A guide to temporary pacing

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Temporary cardiac pacing is a necessary skill for any doctor concerned with managing patients with life threatening bradycardia. Often, in the district hospital setting, an inexperienced member of an acute medical team will be called on to support the heart rate of a sick patient by inserting a temporary pacing electrode. Apart from knowing when to institute pacing, this requires proficient central venous cannulation and manual dexterity for stable positioning of the catheter. Temporary pacing is probably more difficult than permanent pacing for which the electrodes have a pliant stylet, and can be steered to some extent. Also, temporary pacing commonly is required under the most stressful conditions when the patient's life may depend on rapidly achieving and maintaining reliable pacing.

Because temporary pacing may be difficult and may be undertaken by junior staff, factors facilitating the procedure must be optimised. All junior staff should have a clear idea of the indications for pacing, both temporary and permanent. The location of, and access to, pacing facilities should be known to all staff who may be concerned with temporary pacing. Once inside the pacing room it is the doctor's responsibility to know exactly what equipment is available and to direct nursing and radiographic staff. Published work suggests that the performance of temporary cardiac pacing is poor,¹ and in this article we provide some guidelines for a better practice of this skill.

Indications for temporary pacing

The indications for temporary pacing are actual or threatened bradycardia due to conduction tissue disease, acute myocardial infarction, procedures that may be associated with important bradycardia, or overdrive suppression of malignant ventricular arrhythmias (for example, torsades des pointes).

Box 1 gives more details of these indications. With all acute bradycardias it is important to remember that there may be serious underlying heart disease—for example, acute inferior infarction with sinus bradycardia—and important underlying aortic valvular stenosis with complete atrioventricular block. However, usually this will not deter the application of temporary pacing.

There are no categorical rules about the need for temporary pacing. For example, complete atrioventricular block after acute anterior infarction is an indication for immediate temporary pacing, but congenital complete atrioventricular block may not require pacing. The circumstances of actual or threatened bradyarrhythmia are always important and usually the decision to pace will be taken by an experienced doctor.

Pacing after acute myocardial infarction

Early experience in coronary care showed that about 8% of acute myocardial infarctions were complicated

Indications for temporary pacing

- Important bradycardia due to conduction tissue disease

When permanent pacing is not immediately available for:

- Atrioventricular block
- Sinoatrial disease

- Acute myocardial infarction

Anterior infarction

- Complete atrioventricular block
- Second degree atrioventricular block
- Right bundle branch block, left posterior hemifascicular block, and 1° atrioventricular block
- Right bundle branch block, left anterior hemifascicular block, and 1° atrioventricular block
- Left bundle branch block and 1° atrioventricular block
- Left bundle branch block if acquired during present infarction

Inferior infarction

Any of the above where there is actual or threatened haemodynamic compromise (usually the bundle branch patterns will have been pre-existing) and where pacing can be instituted at small risk to the patient

- Cover for potentially bradycardiac procedures

General anaesthesia in:

- Complete atrioventricular block
- Intermittent atrioventricular block
- Right bundle branch block, left posterior hemifascicular block, and 1° atrioventricular block
- Right bundle branch block, left anterior hemifascicular block, and 1° atrioventricular block
- Left bundle branch block and 1° atrioventricular block
- Right bundle branch block, left posterior hemifascicular block, and 1° atrioventricular block
- Right bundle branch block, left anterior hemifascicular block, and 1° atrioventricular block
- Left bundle branch block and 1° atrioventricular block

Cardiac surgery, particularly aortic and tricuspid surgery, ventricular septal defect closure, and ostium primum repair

Cardiac catheterisation, especially right heart catheterisation in the presence of left bundle branch block

Coronary angioplasty (rarely)

- Overdrive suppression of tachyarrhythmias
- Rarely required but may assist drug treatment of acute arrhythmias

by Mobitz type II and complete atrioventricular block.² Of these, 80% were inferior infarctions³ and the mortality at 5-20% was much lower than that for anterior wall infarction at 40-100%.⁴ In inferior infarction the ventricular complexes are often narrow and the escape rate relatively fast, while the converse is true of

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anterior infarction. This often reflects the fact that a dominant right coronary artery supplies the atrio-ventricular nodal artery, and occlusion leads to dysfunction of nodal tissue that is shown on histological testing to be the result of tissue oedema rather than necrosis, and may be mediated by local release of adenosine.⁵ Anterior infarction associated with heart block, however, usually reflects tissue necrosis in the His-Purkinje system. With inferior infarction it may be possible to achieve a satisfactory heart rate without artificial pacing by infusion of atropine in doses of 0.3-1.2 mg, titrated against heart rate response. Occasionally this will be ineffective, usually reflecting poor left ventricular function perhaps due to previous damage. Pacing, however, will sometimes produce striking benefit and should be reserved for patients who fail to respond to atropine and show signs of cardiogenic shock with low heart rate and blood pressure, poor urine output, and poor peripheral perfusion.

With anterior infarction complete heart block is usually accompanied by cardiogenic shock, and heart rate support may be required urgently. Ventricular pacing is usually the minimum requirement, as His-Purkinje necrosis will not respond to atropine. Dual chamber pacing may be even more beneficial, producing its maximum increment to cardiac performance at rest (relatively low heart rate).

Despite these clear indications for pacing there are important arguments against packing. Circumstances in which pacing might be relatively contraindicated include the following:

- Where central venous cannulation is risky—for example, soon after thrombolysis
- If the operator is inexperienced
- If a sick patient would have to be moved to perform the procedure
- In unstable patients who are more likely to develop serious arrhythmias related to the passage through and positioning in the heart of the electrode.

Prophylactic pacing after acute myocardial infarction

Potential complications of the procedure itself must be given greater weight when considering temporary pacing for prophylaxis after myocardial infarction. In order of importance reasons for prophylactic pacing are:

- (1) Right bundle branch block and left posterior hemifascicular block with prolonged PR interval.
- (2) Right bundle branch block and left anterior hemifascicular block with prolonged PR interval.

(3) Left bundle branch block and prolonged PR interval.

(4) Left bundle branch block acquired during the infarction.

In these circumstances it is a matter of judgment as to when the possible benefits of pacing outweigh the risks of insertion.

Thrombolysis

Giving thrombolytic agents to patients with acute myocardial infarction creates special problems if the arterial circulation is accidentally entered. If this happens prophylactic pacing should probably be avoided. If central cannulation is necessary for other reasons, such as for giving inotropic agents, and thrombolysis is also to be given, an introducer sheath can be inserted that could also be used for pacing. This will be an unusual occurrence, and more commonly important bradycardia occurs after the agent has been given. Some benefit may be obtained from giving atropine and isoprenaline (although isoprenaline is best avoided because of its potential for arrhythmogenesis) and from transthoracic pacing as a temporary measure. If temporary transvenous pacing is unquestionably required then an area that can be easily compressed should be used. The femoral venous route is best for this purpose and positioning the tip of the electrode at the right ventricular apex from below is often quite easy. The internal jugular vein can also be considered. Care should be taken to ensure that the vein has been entered before inserting the sheath, which is of much greater calibre than the needle.

Methods of temporary pacing

SUITABLE ENVIRONMENT

All forms of cardiac pacing require surgical asepsis. A temporary pacing electrode is a foreign body that may remain in the circulation for days or even weeks and has a high propensity for infection. The pacing room should be an environment where clean implantation can be made with the aid of good fluoroscopic equipment.

Occasionally a balloon tipped pacing catheter may be warranted in patients who cannot be screened. Sometimes these catheters may achieve a stable position, but they should be regarded as the last resort. In an emergency transthoracic pacing is a better alternative, and several commercially available "life pack" type systems with this facility are readily obtainable. The newer versions of transthoracic pacemaker are sometimes well tolerated, although they are not a substitute for temporary transvenous pacing and represent only a bridge to maintain life. Recent advances have utilised modified transthoracic stimulation variables, particularly a long pulse duration (20-40 ms), allowing a lower pulse amplitude. Briefer stimulation pulses of greater magnitude tend to be more painful.

EQUIPMENT

Introducer sheath—A haemostatic introducer sheath (fig 1) is strongly to be recommended, and money saved on providing cheaper alternatives is too often a false economy. The hub of the haemostatic introducer sheath contains a small rubber valve which easily admits a 5F or 6F pacing electrode but at the same time prevents any blood contaminating the wire and making manipulation more difficult.

Pacing electrode—For ease of manipulation stiffer catheters are better, although they are potentially more harmful. The best are those made from woven Dacron, but most cost conscious departments buy plastic disposable catheters at a fraction of their cost. This

FIG 1—Equipment required for temporary pacing

seems to make good economic sense, especially with new regulations forbidding reuse of such equipment. However, plastic electrodes are more difficult to manipulate and soften rapidly in a warm circulation, rather like spaghetti. It is therefore even more important that other factors are optimised to enable swift access and positioning of the catheter. For temporary atrial or DDD pacemakers, which are now available from several suppliers, plastic atrial J electrodes can be obtained.

Pulse generator—A selection of pulse generators is available for single and dual chamber pacing. The most familiar generator is housed in a relatively large box (fig 2). It is reliable and easy to use with clear functions. Although useful for the immobile patient, it has obvious limitations for patients who are ambulant or even those transferring from bed to chair, when accidental displacements or disconnections may occur. For mobile patients the newer, smaller, lighter generators should be available; these fit easily into a pyjama pocket.

PREPARATION

Ideal preparation for temporary pacing may not be possible in an emergency but is required for elective cases.

The pacing trolley

A pacing pack should contain the following (see fig 1):

- Iodine skin preparation, or equivalent
- At least three large green surgical towels
- Plenty of flush solution; ideally heparinised
- A Seldinger introducer needle
- A short small-J guidewire
- A haemostatic introducer sheath (with dilator)
- Local anaesthetic, needles, and syringes
- A sterile connector cable
- A bipolar temporary pacing catheter

The patient

The patient should be comfortable and supported by a single pillow. Sedation is not usually required. The ideal route of entry is the right subclavian vein. The large surgical towels are used to cover all but a small triangle of skin exposed in the area of the right clavicle.

Getting access to the right subclavian vein

The right subclavian vein is selected as the route of entry for the following reasons:

- It is easy to enter
- The temporary wire will sit on a flat surface below the clavicle and the site of entry is easily cared for. This is particularly important for men—when the jugular approach is used for more than a day or so growth of the beard can make the wire very uncomfortable and increase the risk of infection.
- The right sided approach leaves the left side clear for a permanent implant if required.

The recommended method of right subclavian venepuncture is to place the index finger in the jugular notch and drop the thumb into the space bounded by the clavicle above and the first rib below. The puncture should be as medial as possible without encroaching on the tight "V" formed by the passage of the first rib under the clavicle. Usually the tip of the thumb will nestle just under the clavicle. After the skin has been punctured just below this point with a sharp scalpel the angle of attack to the vein should be about 40°, heading up towards the root of the neck, applying negative pressure while advancing by about 0.5 cm (1/4") steps.⁶ This technique can result in retrograde cannulation of the internal jugular vein, but this can be avoided by using fluoroscopy and a J guidewire.

FIG 2—Standard temporary pulse generators: classic generator (left), and smaller generator for ambulant patients (right)

Once the vein is entered the J guide is directed towards the right atrium. The needle is then removed and the dilator with the sheath mounted on it is passed over the guide. The dilator and wire are then removed together and the sheath flushed with heparinised saline. If there is any question that the subclavian artery has been punctured rather than the vein the introducer sheath must not be advanced over the wire. In this situation, firstly pass the J guide down into the atrium and see that it passes into the inferior vena cava. Arterial punctures should cause the wire to hold up on the aortic valve when the tip of the guidewire is directed inferiorly. Secondly, if there is time, take a heparinised blood sample and confirm that the blood is venous or otherwise by blood gas analysis.

Other approaches and routes—Other approaches to the subclavian vein may be necessary. A supraclavicular approach may be used, but care should be taken to avoid the subclavian artery. A right or left brachial venous insertion should be avoided if possible as movement of the arm may displace the electrode and insertion can be very difficult if the brachiocephalic vein is tortuous. Femoral venous placement is the easiest of all routes for positioning the catheter tip at the right ventricular apex, but negotiating the inferior vena cava and its tributaries can be difficult and requires a freely mobile pacing table or fluoroscope to screen from the groin to the right atrium. In emergencies and in patients who have recently received thrombolysis this is probably the route of choice. However, the risk of infection by the femoral route and subsequent venous thrombosis make it unsatisfactory for anything other than the short term.

The electrode

Most manufacturers erroneously pack their temporary electrodes with a near 90° bend fashioned at the tip, often with a stiff former to keep this shape. This does not aid placement of the electrode. Ideally there should be a 20-30° curve at the tip, and it may be necessary to straighten some of the bend out of the electrode before insertion (fig 3).

INSERTION

Ventricular leads

To insert the ventricular leads push the wire in until it lies almost vertically in the right atrium. It will usually go with the curve and point towards the free wall (to the right). Rotate the wire with index finger and thumb, not at the wrist, through 180° until it points downwards and to the patient's left. Advance the wire steadily; it should pass through the tricuspid valve and slide along the floor of the right ventricle to the apex.

A common mistake is to allow too much of a curve to be created at the tip. This may allow relatively easy passage through the valve but will not allow the tip of

FIG 3—Electrode positioning is greatly facilitated if the curve is straightened out a little to some 20–30°

the wire to point down into the right ventricular apex without a great deal of twisting of the wire, resulting in a great deal of coiled electrode in the hand and very little change at the tip. Figure 4 shows an ideal position.

If difficulty is experienced in crossing the tricuspid valve there are various techniques that may help. Firstly, if the patient is stable remove the wire and try fashioning a different curve at the apex—usually less curve, rather than more, is required. The presence of a haemostatic introducer will make this manoeuvre much easier and cleaner. Secondly, if the valve is still not negotiable, feed the electrode into the right atrium to fashion a large loop and try to flip the tip of the wire through the valve by twisting the electrode first one way then another. This will usually get the wire through, but time must then be devoted to achieving a satisfactory tip position if at all possible:

One common problem is intubation of the coronary sinus. This tends to direct the electrode tip upwards and to the left, towards the left shoulder. The lead may appear to be in the right ventricle, but it will often not capture the ventricle at an acceptable output. In the posteroanterior radiograph the true position will not be clear, but if a lateral projection can be obtained the problem will become clear. Electrodes positioned in the coronary sinus are directed posteriorly, while those in the right ventricle project anteriorly. In addition, electrode tips that are correctly positioned and point downwards and to the left (towards the spleen) in a posteroanterior projection are never wrongly positioned in the coronary sinus (see fig 4).

Atrial leads

Atrial J leads have a preformed shape resembling a fish hook. In exactly the same way as the orifice of the tricuspid valve necessitates leftward orientation of the electrode, so positioning of an atrial electrode in the right atrial appendage requires leftward orientation, with the preformed shape of the catheter directing the tip upwards. Atrial electrode positioning requires experience and should not be attempted in an emergency. It is often useful to try to open the curve of the tip by withdrawing the electrode nearly into the superior vena cava once it has reached the atrium, then turn it to point left and advance the tip into the right atrial appendage. The tip is directed anteriorly, and this can be confirmed if the radiographic equipment can give a lateral view. Atrial leads will rarely achieve a stable position unless they are thus placed.

USE OF FLUOROSCOPY

The use of fluoroscopy is governed by a European Economic Community directive.⁷ Physicians operating such equipment are required to attend a one day course and receive certification of proficiency. These are

sound principles that should be followed. All attendant staff should be adequately protected with lead aprons that are in good condition. The operator should ideally also wear a thyroid shield and protective glasses, particularly if exposure is frequent. The aim of good radiographic practice is to use as little radiation as possible, minimising the dose to patients and staff. Short bursts of fluoroscopy should be used, with attendant staff well out of range if possible.

SECURING THE ELECTRODE

The introducer sheath may be left in place or may be removed depending on the adequacy of the final position and the indication for pacing. We advocate removing the sheath if possible because care of the temporary pacemaker is easier. Sheaths with no haemostatic mechanism have to be removed, making repositioning at a later date difficult. The electrode should be secured with 2/0 silk sutures and looped once or twice before being secured under a clear dressing.

CHECKING THE PACEMAKER

Usually it is adequate to check the pacing threshold and sensing characteristics of the pacemaker with a temporary pacing pulse generator, although more correct and accurate variables will be obtained using a PSA or pacing system analyser.

Pacing—After positioning the pacemaker pace the chamber (atrial or ventricular) 5–10 beats/min above the patient's rate and slowly turn down the amplitude of the voltage delivered until capture is lost. Remember that firstly, the threshold will be higher when coming from lesser to greater output than from greater to lesser output and, secondly, that longer pulse durations will provide lower thresholds. In practice the most important consideration is that threshold testing is always performed at the same pulse duration in the same direction for accuracy, and as a rule the generator should always be set to the lowest possible output, while allowing a safety margin of at least twice the capture threshold. After acute infarction pacemaker output should be kept at a minimum, avoiding unnecessary myocardial irritation.

Sensing—Sensing can be checked only if there is any spontaneous activity in the chamber paced. Most systems provide for adjustable sensing. This is best checked by setting the pacemaker 10–20 beats/min below the spontaneous rate of that chamber and looking for evidence of inhibition of the pacemaker output or, alternatively, of competitive pacemaker

FIG 4—Chest radiograph showing ideal positioning of ventricular electrode at right ventricular apex with tip of lead turned down slightly. There is also a temporary atrial electrode with tip directed upwards and to left into right atrial appendage

output and spontaneous activity in an electrocardiogram or cardiac monitor recording. For temporary pacing with bipolar electrodes, sensitivity can usually be set to a maximum, especially after myocardial infarction, when inappropriate pacing may be hazardous.

Failure to pace—Some causes of failure to pace and their remedies are given in box 2.

Care of the temporary pacing system

RADIOGRAPHY

A posteroanterior chest radiograph should be obtained as soon as possible after insertion of the temporary wire, and the electrode position should be recorded in the patients' notes. Lateral chest radiographs are desirable if an atrial electrode has been positioned as these electrode tips should be seen to point forwards towards the anterior chest wall.

DRESSINGS

The best dressing is a clear self adhesive patch. This covers the wound, the sutures, and one or two coils of electrode that are placed around or below the wound. These coils ensure that traction on the electrode results in pulling on the dressing and not the electrode within the heart. The dressing is transparent so that checking for evidence of purulence at the puncture site is made easier.

THRESHOLDS AND CONNECTIONS

The thresholds should be checked daily as described above and recorded on the patient's chart. Connections to the generator should be checked daily.

ANTIBIOTICS

Antibiotics are not routinely recommended. If infection develops at the site of insertion of the temporary wire the infection will not be eradicated until the electrode is removed. The electrode should therefore be resited. At this stage, after blood samples and wound swabs for culturing have been taken, a course of intravenous, then oral antibiotics is warranted.

Infections are almost invariably due to contamination by skin commensal organisms. Usually there will be *Staphylococcus epidermidis* infection, and this may be serious. Antibiotic treatment should include flucloxacillin if tolerated.

When to stop temporary pacing

Temporary pacing will be stopped when permanent pacing has been instituted in patients with conduction tissue disease, after a trial of pacing, or after a poten-

Causes of and remedies for failure to pace

Problem	Causes	Remedy
No output (no spikes seen)	Battery/generator failure Loose connections Oversensing	Replace battery/generator Check and tighten Reduce sensitivity or go to fixed rate (VOO pacing)
No capture (spikes seen)	Loose connections Exit block (high threshold)	Check and tighten Increase output, consider repositioning of electrode (check radiograph)

tially bradycardiac intervention. After myocardial infarction and cardiac surgery, however, it may not be clear when to stop temporary pacing.

After myocardial infarction, return of reliable atrioventricular conduction may take up to two weeks. Temporary pacing may be stopped after 48 hours of trouble free monitoring under these circumstances.

After cardiac surgery, transient bradyarrhythmias are common. In coronary artery bypass grafting these usually resolve within the first few hours. In patients who have been operated on for valvular disease and have had valve replacement, particularly replacement of the aortic valve, even when there is a return of atrioventricular conduction, a high degree of suspicion should be maintained that permanent pacing may be needed. It is preferable in these cases to rely on temporary epicardial pacing electrodes for the early postoperative period and then later to place a permanent transvenous system, rather than to use permanent epicardial electrodes, which have a poorer long term performance.

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ANY QUESTIONS

Is normal occupational exposure to solvent and adhesive fumes detrimental at any stages of pregnancy?

Many studies have looked at the relation between occupational exposure to organic solvents and fertility and reproduction. The subject has recently been reviewed.¹ It is not an easy subject to investigate: most studies have been retrospective so exposure levels could not be quantified. Most women are exposed to mixtures of solvents and to the chemicals dissolved in them, and it is not possible to measure solvent concentrations in fetal tissues.

Two linked studies have looked at the entire Finnish population.² Both reported appreciable excesses of congenital defects of the lip and palate in infants whose mothers had been exposed to a range of solvents during the first trimester. The first study also found an excess of neurological defects, although the second study did not,

and similar defects have been reported from the United Kingdom in association with leather work.³ When all published reports are considered, however, there is no consistent evidence linking exposure to any particular solvent with spontaneous abortion, retarded fetal development, stillbirth, or congenital malformation. Nevertheless, maternal stress may be a determinant of the outcome of pregnancy, and a prudent employer should provide alternative work if a woman is unduly anxious and commercial considerations permit it. —ALAN SCOTT, senior employment medical adviser, Health and Safety Executive, Nottingham

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