Management of temporary epicardial pacing wires in the cardiac surgical patient

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Abstract

Temporary epicardial pacing wires are used after cardiothoracic surgery to maintain a stable cardiac rhythm. They must be distinguished from the more commonly encountered transvenous temporary pacing wires, which are often used in coronary care units for the same purpose. Patients with temporary epicardial pacing wires may be transferred to hospital wards where these wires are not usually encountered, such as COVID wards, the general intensive care unit, the coronary care unit or general surgical wards if a laparotomy was required in the early period following cardiac surgery. Serious complications may arise in managing patients with temporary epicardial pacing wires, which are well known in the cardiothoracic unit but not so well known elsewhere in the hospital. This article discusses the dangers associated with the management of temporary epicardial pacing wires in adult patients, some of which are common to temporary transvenous pacing wires and others are unique to temporary epicardial pacing wires.

Key words: Cardiothoracic; Pacemaker; Pacing; Post-surgery; Temporary epicardial pacing wires

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Introduction

Temporary epicardial pacing wires are often placed after cardiac surgical operations (Batra and Balaji, 2008). They should be placed following all types of valvular heart surgery and in certain patients undergoing coronary surgery, specifically those with a low resting heart rate, and those with electrocardiogram abnormalities predictive of increased risk of postoperative complete heart block such as bifascicular or trifascicular block. Many surgeons also use temporary epicardial pacing wires following coronary surgery if there is more than mild impairment of the left ventricle (Reade, 2007). Most patients who are still dependent on pacing 1 week after cardiac surgery will need a permanent transvenous pacemaker to be implanted before they can be discharged home. It is usual to wait 1–2 weeks before implanting the permanent pacemaker to allow for spontaneous recovery of cardiac rhythm and for any infection to resolve (Batra and Balaji, 2008).

Epicardial pacing wires

Cardiac pacemakers may be unipolar or bipolar (Reade, 2007). All pacemakers have an anode and cathode, but in bipolar pacing leads the two electrodes are incorporated in a single pacing lead (Figure 1a). With unipolar leads (Figure 1b) the anode and cathode are attached to separate pacing wires which may be separated by several centimetres from one another. Most commonly, two unipolar leads would both be placed on the right ventricle, but one of the leads can be placed in the rectus muscle or in the subcutaneous tissues (the other being on the right ventricle).

For temporary epicardial pacing wires, the standard pacemaker notation is given as a three-letter code according to which cardiac chamber(s) is paced and which is sensed (Lak and Goyal, 2020). The third letter indicates the response to sensing electrical activity. The simplest pacemaker is an automatic pacemaker without any sensory function, denoted as VOO. If the atrium was being paced automatically it would be denoted as AOO. These pacing modes are useful intraoperatively when diathermy might otherwise inhibit a pacemaker that was necessary for a stable cardiac rhythm, but should not otherwise be used.

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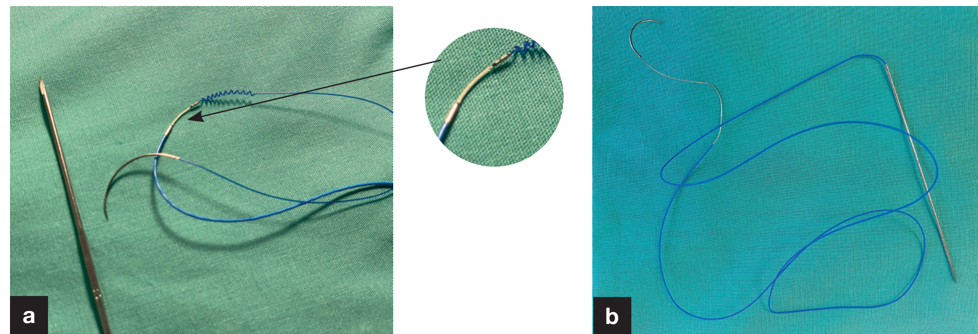

Figure 1. a. The bipolar pacing lead. The enlarged section highlights the metallic anode and cathode separated by a plastic bridge. b. A unipolar pacing lead. Another unipolar lead would be placed to complete the electrical circuit.

The most commonly used arrangement is VVI pacing (Schwerg et al, 2020). The right ventricle is paced and sensed and the response to sensing cardiac electrical activity is to inhibit electrical pacing. Sometimes AAI pacing is used but this is not recommended as many cardiac monitors will count the atrial pacing spikes as QRS complexes even when dangerous bradycardia is present, leading to a potentially fatal delay in correcting such a rhythm. Dual chamber pacing can be denoted as DVI or DDD. In the former, both the right atrium and right ventricle are paced with a specified atrioventricular delay set to mimic the natural atrioventricular delay of 150–200 ms. With DVI pacing the output is inhibited if right ventricular electrical activity is sensed, whereas with DDD pacing both chambers are sensed and paced independently of one another.

Setting up a pacemaker

A patient who is pacing dependent might end up in a non-cardiac surgical clinical area, so this article details how to safely set up a pacemaker. Most temporary pacing units are capable of all the pacing modes mentioned, assuming the correct epicardial wires were placed intraoperatively. Figure 2a shows a typical modern external pacing box. The key variables that need to be controlled are the pacemaker rate, the output voltage and the sensory threshold.

Temporary pacing wires tend to lose their function as time progresses because fibrosis affects the points where they are attached to the myocardium (Reade, 2007). Typically, they will be reliable for at least 2 weeks after surgery. Beyond this period, there is also a risk of infection. The pacing threshold is the minimum output that results in regular capture of the cardiac rhythm by the pacing unit. Confusingly, older pacing boxes (Figure 2b) have the output calibrated in volts whereas newer ones are calibrated in milliamperes. Each 1-unit voltage increase equates to a 2-unit increase in milliamps on the output side of the pacing circuit. The pacing threshold is determined by setting the pacemaker unit to a heart rate higher than that of the patient, starting initially with a high output – 10–15 mA or 5–10 V is usually sufficient – and then gradually turning the output down until failure to pace is observed following pacing spikes. The current output in mA or V at which this occurs is called the pacing threshold. The output can then be turned back up until pacing is recaptured. The output current or voltage should be set at 4 mA or 2 V above the pacing threshold to give a margin of safety. It is recommended that this exercise be repeated daily to minimise the risk of sudden loss of pacing.

Figure 3 shows the kind of electrocardiogram trace that is observed when the sensory side of the pacing unit has not been set up correctly. The problem is that the pacing unit fires inappropriately because the sensory threshold has been set too high. The pacing spikes fire randomly with respect to the cardiac cycle and may result in ventricular tachycardia or fibrillation if they land on the upstroke part of the T-wave. A pacing unit giving an electrocardiogram trace such as that shown in Figure 3, if left to persist, will cause approximately one episode of ventricular tachycardia or ventricular fibrillation per 24 hours.

To prevent this, it is necessary to determine the sensory threshold of the pacing unit. For this the patient must have an underlying cardiac rhythm that is compatible with life.

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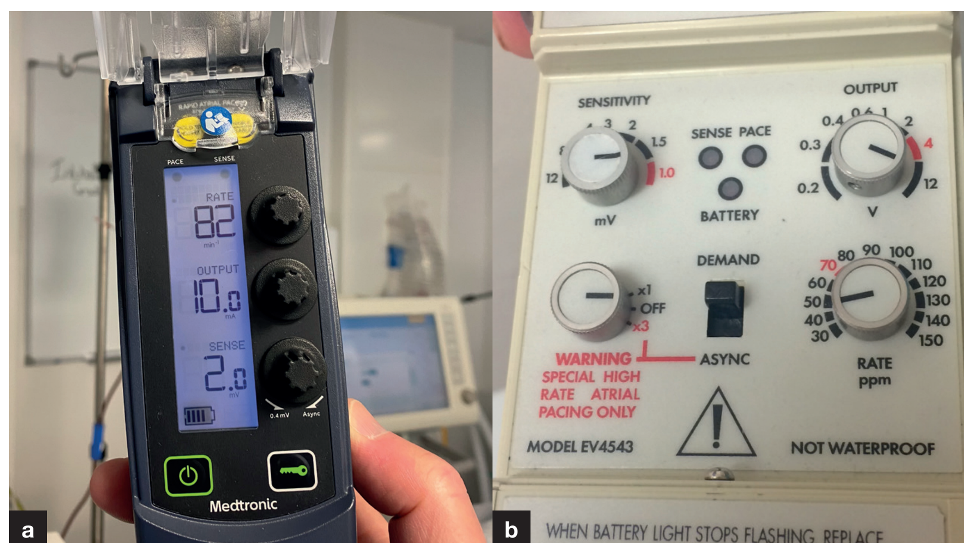

Figure 2. a. A modern external pacing box. b. An older external pacing box.

Figure 3. Electrocardiogram highlighting inability of pacemaker to ascertain if the heart is beating satisfactorily as a result of an incorrect sensory setup of the pacing unit.

The procedure is typically carried out with a VVI pacing arrangement. It involves setting the pacemaker unit to a rate below that of the patient with a low sensory threshold value – 2 mV would be a good starting point. At this level the pacemaker will typically be inhibited by normal electrical signals from cardiac contraction. The sensory value is then gradually increased until regular pacing spikes are seen on the electrocardiogram monitor. Some of these will result in a paced beat while others will not. The value at which inappropriate pacing spikes start to appear is called the sensory threshold. The pacing unit sensory value should be set at half the sensory threshold for safe pacemaker function. Many patients who require cardiac pacing will not have a stable underlying cardiac rhythm, in which case it may not be possible to measure the sensory threshold. For these patients a generic sensory setting of 2 mV will usually suffice. If this is not the correct setting, they will exhibit the electrocardiogram features illustrated in Figure 3, in which case the sensory setting should be adjusted downwards until the inappropriate pacemaker activity disappears.

Accidental extraction of temporary epicardial pacing wires causes serious problems, for instance by a delirious patient or when lifting a patient in bed without first checking

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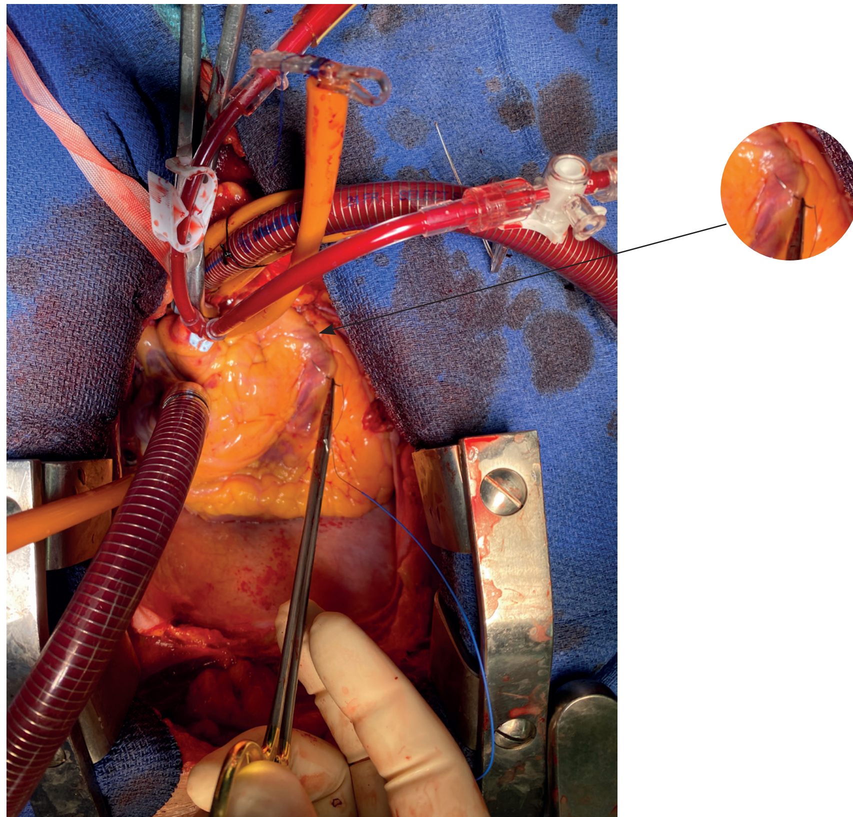

Figure 4. Needle driver holding pacing wire to insert into the epicardium. Highlighted is the pacing lead needle perforating the myocardium.

that the pacing cable had enough slack on it. Where the underlying rhythm was asystole, cardiac arrest swiftly ensues which can be treated by external transcutaneous pacing. In the pacing-dependent patient, pacing wires must be carefully guarded. Figure 4 shows pacing wires being inserted into the epicardium.

The pacing leads are then exteriorised by inserted the long needles (Figure 1b) through the abdominal wall in the left hypochondrium (Figure 5). There is a convention that ventricular pacing wires are always brought out in the left hypochondrium and, when used, atrial pacing wires are brought out in the right hypochondrium.

The needles snap off to leave blunt metallic pins which are then inserted into the pacing cable sockets (Figure 6). When the pacing wires insert into the pacing cable sockets, there is potential for a metallic structure to create an electrical short between the electrodes with the same effect on cardiac rhythm as removing the pacing wires. For this reason, the pacing wires and the attached pacing cable sockets (Figure 6) are usually thoroughly covered with adhesive dressings applied directly to the patient's skin to prevent them from being exposed.

These dressings must be changed carefully without using scissors. The thin temporary epicardial pacing wires are very easily cut which could cause cardiac arrest in the pacing-dependent patient. If this happened, the attending staff could use a pair of scissors to strip the plastic off the severed pacing lead and then insert the bare metal wire into the pacing cable socket but in the panic of the moment, this may not come to mind. Transcutaneous external pacing may be a more reliable rescue plan.

Removing temporary wires

Removing temporary epicardial pacing wires is usually the most dangerous aspect of their management. This is done by applying firm gradually increasing traction with counter pressure on the skin (Video 1 [TEPWs Removal Video.mp4]). The wires usually come out easily. Following removal, the patient is kept on bed rest with blood pressure and pulse recordings taken every 15 minutes for 1 hour. If the patient remains stable over this observation period, no further special measures are required.

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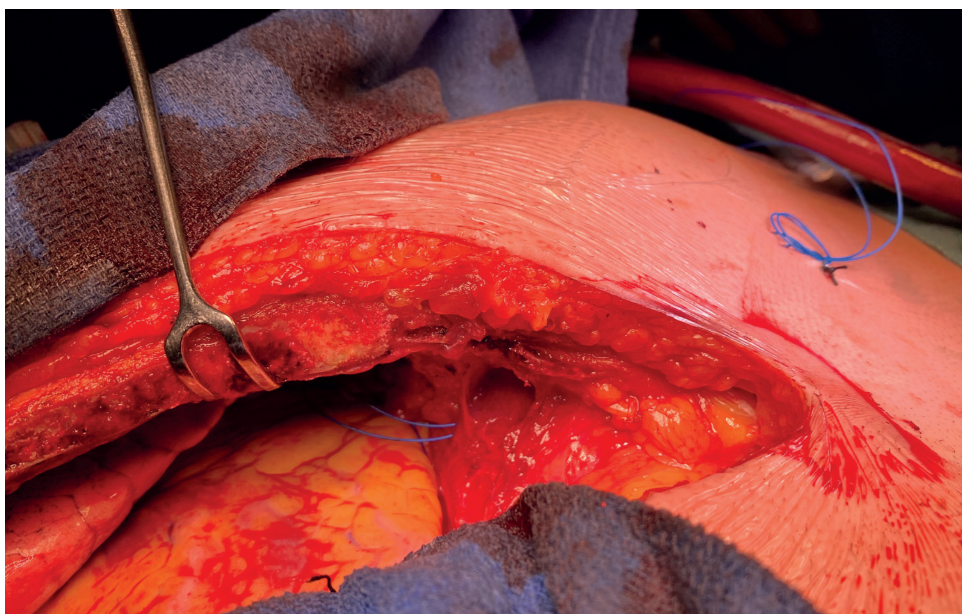

Figure 5. Ventricular pacing lead exiting the surface of the left hypochondrium.

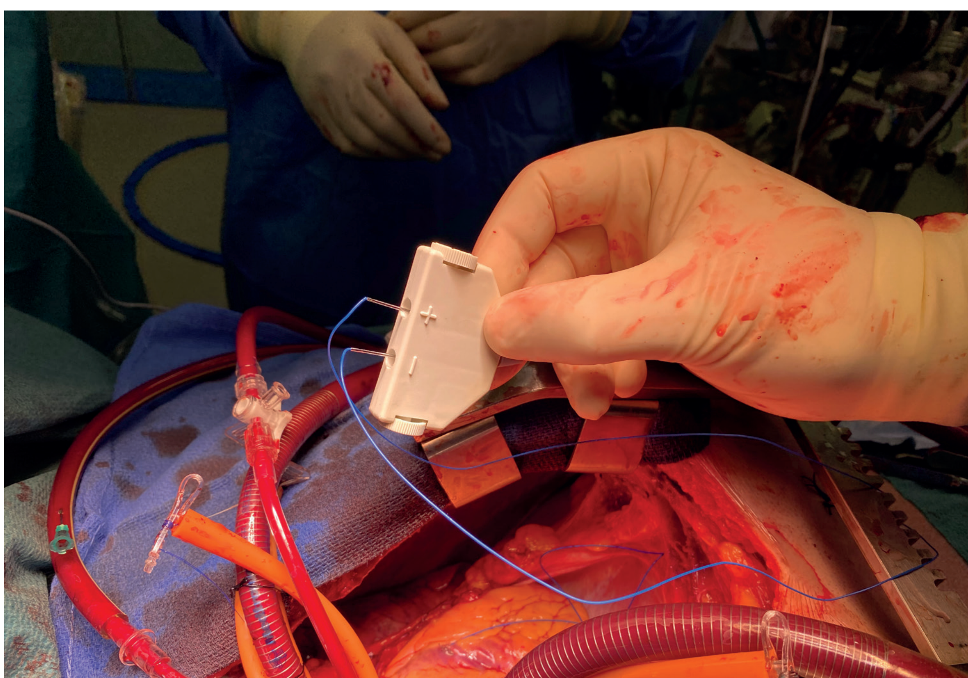

Figure 6. Unipolar pacing leads inserted into the pacing cable sockets.

Patients are usually taking antiplatelets or anticoagulants following cardiac surgery and these drugs can cause the removal of temporary epicardial pacing wire removal to be dangerous for the patient. Temporary epicardial pacing wires can be removed if the patient is taking aspirin but not if they are taking another antiplatelet as well. Novel anticoagulants should not be commenced before removal of temporary epicardial pacing wires (Bougioukas et al, 2017). International normalised ratio or activated partial thromboplastin time ratios of less than 2.5 are required for removal of temporary epicardial pacing wires on cardiac surgical wards, and for removal in other clinical areas these should be less than 2.0 (McRae, 2016). Treatment dose low-molecular-weight heparin should not be used before temporary epicardial pacing wires are removed (Elmistekawy et al, 2016). Platelet count should be greater than 100x109/litre for temporary epicardial pacing wire removal (Richardson, 2011) – if it is less than this, a unit of platelets should be given just before removal.

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Human error occasionally leads to one of these factors being overlooked or not checked before temporary epicardial pacing wire removal, in which case life-threatening intrapericardial bleeding can occur (Mahon et al, 2012). This is especially likely when new members of junior medical staff are making decisions about temporary epicardial pacing wire removal. In most cardiothoracic units, chest re-opening is required once every year or two following removal of temporary epicardial pacing wire and in most cases, errors in the decision-making process can be identified (Bougioukas et al, 2017).

Complications

A number of rare but unique complications of temporary epicardial pacing wires have been identified from a review of the literature. Electronic databases (PubMed, Science Direct, Cochrane Library, and Google Scholar) were searched with the key words temporary epicardial pacing wires, TEPW, pacemaker, post-surgery, cardiothoracic, arrhythmia and pacing.

In addition to the aforementioned problems that may occur with temporary epicardial pacing wires, a number of unique complications were identified. These included infection of pacing wires (Reade, 2007), and pacing wires having been passed through the transverse colon when being exteriorised at the time of implantation leading to peritonitis and the need for laparotomy (Salami et al, 2012; Gonzales et al, 2015). Intractable hiccups were observed when the pacing wire was placed near the phrenic nerve (Doshi et al, 2008), and entanglement with bypass grafts was seen leading to damage to coronary anastomoses at the time of pacing wire removal (Batra and Balaji, 2008).

Some institutions do not remove the pacing wires but cut them flush with the skin under traction so that the retained cut end retracts well below the skin surface (Shaikhrezai et al, 2012). In units that would normally remove pacing wires, this may be necessary if the pacing wire becomes trapped between the sternal edges during chest closure.

Some bipolar temporary epicardial pacing wires are more traumatic to implant than others, especially when they have to be placed with a deep bite into the right ventricle. In older patients the tissue quality of the free wall of the right ventricle can be very poor (Strait and Lakatta, 2012). Under these conditions, attaching the pacing lead to the heart may provoke significant haemorrhage; rarely this may be impossible to control, resulting in the death of the patient (Smith and Tatoulis, 1990).

Unipolar pacing leads are generally the least traumatic to implant. Where two unipolar leads have been placed on the anterior surface of the right ventricle, a figure of eight configured sternal wire may touch both pacing electrodes thus shorting the pacing circuit and thereby rendering it ineffective. It is important to keep the two unipolar leads as far apart as possible on the free wall of the right ventricle to avoid sternal wire-mediated circuit shorting.

Conclusions

This review highlights the potential hazards of temporary epicardial pacing wires and gives guidance for safe practice in their management. They are an indispensable part of clinical cardiac surgical practice and their use saves many lives in cardiothoracic units each year. A number of rare complications have been described, mainly in case reports. Some relate to the technical aspects of anchoring the pacing leads directly to the heart, and are included here for the benefit of cardiac surgical personnel. Unless such complications are highlighted, they are likely to be repeated.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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Key points

- Temporary epicardial pacing wires are an indispensable part of clinical cardiac surgical practice and their use saves many lives in cardiothoracic units each year.
- Potential complications that could arise with regards to the removal of the pacing wires relate to patients taking certain anticoagulants or to the technical aspects of anchoring the pacing leads directly to the heart.

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