

TECHNIQUES

Transvenous Temporary Cardiac Pacing*

Emmanouil Poulidakis, MD, Antonis S. Manolis, MD

Department of Cardiology,
Evangelismos Hospital, Athens, Greece

KEY WORDS: *temporary cardiac
pacing; bradycardia; transvenous
pacing; overdrive pacing*

LIST OF ABBREVIATIONS

AMI = acute myocardial infarction
AV = atrio-ventricular
BBB = bundle branch block
CHB = complete heart block
ECG = electrocardiogram
LAFB = left anterior fascicular block
LBBB = left bundle branch block
LPFB = left posterior fascicular block
RA = right atrium
RBBB = right bundle branch block
RV = right ventricle
SVT = supraventricular tachycardia
SuVT = sustained ventricular tachycardia
TCP = temporary cardiac pacing
TdP = torsade de pointes

Correspondence to:
Antonis Manolis, MD,
Department of Cardiology,
Evangelismos Hospital, Athens,
Greece;
E-mail: asm@otenet.gr

ABSTRACT

Transvenous temporary cardiac pacing is a rather old but still contemporary life-saving technique, with a unique value in the treatment of critically ill patients suffering from rhythm disturbances and associated hemodynamic compromise. Physicians involved in the management of such patients should always keep in mind the indications and contraindications of transvenous temporary cardiac pacing, and should be at least familiar with the insertion technique and the post-insertion care.

INTRODUCTION

Temporary cardiac pacing is a life-saving procedure used as a means of electrical stimulation of the heart through the use of pacing leads, in order to treat dysrhythmias, until they are resolved or until a long-term therapy is adopted.¹⁻⁵ Temporary pacing is effected via transvenous, transcutaneous, or epicardial approaches. Transcutaneous pacing is delivered via cutaneous adhesive pads placed in an anteroposterior position, has the advantage of being immediately available for emergency cases of asystole but it requires high energy to capture the heart, causing significant discomfort to the awake patient, and is reserved for those who are comatose or as a bridge until transvenous endocardial pacing is rendered feasible.^{1,5,6} Epicardial wires are routinely placed during cardiac surgery to provide backup pacing in the event of perioperative bradyarrhythmias, but also to diagnose and overdrive certain tachyarrhythmias (e.g. atrial flutter).⁷ However, the most common and reliable approach to temporary pacing is provided with transvenous insertion of temporary pacing wire.¹⁻⁵

Transvenous temporary cardiac pacing (TCP) was first described by Furman et al in 1958 in dogs and in 1959 in human beings,^{8,9} initially for the correction of complete heart block, but the indications have subsequently expanded to comprise a variety of bradyarrhythmias but also a list of tachyarrhythmias, including the diagnosis and overdrive suppression of supraventricular and ventricular tachycardias.^{1,3,4} In its most common use of supporting the patient with bradycardia, temporary pacing typically serves as a bridge to a more definitive solution to a low heart rate, such as permanent pacemaker implantation, or resolution of a transient or reversible cause, e.g. bradycardic effect of drugs, electrolyte disturbance, inferior-wall myocardial infarction, etc.

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INDICATIONS

Transvenous temporary cardiac pacing is most commonly used to treat symptomatic bradycardia due to sinus node dysfunction or atrioventricular (AV) block. In general, indications could be divided into those associated with acute myocardial infarction (AMI), and those not linked to AMI.^{1,10} The former are clearly outlined in the American Heart Association guidelines for AMI management,¹¹ and presented in Table 1. It should be noted, that in a patient with AMI, a more aggressive management of bradycardia is warranted in order to maintain an adequate coronary blood flow in the infarcted

TABLE 1. Recommendations for Temporary Transvenous Pacing in the Course of AMI¹¹

Class I
1. Asystole
2. Symptomatic bradycardia (includes sinus bradycardia with hypotension & type I 2° AV block with hypotension not responsive to atropine)
3. Bilateral BBB (alternating BBB or RBBB with alternating LAFB/LPFB) (any age)
4. New or indeterminate age bifascicular block (RBBB with LAFB or LPFB, or LBBB) with 1° AV block
5. Mobitz type II 2° AV block
Class IIa
1. RBBB and LAFB or LPFB (new or indeterminate)
2. RBBB with 1° AV block
3. LBBB, new or indeterminate
4. Incessant VT, for atrial or ventricular overdrive pacing
5. Recurrent sinus pauses (>3 s) not responsive to atropine
Class IIb
1. Bifascicular block of indeterminate age
2. New or age-indeterminate isolated RBBB
Class III
1. 1° heart block
2. Type I 2° AV block with normal hemodynamics
3. Accelerated idioventricular rhythm
4. BBB or fascicular block known to exist before AMI

AMI = acute myocardial infarction; AV = atrio-ventricular; BBB = bundle branch block; LAFB = left anterior fascicular block; LBBB = left bundle branch block; LPFB = left posterior fascicular block; RBBB = right bundle branch block; VT = ventricular tachycardia.

myocardium. However, special precautions should be taken in a patient who has undergone thrombolysis, such as using different access site or using transcutaneous pacing. Also, in the more recent AHA 2010 Guidelines,¹² for the management of cardiac arrest, the routine use of pacing in asystole is listed as a grade III recommendation.

In the setting of an AMI, the benefits of transvenous TCP should be weighed and balanced against the higher risk for bleeding if the patient has recently received thrombolysis or is on heparin and/or other antithrombotics during the process of primary percutaneous coronary intervention (PCI). If the patient remains hemodynamically stable, transcutaneous pads could be used as backup instead. In general, due to the adoption of rapid reperfusion therapies over the recent years (e.g. primary PCI),¹¹ and also due to observed higher risk of complications of TCP in the setting of AMI (e.g. ventricular tachyarrhythmias),¹³ and with the availability of transcutaneous pacing, transvenous TCP use has significantly declined to <1%.¹⁴

Beyond the use of pacing in the setting of AMI, the indications of transvenous TCP are similar to those of permanent pacing,¹⁵ especially when the latter is not immediately available or finally not indicated, such as in bradycardia due to reversible causes (Table 2). Nevertheless, in such cases transvenous TCP should be reserved for patients with hemodynamic compromise, episodes of asystole or tachyarrhythmias in response to bradycardia, such as polymorphic ventricular tachycardia in the form of torsades de pointes (TdP) in the setting of long QT interval. The application of TCP in asymptomatic and hemodynamically stable patients with good escape rhythms may render these individuals pacemaker dependent, and in case pacing fails, asystole could occur. In addition, there is the risk of infection in the access site, that could possibly be used later for permanent pacing.¹³ A special cautionary note concerns

TABLE 2. Indications for Temporary Cardiac Pacing

Acute MI	Bradyarrhythmias	Tachyarrhythmias
Asystole	Asystole / CHB	Torsades de pointes
CHB	Symptomatic sinus bradycardia (<40 bpm)	SVT
Mobitz II AV block	Prolonged sinus pauses (>3-4 s)	SuVT
(see Table 1)	PPM failure/ replacement (see Table 3)	

AV = atrioventricular; CHB = complete heart block; MI = myocardial infarction; PPM = permanent pacemaker; SuVT = sustained ventricular tachycardia; SVT = supraventricular tachycardia.

patients, more commonly women, presenting with complete heart block, who have increased propensity to develop TdP unassociated with QT prolonging drugs.¹⁶ Thus, in patients presenting with acquired complete heart block and low heart rate, even when hemodynamically stable or oligosymptomatic, it may be prudent to use prophylactic transvenous TCP in all of them, while waiting for a permanent pacemaker, to avoid this worrisome scenario of bradycardia-induced long QT and TdP.

Reversible causes of bradycardia, where transvenous TCP should be considered, are listed in Table 3.^{3,4,15}

Transvenous TCP might be necessary in patients fitted with a permanent pacemaker if permanent pacing fails, or when pacemaker-dependent patients undergo pulse generator replacement.¹ Moreover, TCP might be considered in ambiguous cases to verify the potential benefit of possible permanent pacing. In rare cases dual-chamber DDD TCP with use of an additional atrial lead with a preformed j-curve positioned in the right atrial appendage under fluoroscopy guidance has been employed to improve cardiac output in patients who have lost AV synchrony;^{1,3,4} alternatively, VDD pacing via a single atrial-sensing ventricular-pacing lead has been proposed for use in patients with acute sepsis and heart failure;¹⁸ at the same time there are scarce reports about the use of temporary biventricular pacing in cases of refractory cardiogenic shock.¹⁹ Elective use of transvenous TCP has been reported in patients with underlying conduction abnormality (such as “trifascicular” block), who undergo non-cardiac surgery or high risk angioplasty in the right coronary artery.¹ When TCP is unexpectedly needed during the performance of a PCI procedure, pacing can be accomplished faster using the coronary artery guidewire, as an alternative to insertion of a transvenous temporary pacemaker.²⁰ Finally, during newer types of percutaneous procedures, such as transcatheter aortic valve implantation (TAVI), transvenous TCP is employed for both prophylaxis for the occurrence of heart block (standby

pacing) and for facilitation of balloon valvuloplasty and/or balloon-expansion of the artificial valve (rapid pacing).^{21,22}

An important, albeit less known or less frequently employed, use of transvenous TCP relates to the management of tachyarrhythmias. In the setting of sick sinus syndrome or prolonged QT interval, rapid pacing (90-110 bpm) could minimize the incidence of atrial fibrillation, and polymorphic ventricular tachycardia (TdP), respectively. In addition, several tachyarrhythmias, such as supraventricular tachycardia, atrial flutter or monomorphic ventricular tachycardia could be terminated with overdrive pacing, which involves pacing at slightly faster rates than the tachycardia rate.^{1,2,23} Overdrive pacing requires expertise, as inadvertent implementation could lead to acceleration of the tachycardia.^{1,2}

CONTRAINDICATIONS

Transvenous TCP should be avoided when the possible risks outweigh the potential benefits, such as in asymptomatic stable patients or in those which excessive bleeding risk, especially after thrombolysis administration. The presence of a prosthetic tricuspid valve is an absolute contraindication, while infarction of the right ventricle could minimize the possibility of successful pacing capture.¹

INSERTION TECHNIQUE

The physicians who are credentialed to place a temporary pacemaker should be familiar with the insertion equipment (puncture needle and sheath), electrode-catheters and connectors, and the external pulse generator available in their own hospital settings. Apart from understanding the indications of temporary cardiac pacing (Tables 1-3) and acquiring the technical skill of safe vessel puncture and lead insertion, another very important aspect is how capable and knowledgeable the physician is in order to recognize the morphology of the *endocardial electrograms* of the superior vena cava, right atrium, and right ventricle and use this electrocardiographic (ECG) monitoring to guide proper pacing lead positioning.^{2,24}

TRANSVENOUS ACCESS

Access sites for transvenous pacing include the internal jugular, subclavian, femoral and even the antecubital or brachial veins. The internal jugular vein is favored by some as it may be associated with fewer complications and spares subclavian access for future permanent pacemaker placement.^{1,25} However, patient convenience and maintenance of site sterility may be less than desirable. The subclavian route appears to be a more stable position and provides a more convenient site for patient mobility.²⁶ The femoral vein is generally undesirable due to increased incidence of deep vein thrombosis and infec-

TABLE 3. Temporary Pacing for Reversible Causes of Bradycardia

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|--|
| 1. Metabolic or electrolytes abnormalities (hypothyroidism, hypothermia, hyperkalemia) |
| 2. Drug induced bradycardia (beta blockers, calcium channel blockers, digitalis, amiodarone) |
| 3. Injury to the sino-atrial node or to other parts of the conduction system, after cardiac surgery, heart transplantation, radiofrequency ablation of arrhythmias or cardiac trauma during motor vehicle accident; ischemia (inferior-wall AMI) |
| 4. Other diseases associated with temporal injury to the conduction system, such as Lyme's disease, or endocarditis with an aortic valve abscess (early ECG sign: 1° AV block). |

tion. However, during cardiac procedures performed in the catheterization or the electrophysiology laboratory, this site is a readily accessible site, albeit for cases requiring pacing coverage for a very short duration. If the need for temporary pacing coverage is expected to be of longer duration, then the temporary pacing lead initially inserted via the femoral access should be exchanged with a more stable position, e.g. the subclavian route, at the end of the main procedure. Finally, the external jugular, brachial or antecubital and femoral veins may be used in special circumstances, mostly after thrombolysis.¹ With the availability of 4 or 5Fr balloon-tipped electrode catheters, the use of the antecubital (median basilic) vein may be a safer and more convenient approach, through which a transvenous TCP lead can be inserted and placed endocardially with relative ease when guided by ECG monitoring (see below) conferring fewer complications, especially in patients at risk for hemorrhage or when a less well trained physician is involved.

GUIDANCE

After obtaining transvenous access, a single balloon-tipped bipolar electrode-catheter (4-5Fr) may be used.^{2,27} This temporary pacing lead can be introduced transvenously without fluoroscopy in a bedside procedure, similar to a Swan-Ganz catheter insertion aided by blood flow directing placement of the balloon-tipped catheter or via electrocardiographic monitoring. Of course, placement of a temporary pacing wire with use of fluoroscopy is easier and safer due to direct visualization of the lead, and it would be preferable if a procedure room is readily available next to the cardiac care unit or in the vicinity of the patient's whereabouts. Use of fluoroscopy may become necessary when the other approaches fail and the patient is then transferred to the catheterization or electrophysiology laboratory to perform the procedure. In this case a hard-tipped bipolar electrode catheter can be used and maneuvered under visualization into the right ventricular apex.

Without fluoroscopic imaging, a balloon-tipped pacing lead is employed and advanced "blindly" with the external pulse generator switched on, guided by the length of the catheter insertion and/or observing after each pacing spike for the appearance of ventricular capture with a left bundle branch morphology on 12-lead ECG confirming the correct placement of the lead within the right ventricle. While any site within the right ventricle, except for the high right ventricular outflow tract sites, will provide adequate pacing threshold and safe temporary pacing, placement of the pacing wire at the right ventricular apex will afford the greatest lead stability.

Newer active fixation temporary pacing wires have been advocated for better lead stabilization, but require more operator expertise and their safety has not been corroborated. Others have proposed the use of a permanent pacing lead inserted with use of a stylet similar to the procedure of a permanent pacing lead insertion and connected to a used or old permanent pacemaker pulse generator adhered exter-

nally to the chest. This approach may be particularly useful for pacemaker-dependent patients undergoing pacing lead extraction and pacemaker removal due to infection and thus bridged until a new permanent pacemaker is implanted on the contralateral side.²⁸⁻³¹

ELECTROCARDIOGRAPHIC MONITORING

A more effective and safe, albeit a bit more time consuming, approach utilizes the pacing bipolar electrode catheter as an ECG lead to monitor the advancement and correct endocardial placement of the pacing lead by observing the changes in the endocardial electrogram pattern during passage of the catheter through the right heart chambers.^{2,24} This can be easily accomplished by connecting the distal (negative) pole of the lead with one of the precordial leads (e.g. V1 or V2) of the ECG with use of alligator connectors (crocodile clips) to record a unipolar ECG lead; alternatively, the distal electrode can be connected to the right arm lead and the proximal electrode to the left arm lead to record a bipolar lead I electrocardiogram. Recording of a QS pattern indicates traversing the tricuspid valve, at which point the balloon is deflated and the lead is advanced with a clock-wise rotation to direct it towards the apex and make contact with the endocardium, which is confirmed by the appearance of ST elevation (current of injury pattern) on the endocardial electrogram (Fig. 1). If the balloon is not deflated in time, the lead will further advance to the outflow tract and the pulmonary artery; a position in the outflow tract is prone to dislodgement and less reliable pacing. Upon recording of a QS/ST elevation type of intracardiac electrogram, connection of the lead is switched to the external pacemaker device and pacing threshold testing is performed. A pacing threshold <1 mA attests to excellent endocardial contact of the pacing lead.

This ECG-guided approach can only be applied in patients who have an underlying native (escape or other) rhythm and, of course, not in patients with ventricular asystole. During the insertion process, a loop in the right atrium may be formed and pose difficulty in further advancing the lead; this is best avoided by paying attention to the length of the lead being advanced (>30-40 cm), in which case the lead is withdrawn (with the balloon deflated) and the process repeated. During monitoring of the endocardial ECG, the appearance of an R wave should raise the suspicion of possible perforation, when the lead is immediately withdrawn and the patient monitored for possible hemopericardium or tamponade; in the majority of cases this remains uneventful. After final lead placement, some have suggested partial inflation of the balloon that could reduce the risk of perforation. At this point obtaining a 12-lead ECG can further confirm correct lead placement close to the right ventricular apex, by recording a pacing rhythm with LBBB pattern with superior (left) axis; recording a RBBB pattern indicates epicardial pacing either via a perforating lead or a lead inserted inadvertently into the middle cardiac or other

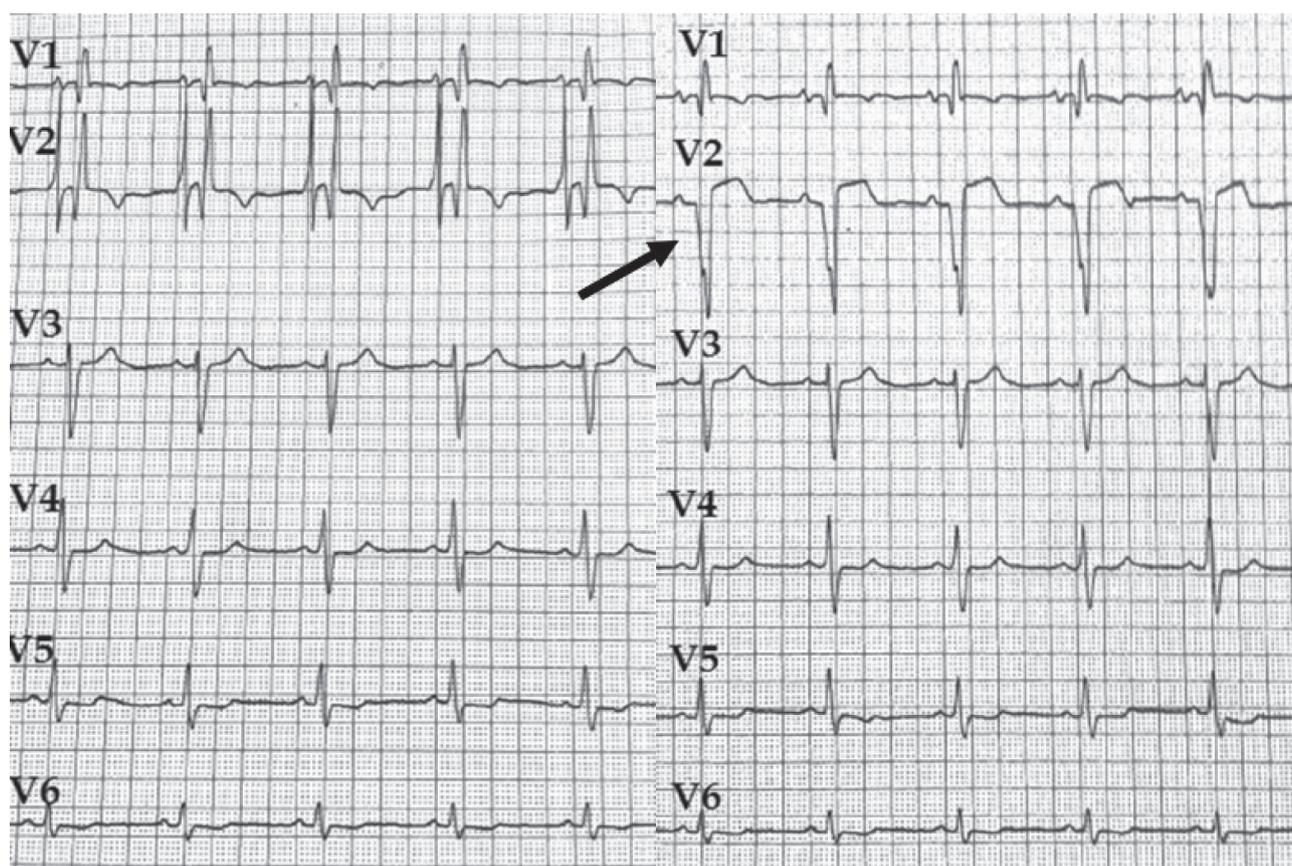


FIGURE 1. Lead V2 displays the endocardial electrogram (EGM) during passage of the pacing lead from the right atrium (left panel) to the right ventricle (right panel); transition is indicated by the QS pattern of the EGM and the ST elevation (arrow).

coronary vein (Fig. 2). Note also that echocardiography may be another, less often used option, for lead guidance.⁴

When the lead is in place, the external generator is securely connected to it, and the appropriate pacing mode is selected (usually VVI). The capture and sensing thresholds are being tested as described above. In an emergency, the highest output should be tried first (e.g. 15-20 mA); it should then be gradually reduced until capture is lost. If the situation is not an emergency, the rate is set 10-20 beats/min above the intrinsic heart rate, and the output is initially set very low and then gradually increased until capture occurs or set high and gradually decreased until capture is lost. The output should be set to a value at least 2-5 times higher than the threshold to ensure a safe margin for any change that occurs in the capture threshold, which is usually less than 1 mA. A position with low pacing threshold (≤ 1 mA) should be sought; a high pacing threshold >5 mA in the right ventricular lead indicates a need for repositioning. A slightly higher capture threshold is acceptable for atrial leads because they are less stable than ventricular leads.

To check the sensing threshold (if it is needed in the de-

mand pacing mode), the pacing rate should be set lower than the intrinsic heart rate. The value of the sensitivity setting should then be gradually increased until the pacemaker fails to sense the intrinsic activity and consequently begins firing. The sensing threshold is usually more than 5 mV in the ventricle and is much lower in the atrium. The final sensitivity should then be set at a low value (high sensitivity) to effect adequate sensing of native electrical activity including extrasystoles and thus avoid inappropriate pacing and arrhythmia triggering. On the other hand, the sensitivity setting should not be too low (indicating high sensitivity) as the external pacemaker devices are more prone to electromagnetic interference from various external sources and equipment in the intensive care unit (e.g. respirators, monitors, even mobile or wireless phones, etc.) and thus risk pacemaker inhibition. In case of pacemaker dysfunction in the form of absent pacing, one should discern between visible pacemaker spikes that do not capture, which points to increased threshold or lead dislodgment, and absent pacing spikes which indicates disconnected leads or pacemaker inhibition due to oversensing; when proper connections are confirmed, increasing the sensitivity setting or selecting a VOO

TEMPORARY PACING

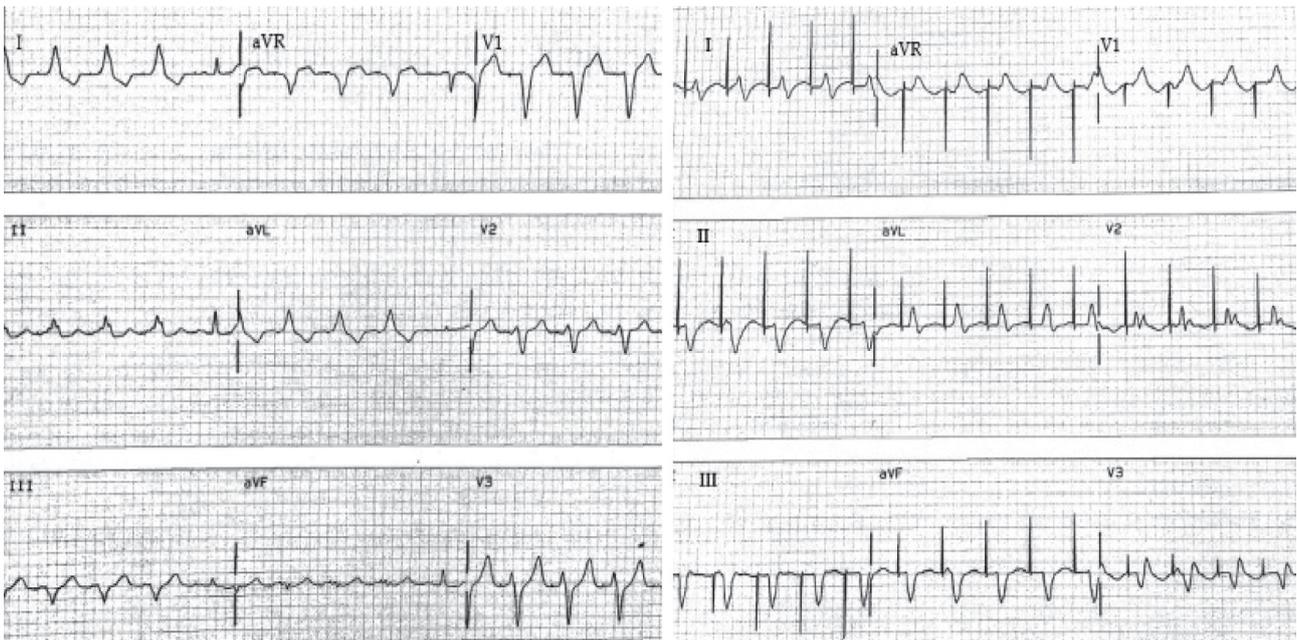


FIGURE 2. When the pacing lead lies within the right ventricle, pacing produces a LBBB-like QRS morphology (left panel); when it has inadvertently entered the left ventricle or an epicardial coronary vein (e.g. the middle cardiac vein), pacing produces a RBBB-like QRS morphology (right panel). LBBB = left bundle branch block; RBBB = right bundle branch block.

mode might correct the oversensing problem. Finally, the AV interval in AV sequential pacing is usually set between 100 and 200 ms, which is comparable to a normal PR interval.⁴

ENTRY SITE / PERI-PROCEDURAL CARE

At the end of the procedure, the introducing sheath should be carefully removed from the vein and moved all the way back to the proximal end of the pacing lead, since leaving the introducer in place may be an important gate of bacteria entry and infection. A first suture is placed at the entry site to secure the lead in place, but also a second suture is even more important to be placed at a small wire loop created just a bit more proximally (to prevent lead dislodgment from accidental pulling), all contained within the sterile field which should subsequently be covered with a sterile dressing. The remaining length of the pacing wire can be looped and secured in the ipsilateral arm of the patient together with the connectors and the external pacing device, so that the patient could ambulate early, if clinically deemed appropriate, rather than sentenced to being bed ridden. Leaving the sheath in place and using long sleeves over the pacing wire has been suggested by some as convenient for repositioning the pacing wire in case of displacement, in analogy to the sleeve used for the Swan-Ganz catheter. This strategy should though be limited to those patients who are bed ridden, hemodynamically unstable, perhaps on respiratory support in the intensive care unit, but this approach may confer an increased risk of infection. For patients who are otherwise

stable, except for their need for temporary pacing, an entirely different strategy is proposed, as described above, rendering them capable for early ambulation.

COMPLICATIONS

Although the complication rate of temporary cardiac pacing has been reported to be as high as 32-35% in British and Danish studies,^{32,33} especially for less experienced operators, more commonly this rate is limited to 2%-10%. Complications may comprise local access bleeding, air embolism, nerve damage, pneumothorax or hemothorax during the subclavian puncture, hemopericardium and pericardial tamponade, atrial and ventricular arrhythmias during catheter insertion, including atrial fibrillation and occasionally ventricular tachycardia and ventricular fibrillation; this is why an external defibrillator should always be present during TCP.^{1,34} A more common complication relates to post-procedural lead displacement resulting in loss of pacing capture and need for re-intervention. An important and avoidable, albeit risky, complication relates to infection leading to bacteremia and endocarditis. Thus, an aseptic technique and antiseptic measures during the procedure, avoidance of the femoral route and diligent local care and vigilance post-procedurally are of utmost importance to avoid this potentially dangerous complication. Emergence of pericardial pain and an audible pericardial rub dictates a need for repositioning; fortunately, rarely does this condition lead to tamponade.

POST-PROCEDURAL PATIENT CARE

Most studies have shown a relatively low rate of infection during the first week of transvenous temporary pacing. However, when there is need for longer duration of temporary pacing, the complication rate may increase. Infection can be reduced by avoiding femoral access and maintaining high standards of local access care. There has accumulated significant experience from the time when electropharmacological testing was routinely performed in patients with ventricular tachyarrhythmias to test the efficacy of anti-arrhythmic drugs, before the implantable defibrillator became more widely available. At that time, after the first (primary) electrophysiology study, a small (4 or 5F) bipolar temporary wire was routinely inserted via the subclavian vein and placed at the right ventricular apex, which stayed in place for the duration of the period of drug testing via repeat sessions of programmed stimulation, which occasionally could last 3-4 weeks. Carefully sterile initial procedure and meticulous local care of the access site (cleaning and dressing change), together with daily cardiac auscultation for the appearance of pericardial rub and periodic threshold testing of the pacing wire and/or recording of the endocardial electrogram when needed, resulted in only rare occurrence of infections or other complications, or at least these measures permitted early recognition of such complications. Finally, recording the time of replacement of batteries of the external pacemaker device by placing a label on the device and watching for battery depletion, as well as securing and conducting surveillance of the lead connections to the pacemaker device are also other important measures to both prevent and detect further problems.

The connections of the lead with the pulse generator should be securely attached and the generator should be secured in place to prevent an unexpected drop in the ground. Attaching it to the patient's arm would be ideal, in an ambulatory patient.^{4,34} Thorough care should be implemented to prevent infection. Use of antiseptic and a sterile, preferably transparent, dressing at the access site is of utmost importance; the entry site should be cleaned and the dressing changed daily.³⁴ Routine use of prophylactic antibiotics is not necessary unless there is a sign of infection, pacing is prolonged (>7 days) or femoral access is used. Twelve-lead-ECG, pacing and sensing thresholds should be assessed daily, as they fluctuate over time. Threshold testing in pacemaker dependent patients (with >90% pacing) should be performed with caution. Whenever there is a suspicion of lead dislodgement a new chest x-ray should be ordered.^{1,4,34} Indeed, transvenous TCP, using standard temporary wires, has been plagued with loss of capture more frequently compared to the very low risk with permanent pacemakers. The patient should be maintained on telemetry for the duration of temporary pacing. This caveat together with the declining skill and capability of operators, mainly due to lack of training,^{35,36} all culminating into an inordinate rate of complications of transvenous TCP in some, mostly European, countries, is the

main reason why some clinicians have declared this life-saving procedure as an "orphan" and advocated a 24-hour permanent pacemaker implantation service.^{36,37} However, this strategy may lead to a hastened decision regarding the need for permanent pacemaker, poses the risk of missing indolent infection with subsequent severe consequences of device infection, and also missing other serious underlying disorders which may come up when the routine pre-procedural test results become available at a later time. Since, there is definitely a way to make TCP a safe procedure and durable process, educational bodies and societies should aim at restructuring the training guidelines for TCP, rather than compromising patient safety with hasty and frivolous approaches.

PHYSICIAN TRAINING

Currently, there are limited guidelines on training requirements to achieve competency on temporary cardiac pacing. The Accreditation Council for Graduate Medical Education (ACGME) guidelines recommend that residents perform 6 cardiac pacing attempts during residency training, either in patients or simulators, but make no distinction between transcutaneous or transvenous pacing.³⁸ According with the joint statement released in 1994 by the American College of Physicians, American College of Cardiology (ACC), and American Heart Association (AHA) regarding clinical competence in insertion of a transvenous TCP, a minimum of 10 TCP procedures are required of the trainee.³⁹ Over the recent years, it has become apparent that simulation techniques are adequate and effective in measuring procedural competency and may thus constitute a substitute of "hands on" patient practice and experience as a training tool for physicians in various procedures, including training on transvenous TCP.³⁸ In the US, medical and surgical residents usually receive training right from the start in their first year of residency how to place a transvenous TCP lead, and thus there is usually no need to call upon a cardiology fellow or attending physician to perform the procedure except for difficult cases. However, in Europe and other parts of the world, this task is relayed to a cardiologist rather than a physician of other specialties. In either case, adequate training is the key to successful and safe performance of this life-saving procedure.⁴⁰ In addition to cardiologists, other specialists with an aptitude for this procedure may be emergency medicine physicians, intensivists, and anesthesiologists.

CONCLUSION

Transvenous temporary cardiac pacing is an indispensable treatment modality for the acute treatment of a variety of dysrhythmias, mostly bradyarrhythmias, and therefore it

is considered a critically important skill for the clinician. Its implementation, however, requires both competent interventional skills and experience in cardiac pacing, as well as continuous care after the successful insertion, in order to maximize the potential benefit for the patient and to mitigate the risk of complications.

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