

ELECTROPHYSIOLOGY

Temporary cardiac pacing

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Paul Zoll first applied clinically effective temporary cardiac pacing in 1952 using a pulsating current applied through two electrodes attached via hypodermic needles to the chest wall in two patients with ventricular standstill.¹ Although this technique was uncomfortable for the patients it was effective for 25 minutes in one patient and nearly five days in the second; this report heralded the ability to provide temporary ventricular rate support for patients with clinically significant bradycardia. Subsequent technological developments have provided endocardial, epicardial, and gastroesophageal approaches to temporary cardiac pacing in addition to the refinement of external pacing. All approaches, however, are based on the provision of rate support from an external pulse generator via an electrode or electrodes which can be removed easily after a short period of pacing, as many of the situations requiring temporary pacing are transient and resolve spontaneously or have a correctable underlying cause. In a selected group of patients, permanent pacing treatment will need to be instigated before removal of the temporary system.

Indications for temporary pacing

The indications for temporary pacing can be considered in two broad categories: emergency (usually associated with acute myocardial infarction) or elective. There is, however, no clear consensus on indications for temporary pacing with most recommendations coming from clinical experience rather than scientific trials.² For many patients presenting with bradycardia, however, conservative therapy and treatment of the underlying problem is the most appropriate management strategy. As a general rule, patients who may need to go on to permanent pacing should only have a temporary transvenous pacing wire placed if they have suffered syncope at rest, are haemodynamically compromised by the bradycardia or have ventricular tachyarrhythmias in response to bradycardia. In particular, patients presenting with sinus node disease rarely need temporary pacing, and the risks of infection and compromise of subsequent venous access for permanent pacing usually outweigh the benefits in these patients. In patients requiring permanent pacing, prompt transfer for the procedure is appropriate but consideration of rate support to cover transfer to another hospital (where necessary) may occasionally require provision for temporary pacing, preferably transcutaneous.

Emergency temporary pacing

Any patient with acute haemodynamic compromise caused by bradycardia and/or episodes of asystole should be considered for temporary cardiac pacing. For the majority of patients, this is likely to occur in the setting of acute myocardial infarction; complete heart block with anterior infarction usually indicates a poor prognosis and a need for pacing whereas complete heart block with inferior infarction is usually reversible, associated with a narrow QRS, and responds to atropine. The American College of Cardiology/American Heart Association (ACC/AHA) guidelines for the management of acute myocardial infarction provide indications graded according to weight of evidence for benefit of pacing rather than site of infarction (table 1).³ Table 2 gives the indications for temporary transvenous pacing, table 3 details situations where temporary pacing may offer benefit after acute myocardial infarction, and table 4 indicates those patients where temporary pacing is not indicated.

In the era of thrombolytic treatment, the occurrence of bradycardia often presents a dilemma for the admitting junior doctor. Should thrombolytic treatment precede or follow temporary pacing? There is a very clear pathway of management under these circumstances; thrombolysis is the priority and should not be delayed by temporary transvenous endocardial pacing. If the bradycardia is unresponsive to medical treatment (for example, atropine, isoprenaline), temporary external pacing should be instituted while the thrombolytic treatment is being prepared. If haemodynamically significant bradycardia continues after institution of thrombolytic treatment, a transvenous temporary pacing electrode should be placed by experienced staff from the external jugular, brachial or femoral route.⁴

Although temporary pacing is clearly indicated in patients suffering episodes of asystole, there is little evidence for haemodynamic benefit of temporary ventricular pacing over spontaneous rhythm in patients with bradycardia following acute myocardial infarction, although temporary dual chamber (atrioventricular synchronous) pacing has been shown to be beneficial.⁵ There have been studies, however, suggesting prognostic benefit of continuous pacing in patients with transient high degree heart block following myocardial infarction, although the role of subsequent permanent pacing remains unproven in this group.^{6,7}

Table 1 ACC/AHA classification of indications for pacing³

Class I	Conditions for which there is evidence and/or general agreement that a given procedure or treatment is beneficial, useful and effective
Class II	Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a procedure or treatment
Class IIa	Weight of evidence/opinion is in favour of usefulness/efficacy
Class IIb	Usefulness/efficacy is less well established by evidence/opinion
Class III	Conditions for which there is evidence and/or general agreement that a procedure/treatment is not useful/effective and in some cases may be harmful

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Practice point

- Always institute thrombolytic treatment before considering transvenous temporary pacing in the bradycardic patient with an acute myocardial infarction.

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Patients presenting with bradycardia outside the setting of acute myocardial infarction less frequently need to be considered for temporary pacing; in particular, those with indications for subsequent permanent pacing (for example, high degree heart block, sinus node disease) are often better managed without temporary pacing to reduce the risk of infection and to prevent compromise of subsequent venous access sites. Temporary pacing may, however, need to be considered if the patient has episodes of asystole, is haemodynamically compromised or develops tachyarrhythmias in response to bradycardia (for example, ventricular tachycardia or fibrillation). These tachyarrhythmias may occur as escape rhythms, either spontaneously or following ventricular ectopic beats.

ELECTIVE TEMPORARY PACING

This is generally undertaken in the setting of surgical or other intervention; either the patient has the potential for transient bradycardia as a result of their underlying pathology or the procedure to be undertaken is likely to produce transient or permanent bradycardia. Many authors continue to recommend temporary pacing to cover general anaesthesia in the presence of bifascicular block and first degree heart block, although there is little evidence to support the need for this approach.⁸ Temporary transvenous pacing may also be used to terminate tachycardia through overdrive pacing (table 2).

Approaches to temporary pacing

TRANSVENOUS, ENDOCARDIAL PACING

There are arguments in favour of and against all the major venous access sites (internal and external jugular, subclavian, brachial, femoral); each is associated with particular problems including lead stability, infection, haemorrhage, pneumothorax, patient discomfort, etc. As this procedure is often performed in emergency/acute situations by relatively junior staff, the choice of route is often dictated by individual experience. Other considerations should include length of time that the temporary wire is anticipated to need to stay in situ; femoral placement probably offers the least stable wire position and limits patient mobility more than other routes. Current guidelines from the British Cardiac Society recommend the right internal jugular route as most suitable for the inexperienced operator; this offers the most direct route to the right ventricle, and is associated with the highest success rate and fewest complications.⁴ This was also the recommendation of Hynes and colleagues as a result of five years of temporary pacing experience in a coronary care unit setting.⁹ In patients

Table 2 Indications for temporary transvenous cardiac pacing

Emergency/acute	
<i>Acute myocardial infarction: (Class I: ACC/AHA)³</i>	
<ul style="list-style-type: none"> • Asystole • Symptomatic bradycardia (sinus bradycardia with hypotension and type I 2nd degree AV block with hypotension not responsive to atropine) • Bilateral bundle branch block (alternating BBB or RBBB with alternating LAHB/LPHB) • New or indeterminate age bifascicular block with first degree AV block • Mobitz type II second degree AV block 	
<i>Bradycardia not associated with acute myocardial infarction</i>	
<ul style="list-style-type: none"> • Asystole • 2nd or 3rd degree AV block with haemodynamic compromise or syncope at rest • Ventricular tachyarrhythmias secondary to bradycardia 	
Elective	
<ul style="list-style-type: none"> • Support for procedures that may promote bradycardia • General anaesthesia with: <ul style="list-style-type: none"> 2nd or 3rd degree AV block Intermittent AV block 1st degree AV block with bifascicular block 1st degree AV block and LBBB • Cardiac surgery <ul style="list-style-type: none"> Aortic surgery Tricuspid surgery Ventricular septal defect closure Ostium primum repair 	
Rarely considered for coronary angioplasty (usually to right coronary artery)	
Overdrive suppression of tachyarrhythmias	

receiving or likely to receive thrombolytic treatment, the femoral, brachial or external jugular are the routes of choice. It is also generally best to avoid the left subclavian approach if permanent pacing may be required, as this is the most popular site for permanent pacing. Some permanent implanters prefer the right side, however, and establishing a relationship with the physician or surgeon responsible for permanent pacing is important. Many implanters also prefer to use the non-dominant side; assessing the patient's dominant hand is, therefore, appropriate.

Positioning the temporary pacing wire requires the combination of satisfactory anatomical and electrical data. Different venous approaches will require different techniques; probably the most important difference will be the result of approaching the right atrium from below (femoral route) or above (all other routes). The procedure needs appropriate instruments, a sterile environment, trained support staff, and good quality fluoroscopy equipment.²

Table 3 Situations where temporary pacing may offer benefit after acute myocardial infarction; placement of transcutaneous electrodes may be more appropriate than transvenous pacing (class II ACC/AHA)³

Class IIa	<ul style="list-style-type: none"> RBBB with LAFB or LPFB (new or indeterminate) RBBB with 1st degree AV block LBBB (new or indeterminate) Recurrent sinus pauses (> 3 seconds) not responsive to atropine Incessant VT, for atrial or ventricular overdrive pacing (transvenous pacing required)
Class IIb	<ul style="list-style-type: none"> Bifascicular block of indeterminate age New or age indeterminate isolated RBBB

Table 4 Situations where temporary pacing is not indicated

Acute myocardial infarction (Class III ACC/AHA)³

- First degree heart block
- Type I 2nd degree heart block (Wenckebach) with normal haemodynamics
- Accelerated idioventricular rhythm
- Bundle branch block or fascicular block known to exist before acute MI

Bradycardia not associated with acute myocardial infarction

- Sinus node disease without haemodynamic compromise or syncope at rest
- Type II 2nd degree or 3rd degree heart block (constant or intermittent) without haemodynamic compromise, syncope or associated ventricular tachyarrhythmias at rest

Temporary transvenous ventricular pacing

The lead must be advanced to the right atrium and then across the tricuspid valve. With a temporary wire, crossing the tricuspid valve is often performed most easily by pointing the lead tip downwards and towards the left cardiac border and advancing across the valve. The lead is then advanced to a position at the right ventricular apex. If difficulty is experienced with this technique, an alternative is to create a loop in the right atrium by pointing the lead tip to the right cardiac border and then prolapsing the loop across the valve by rotating the lead. The lead tip may then require manipulation to the apex; this is often performed most easily by passing the lead tip to the right ventricular outflow tract, gently withdrawing the lead, and allowing the tip to drop down into the apex.

Temporary transvenous atrial pacing

Temporary atrial pacing leads have a preshaped J curve to enable positioning in the right atrial appendage. This necessitates approach from a superior vein and positioning is greatly assisted by a lateral screening facility on fluoroscopy. The tip of the lead should point forward with the J shape slightly opened out when slight traction is applied; unless this is achieved it is unlikely that the lead will be stable.

Following positioning of either or both leads, the leads must be secured to the skin to prevent displacement by movement or traction.



Figure 1. A modern monitor/external pacemaker/defibrillator.

The majority of current temporary transvenous electrodes have a smooth, isodiametric profile with no fixation mechanism; this is to enable easy removal but does tend to make displacement more likely. Newer active fixation temporary leads are available with a fixation screw; these are small diameter (3.5 French), catheter delivered leads which remain easy to remove after 1–2 weeks. The active fixation mechanism improves lead stability and may improve the ease and acceptability of more physiological atrial based pacing in the temporary setting.

Epicardial pacing

This route is used following cardiac surgical procedures as it requires direct access to the external surface of the myocardium. Fine wire electrodes are placed within the myocardium from the epicardial surface and the connectors emerge through the skin. These electrodes can be removed with gentle traction when no longer required; their electrical performance tends to deteriorate quite rapidly with time, however, and reliable sensing/pacing capability is often lost within 5–10 days, especially when used in the atrium.

External (transcutaneous) pacing

This is a development of the original temporary pacing technique described by Zoll in 1952,¹ but has been refined to make it more clinically acceptable and easier to institute (fig 1); such devices should now be available in all coronary care units and accident and emergency units. The UK Resuscitation Council, as part of advanced life support, currently recommends this approach as pacing can be achieved rapidly with very little training and without the need to move the patient. Clinical studies have demonstrated the efficacy of the Zoll type non-invasive temporary pacemaker^{10,11} for periods of up to 14 hours of continuous pacing with success rates of 78–94%, although many patients require sedation if conscious.¹¹ This approach certainly offers a “bridge” to transvenous approach for circumstances where the patient cannot be moved or staff with transvenous pacing experience are not immediately available. Positioning of the transcutaneous pacing electrodes is usually in an anteroposterior configuration (fig 2), but if this is unsuccessful, if external defibrillation is likely to be needed or if electrodes are placed during a cardiac arrest situation, the anterior-lateral configuration should be considered (fig 3).

Transoesophageal pacing

The oesophageal or gastro-oesophageal approach has been advocated for emergency ventricular pacing as it may be better tolerated than external pacing in the conscious patient.¹² Success rates of around 90% are claimed for ventricular stimulation using a flexible electrode positioned in the fundus of the stomach and pacing through the diaphragm. Transoesophageal atrial pacing (performed by placing the electrode in the mid to lower oesophagus to obtain atrial capture) is also well described,^{13,14} but this approach is rarely used

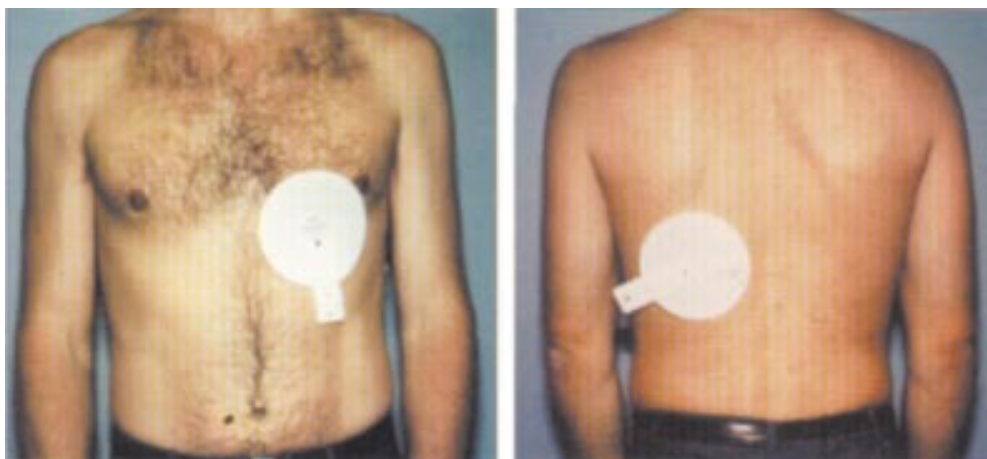


Figure 2. Typical anteroposterior positioning of transcutaneous pacing electrodes.

in the acute setting as electrode stability can be difficult to achieve and there is no protection against atrioventricular conduction disturbance.

Complications of temporary pacing

Complications may relate to the venous access, mechanical effects of the lead within the heart, the electrical performance of the pacemaker lead, or infection or thromboembolism caused by the presence of a foreign body. Complications can be expected in around 14–20% of patients^{8 15} and the majority of these will be manifest as development of a pericardial rub, ventricular arrhythmias produced during electrode positioning, or infection.

Venous access

Apart from failure to gain venous access, pneumothorax or haemothorax relating to subclavian puncture are the most common problems, particularly in inexperienced hands. These can be avoided most easily by choosing another route; the anatomy of the subclavian vessels is very variable and there is no guaranteed method for avoiding pneumothorax or accidental puncture of the artery.



Figure 3. The anterolateral position for transcutaneous pacing electrodes.

Mechanical effects of the lead

In many patients, particularly after acute myocardial infarction, placing a pacing lead within the right ventricle will promote ventricular ectopic activity and occasionally prolonged ventricular arrhythmias.¹⁵ These will usually resolve once manipulation of the lead has ceased but will occasionally require removal of the lead or repositioning. More frequently, patients become dependent on pacing immediately after placing the lead, making repositioning difficult. The temporary pacing lead is relatively stiff and of small diameter (usually 5–6 French); it is not unusual for these leads to penetrate and occasionally perforate the right ventricular wall. This is usually manifest by raised pacing thresholds and occasionally by pericarditic pain and a pericardial friction rub.⁹ The lead can usually be withdrawn back into the ventricle and repositioned without problem; rarely this will result in cardiac tamponade caused by haemorrhage and will require appropriate urgent treatment. Echocardiographic assessment is recommended after repositioning under these circumstances.

Electrical performance of the lead

Pacing thresholds will vary according to the underlying pathology for which the patient is paced, and these can be affected further by concomitant drug treatment. Initial thresholds should be recorded and then checked and recorded at least once daily thereafter by competent staff. The patient should be paced with an output of at least twice voltage or current threshold; if pacing output needs to exceed 5.0 volts or 10.0 milliamps, repositioning of the lead should be considered. If pacing fails suddenly, always check connections to the external generator, generator batteries, and possible oversensing (go to VOO, fixed rate pacing). If pacing spikes can be seen but no capture occurs, increase output and consider repositioning or replacing the electrode.² The connectors on temporary epicardial wires are particularly fragile and prone to fracture. In one series of 113 temporary transvenous pacemakers, failure to sense or capture was seen in 37% of patients and was more common after 48 hours.¹⁵

Practice point

- Temporary pacemakers must be checked by competent staff *at least once daily* for pacing thresholds, evidence of infections around venous access sites, integrity of connections, and battery status of the external generator. Underlying rhythm should also be assessed and recorded at these checks.

Infection and thromboembolism

With careful attention to wound cleanliness, routine antibiotic treatment is not required but any sign of infection indicates the need to change the wire. In patients with prolonged temporary transvenous pacing from most routes (> 7 days) or when the wire is introduced via the femoral route, antibiotic prophylaxis should be considered. Most infections are caused by *Staphylococcus epidermidis*,² but coliforms should be considered when the femoral route is used; this route is probably best avoided in immunocompromised patients.¹⁵ Thromboembolism is probably more common when the femoral route is used, with 5/25 patients in one series suffering deep venous thrombosis.¹⁶ This route may be valuable following administration of thrombolytic treatment but should probably be avoided for prolonged use or in patients with increased thromboembolic risks.

The external generator

The generator allows adjustment of pacing output (voltage and/or current, and with newer devices also pulse width), pacing rate, pacing mode, and sensitivity to intrinsic activity. Dual chamber generators will allow greater flexibility in pacing mode and will offer adjustment of atrioventricular delay and refractory periods. Generators may be small enough to allow the patient to be ambulant or need to be placed at the bedside. The generator batteries must be checked at least daily and the generator sited so that it cannot fall and exert traction on the pacing lead.

Some generators may also offer high rate pacing (usually three times normal upper pacing rate) to allow overdrive pacing of tachyarrhythmias. Activation of this function is usually locked by a key or requires a sliding cover to be removed.

Newer digital temporary generators are usually locked after checking and adjustment to prevent inadvertent changes in programming.

Functional effects of pacing mode

Most temporary transvenous pacing involves stimulating from the right ventricular apex. This is associated with detrimental effects on cardiac function and, associated with loss of atrioventricular synchrony, results in a reduced cardiac output when compared with normal

Abbreviations

ACC/AHA: American College of Cardiology/American Heart Association
 AV: atrioventricular
 BBB: bundle branch block
 DDD: dual chamber pacing
 LBBB: left bundle branch block
 LAHB: left anterior hemiblock
 LPHB: left posterior hemiblock
 RBBB: right bundle branch block
 VOO: fixed rate, non-sensing ventricular pacing

sinus rhythm at a similar rate. This was demonstrated by Murphy and colleague in 1992⁵ who showed that temporary ventricular pacing at 80 beats per minute was no better than spontaneous bradycardia (10 had heart block, two had junctional bradycardia), whereas physiological dual chamber (DDD) pacing resulted in improved cardiac output, blood pressure, and falls in pulmonary wedge pressure and right atrial pressure. This would suggest that the majority of temporary pacing should be AV synchronous in the presence of normal sinus node activity but, despite this, the more complex procedure associated with temporary transvenous dual chamber has led to the continued routine use of ventricular pacing in the temporary setting. In the emergency/acute situation, the use of higher pacing rates can partially compensate for this,⁵ but restoration and maintenance of AV synchrony should be considered in any patient remaining hypotensive after temporary ventricular pacing. Atrioventricular synchrony may be of particular value in optimising cardiac performance and reducing atrial fibrillation in the postcardiac surgical patient; careful attention should be paid to the electrical performance of the atrial epicardial leads as sensing characteristics often deteriorate after 4–5 days.

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