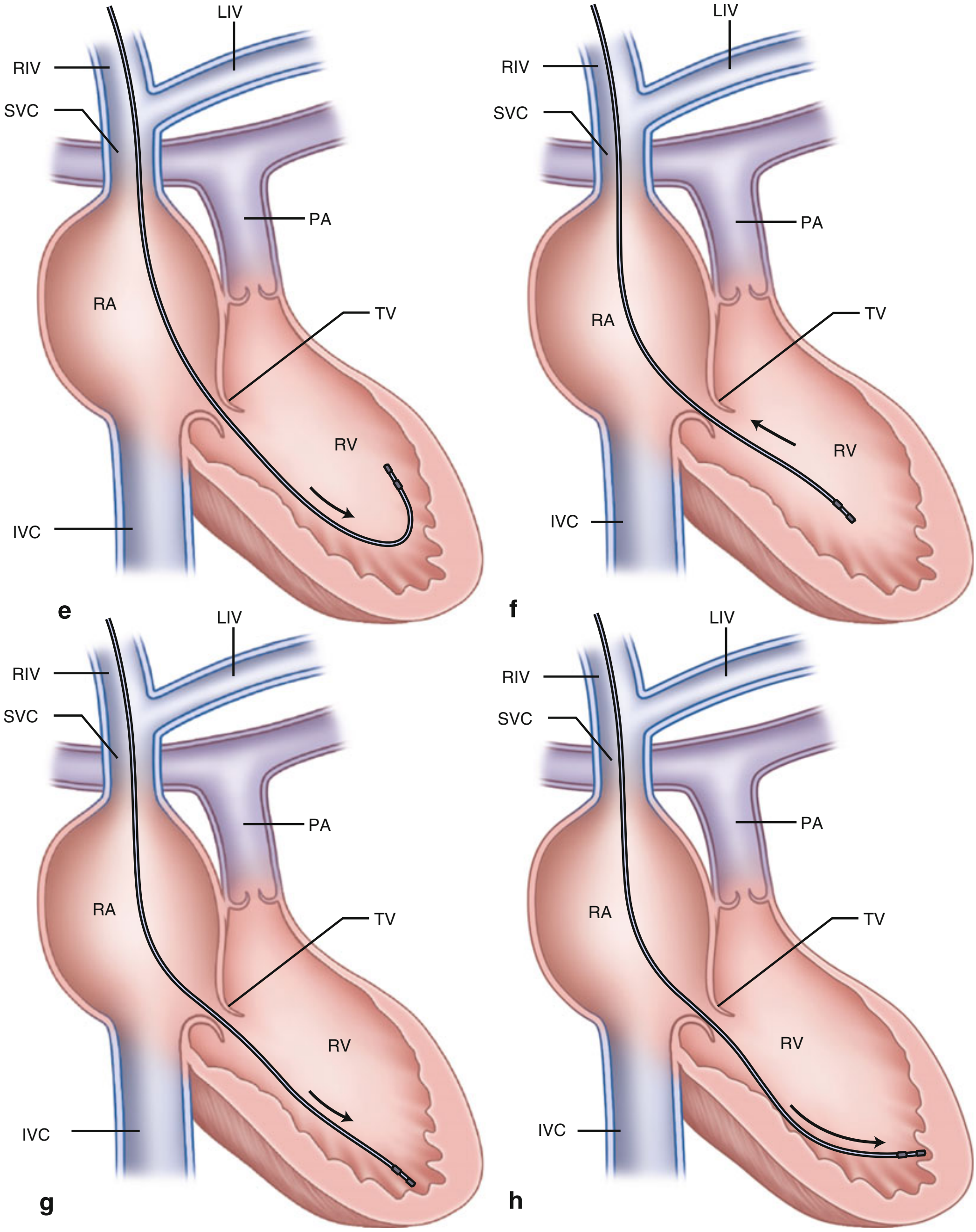

Fig. 13.47 (continued)

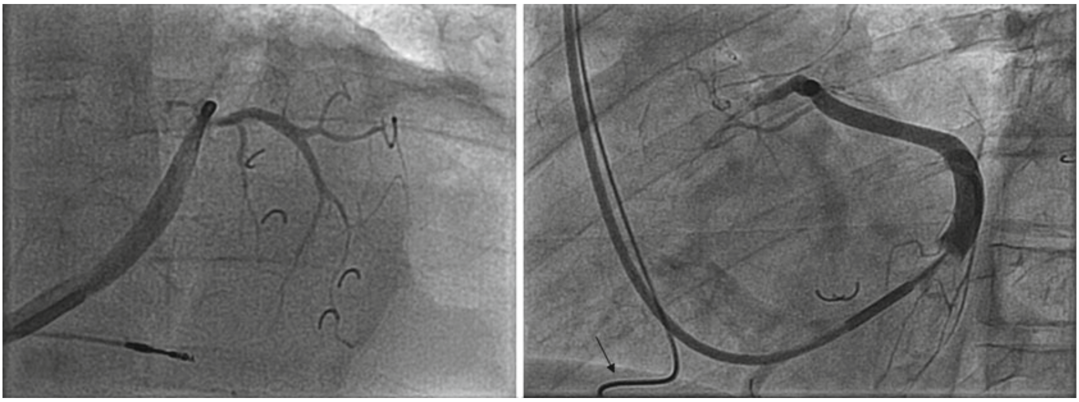

Fig. 13.48 *Left* (*PA view*): Contrast filling of the coronary sinus (CS) shows how placement of a lead into the CS may look similar to an RV outflow tract position. *Right* (*left lateral view*): contrast filling of the CS shows that such a lead is positioned posteriorly. Note the permanent pacemaker lead in the apex of the RV and pointing anteriorly (*arrow*)

Fig. 13.49 The temporary pacing lead and sheath are sutured to the skin and extended across the drape to be connected to the pacing cable attached to the temporary pacing generator/box

In an emergency, if the position is not ideal and the threshold high, repositioning the lead is necessary. However, if the patient has become pacemaker dependent, a second pacemaker lead should be placed from the femoral vein until the subclavian lead is safely repositioned.

The pacing lead is then sutured to the skin with two sutures at its point of entry with separate sutures securing redundant loops to the skin. After cleaning the skin with povidone-iodine or chlorhexidine solution, the site should then be covered with a sterile dressing.

The pacing threshold should be checked daily as should the battery and electrical connections. Unnoticed accidental disconnection might lead to ventricular standstill and death.

Paced patients should be monitored on a coronary or intensive care unit.

Fig. 13.50 Operator gives the sterile connections to the technician who plugs them into the cable connections

Fig. 13.51 Pacing connections being made

AV Sequential Pacing

For patients with a low cardiac output and sinus bradycardia or heart block, AV sequential pacing can improve cardiac output by up to 30% more than ventricular pacing alone. Two pacing leads – a pre-shaped J lead placed in the RA appendage and a straight pacing lead placed into the RV apex – are necessary (see above). A special AV sequential temporary pacing generator is required to which the anode and cathode of each pacing lead must be connected (Fig. 13.56). The atrial pacing threshold tends to be higher than the ventricular threshold.

Fig. 13.52 Pacing threshold being tested using the ECG on the Lifepak 12 as the voltage output from the temporary pacing box (Medtronic Inc.) is slowly reduced

Complications

Although transvenous temporary pacing is superficially a simple procedure, complications are not uncommon. They may be avoided by ensuring that the procedure is only performed by experienced or supervised operators and only when indicated.

Insertion and positioning of a temporary transvenous pacemaker lead may be associated with cardiac arrhythmias such as atrial and ventricular ectopic beats, atrial tachycardia, flutter or fibrillation, ventricular tachycardia, ventricular fibrillation, complete heart block, and asystole. Other complications include pneumothorax, hemothorax, right ventricular perforation, hemopericardium and cardiac tamponade and are all serious. Pericarditic pain and a pericardial friction rub suggest RV perforation. An "intracardiac signal" can be recorded by connecting the TPM lead to the V lead of an ECG machine. If the lead tip is against the endocardium, a good endocardial potential of 1.5–10 mV should be evident. After myocardial perforation and with the lead tip in the pericardium, the endocardial signal is lost and ST-depression and T-wave inversion will be recorded.

Injury to the brachial plexus and thoracic duct, bleeding from the subclavian vein, and even hemothorax as a result of subclavian artery puncture are potential but rare complications when pacing is performed via the infraclavicular route. Lead displacement may result in failure to pace and failure to sense and inappropriate pacing.

Microdisplacement (no obvious displacement on CXR) may be overcome by increasing the pacing output voltage and/or pulse width. If

Fig. 13.53 An example of a rhythm strip showing loss of ventricular capture at 0.27 V

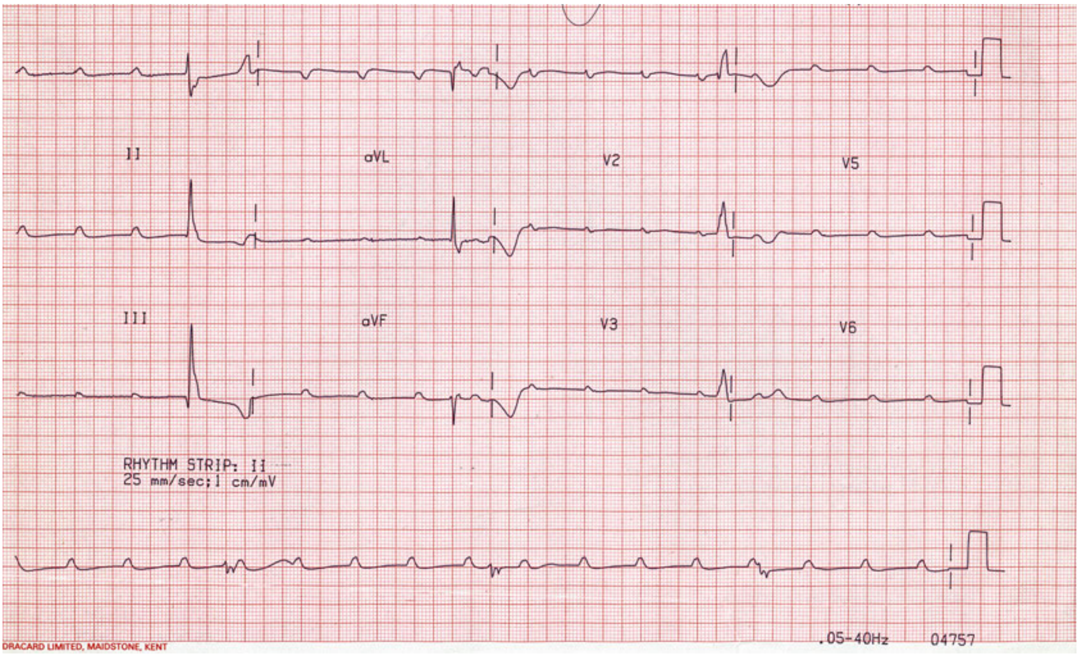

Fig. 13.54 12-Lead ECG showing complete heart block prior to pacing

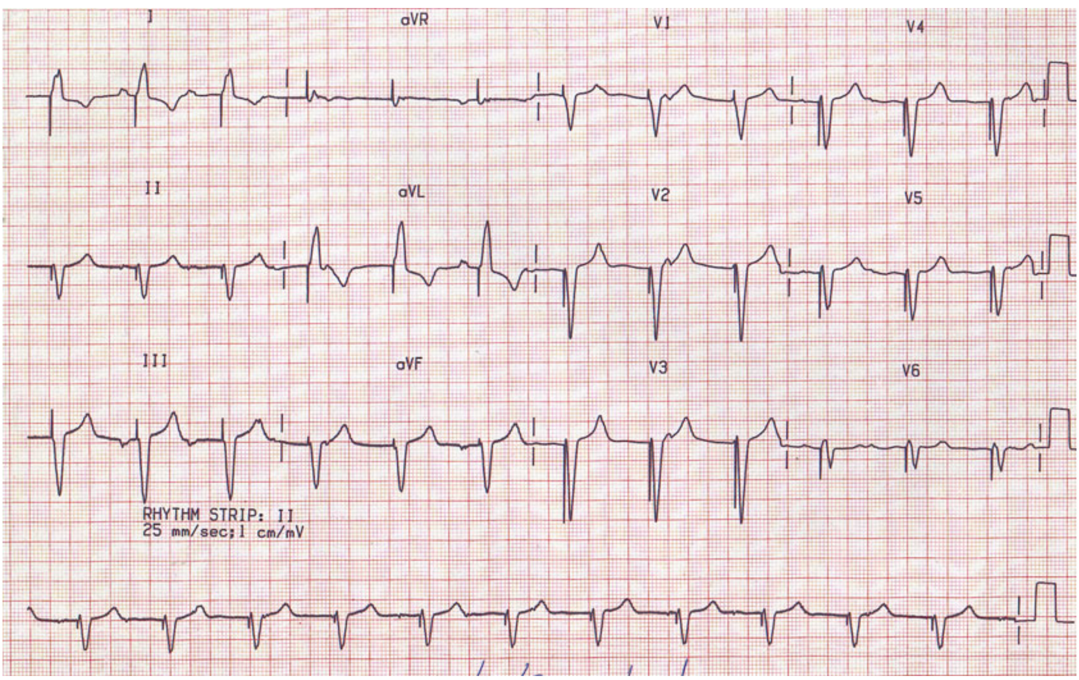

Fig. 13.55 12-Lead ECG showing VVI pacing

Fig. 13.56 Dual-chamber temporary pacing generator (Courtesy of Oscor® Inc., Palm Harbor, FL, USA)

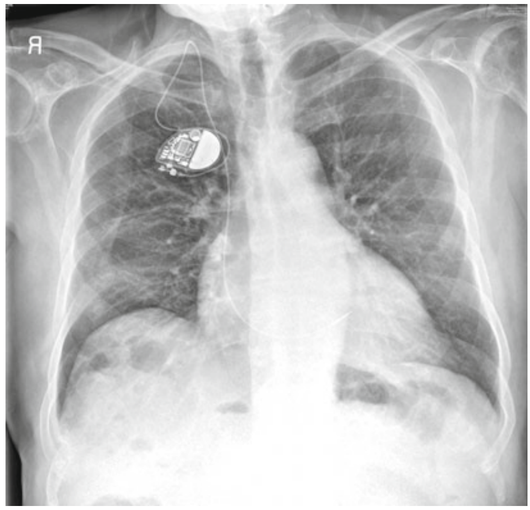

Fig. 13.57 Semi-permanent pacing. Here a permanent pacing lead is placed and actively fixed into the interventricular septum via the right internal jugular vein and then inserted into a nonsterile permanent generator attached to the skin on the chest wall by adhesive tape

this fails, repositioning of the lead will be necessary – as when lead displacement is obvious radiologically.

Disconnection of the lead from the pacing box or inappropriate settings may result in pacing failure as may breakage of the lead or its connections.

Once the TPM is placed in the RV, the patient may become immediately pacemaker-dependent, making repositioning difficult.

Infection is not uncommon when temporary pacing is required for several days. At the first signs of infection, swabs should be taken from the site and antibiotics commenced. If pyrexia occurs, blood cultures should be taken. *Staphylococcus epidermidis/aureus* are the commonest organisms responsible for infection, although coliforms may be responsible when the femoral route has been used. In the presence of pyrexia, IV antibiotics, for example, IV flucloxacillin 1 G QDS should be commenced once blood cultures have been sent to the microbiology laboratory, since staphylococcal septicemia is likely. A move should be made to remove the infected TPM and replace it with a new TPM on the opposite side if temporary pacing is still required.

Deep venous thrombosis and thromboembolism may be a complication when pacing is performed from the femoral vein.

Semi-permanent Pacing

Occasionally, temporary pacing is required for several weeks, for example, in patients with infective endocarditis affecting the tricuspid valve as a result of an infected pacing system and requiring several weeks of IV antibiotics. In this situation, a permanent lead may be placed into the RV apex via the internal jugular vein, and tunneled under the skin to the pectoral region where it is inserted into a nonsterile permanent generator attached to the skin by a tape and/or a suture (Figs. 13.57 and 13.58).

Temporary Epicardial Pacing

If temporary pacing is indicated during cardiac surgery, special myocardial pacing leads can be sutured directly to the surface of the right atrium, right ventricle, or left ventricle (Fig. 13.59) and

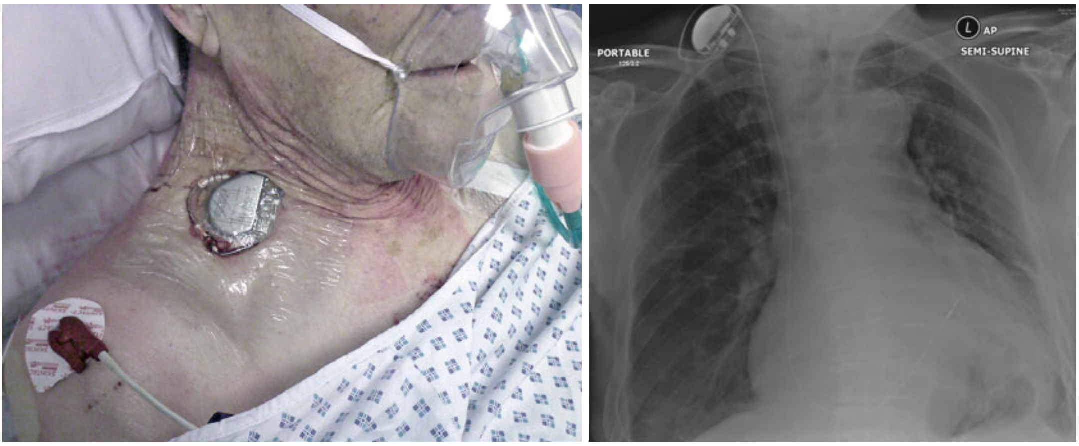

Fig. 13.58 Permanent pacemaker is fixed externally to the skin above the clavicle by a clear adhesive dressing. A lead is actively fixed to the right side of the interventricular septum and attached to the permanent pacemaker in order to provide semi-permanent pacing

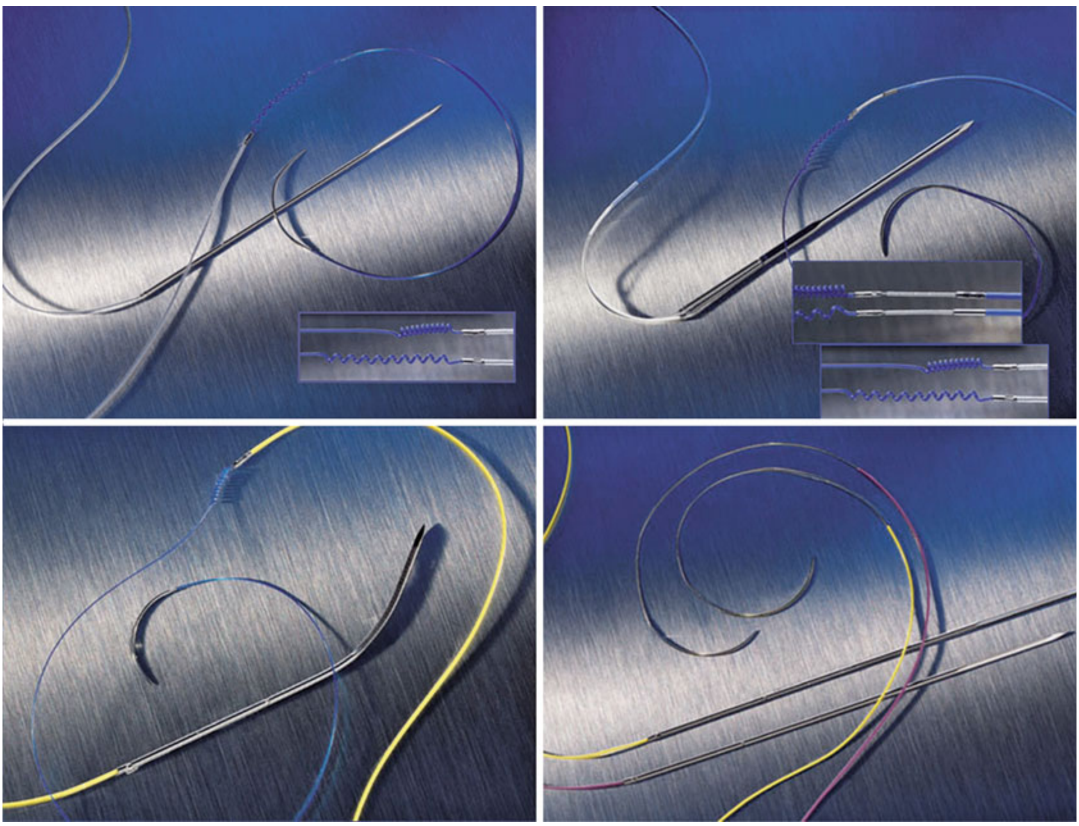

Fig. 13.59 Epicardial leads from Medtronic. *Top left*: Unipolar myocardial lead (Premium 6500); *Top right*: Bipolar coaxial (Model 6495) lead with fixation coil; *Bottom left*: Pediatric unipolar lead (Model 6491) has features specifically useful for children, e.g., smaller fixation coil; *Bottom right*: The Convenience (Model 6494) unipolar lead has some improved features such as smaller diameter needles and color-coded wires (Image reproduced with permission of Medtronic, Inc.)

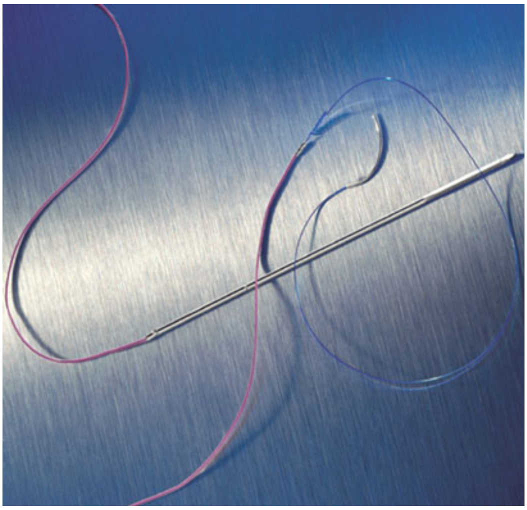

Fig. 13.60 Atrial epicardial unipolar lead from Medtronic (Model 6492) is well suited for suturing to thin, delicate atrial tissue (Image reproduced with permission of Medtronic, Inc.)

the proximal ends tunneled out through the skin for connection to a temporary pacing box (Fig. 13.2). The leads can be unipolar or bipolar. Atrial epicardial leads are also available (Fig. 13.60). The leads can be removed when no longer required by simply applying firm traction to the leads exiting the skin.