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Review

Rhythm or Blues: Managing the Electrical State of the Heart with Temporary Pacing Wires

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Abstract

Temporary pacing wires are commonly used in cardiac surgical operations. We will review the basic principles of the use of these temporary pacing wires that we teach our residents, with the goal of providing cardiac surgical trainees guidance in the placement and use of these wires.

Keywords

temporary cardiac pacing wires; the electrical state of the heart; setting up a temporary pacer

Introduction

There are five conditions or 'states' of the heart that should be considered when attempting to optimize cardiac output [1]. These five states of the heart are:

- Preload
- The compliance of the heart
- The inotropic state of the heart
- The electrical state of the heart
- Afterload

Each of these conditions is worth considering, in turn, as one tries to separate from cardiopulmonary bypass during cardiac surgical operations or to optimize cardiac function in other situations. A specific indication for the use of pacing wires is when a MAZE ablation has been performed to treat atrial fibrillation.

In this treatise, we will address some of the aspects of optimizing the electrical state of the heart, specifically with temporary cardiac pacing.

It is obvious that having control of the rhythm and rate of the heart is vital to the outcomes for patients undergoing cardiac surgical operations. While the optimal electrical state of the heart is one in which the rate and rhythm approximate normal electrophysiological conditions, it is frequently incumbent on the cardiac surgical team to ensure that these conditions are met and maintained, often with the use of temporary pacing of both the atria and the ventricles. While there are many facets of controlling or managing the electrical state of the heart after cardiac surgery, understanding the nuances of temporary cardiac pacing is of paramount importance. And, placing and using the temporary pacing wires are key aspects of managing these issues.

Therefore, we will focus on the technical aspects of placing and using the pacing wires that are necessary for temporary cardiac pacing, with attention to the wires used to pace the ventricles and those used to pace the atria. Inadequate management of the rhythm of the heart can, indeed, lead to 'the blues' for all concerned. It is noteworthy that this important topic is relatively unaddressed, even in some of the most popular cardiac surgery techniques books [2,3].

Ventricular Pacing Wires

Ventricular pacing wires (V wires) have 'swedged-on' needles that have a segment of bare wire just behind the curved needle, which is the area of the wire that will be in contact with the ventricle, once the wire is placed. The needle is cut off after it is passed into ventricular muscle. Here's a diagram of such a wire (Fig. 1):

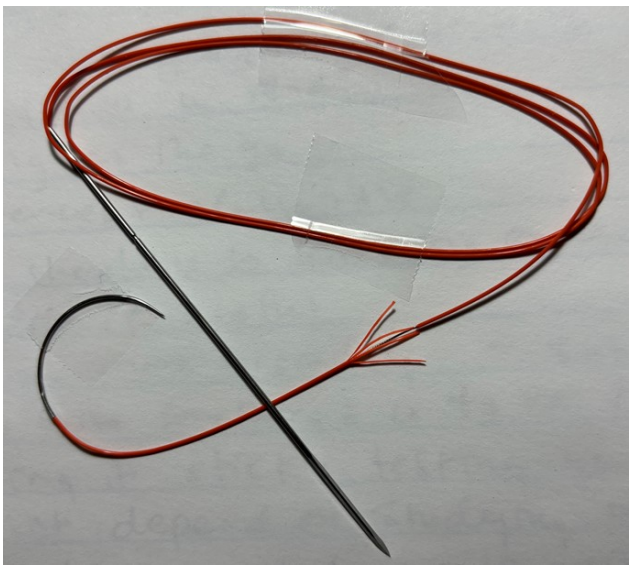

Fig. 1. A Typical Temporary Pacing Wire.

The ventricular pacing wires should be placed into the ventricular muscle, just beneath the visceral pericardium, using the swedged on curved needles that are attached to the wires. This method of placing the ventricular wires is in contrast to the optimal method of attaching the atrial wires, which we will address later in this treatise. Temporary ventricular wires are usually placed on the right ventricle but can also be placed on the left ventricle or on both ventricles. While most cardiac surgeons place two of these ventricular wires, some advocate putting on three wires, since one will function as a ground, and an extra wire might help if one of the others is not 'capturing' the ventricle. Alternatively, some surgeons place only one ventricular wire while placing a second wire elsewhere, such as the diaphragmatic surface or even the skin, to serve as a ground wire.

The electrical output of a cardiac pacemaker is direct current. You can experiment, as needed, to see which way the wires work best when they are hooked up to the pacer after they are placed, since one of the wires is 'active' and the other is a ground. It is worth noting that right ventricular pacing has been used as a laboratory model for creating heart failure (over time) and that bi-ventricular pacing is good for impaired ventricles. However, these issues are not commonly considered in the setting of temporary pacing of the heart after a cardiac operation.

The ventricular wires should be placed so that they are in good contact with the muscle of the ventricle. Thus, it is best to find an area on the ventricle that is not covered in epicardial fat, because you cannot pace through fat and because you will want to see precisely where you are placing these wires. The pacing wires should also be placed with consideration for how they will be pulled out, when they are no longer needed postoperatively. That is, you should situate them on the heart and lead them out through the upper abdominal wall in such a manner and direction that, when pulled, the wires pull straight out from the 'tunnel' in which they were placed on the heart. This strategy will lessen the likelihood of causing bleeding when the wires are eventually pulled out in the postoperative period. Even more specifically, the insulated end of a ventricular wire should face the left side of the patient, as that end of the wire will eventually be led out of the left side of the upper abdominal wall. That is, the curved needle on the wire should pass from left to right as the wire is placed on the ventricle. One must also avoid hitting epicardial vessels, which is easier to do accurately if you can see a patch of ventricular muscle that is not covered by fat, since the fat might cover a vessel that could be injured while placing (or when pulling) the wire.

It also makes sense to place the wires out toward the apex of the heart, as that is where you want the heart to contract first. Some authors have suggested that one should avoid placing the wires on the right ventricular outflow tract, for two reasons:

• It is thin and may bleed with the placement or the removal of the wires postoperatively, when they are no longer needed.

• You may want to avoid having the right ventricle to contract there first, as it may create an element of outflow tract obstruction, which is a form of 'iatrogenic' IHSS (idiopathic hypertrophic subaortic stenosis or, in the case of the right ventricle, idiopathic subpulmonic obstruction of the right ventricular outflow tract).

However, others have found that positioning the ventricular wires higher on the right ventricle may actually enhance ventricular function, possibly by activating the His-Purkinje System and, therefore providing more symmetrical depolarization of both ventricles [4].

In passing the other end of the pacing wires out through the upper abdominal wall, you should try to avoid hitting the superior epigastric artery which runs in the rectus sheath. If you do hit that artery, you will likely see arterial blood coming out along the track of the wire. If this happens, you should pull that wire out, and the bleeding will almost always stop. If the bleeding does not stop, you should put a figure of eight stitch around the entry site of the wire into the underside of the rectus sheath and hold pressure on the site for a bit. Pacing wires should rarely, if ever, be passed out between the ribs, as it is hard to cut them off so that they will retract, if the wires end up being cut rather than pulled later, as is the practice of some surgeons.

Some surgeons insert and position the posterior pericardial chest drain before placing the V wires because, in positioning that drain, the pacing wires can be dislodged. Furthermore, since it is quite important to drain the posterior pericardium well after a cardiac operation, it is optimal to get those tubes positioned early and accurately. Another reason to place the posterior pericardial drain early is that it can help keep the field clear while you are finishing up the case. (We will address the insertion and use of chest drains in cardiac surgery in a separate treatise).

You should also consider placing the V wires before the heart is beating vigorously, because it can be hard to hit the exact spot you are aiming for on the ventricle when the heart is moving around a lot. It takes only a minute or two to put the wires on when the heart is not beating, so placing the wires while the heart is quiet and decompressed is optimal. (You can always drain the heart out while still on cardiopulmonary bypass, even if it is already beating, to facilitate the placement of the V wires). Although the ventricular wires will not usually be near a coronary artery bypass graft, you must always be thinking about the possibility of an 'untoward interaction' between pacing wires and these grafts, which has, most certainly, been known to happen and can be catastrophic. So, you must ensure that the pacing wires are kept away from those grafts.

Since the pacing wires can pace the phrenic nerves, you need to keep them (at least the stripped portions) away from those nerves on both sides of the pericardium. You

should test the wires after you put them in to be sure that you are not pacing the phrenic nerves. This is more of an issue on the right side of the heart (where the atrial wires will be placed) than on the left side (where the ventricular wires will be located).

You should not leave excess wire in the pericardial space with hope of avoiding traction on the wires, as they are actually more prone to getting caught on things while you are closing the chest, if the wires are left too long. However, you should leave enough 'slack' in the wires to be able to lift the heart to inspect bypass grafts and to do other things that might be necessary as you finish up the case. Therefore, leaving some moderate amount of slack in the V wires is appropriate. If there is oozing from the site of the wire placement on the epicardium, a small, gently tied figure of eight stitch of fine Prolene can be placed around the wire. Stitches of this sort will not interfere with pulling the wires postoperatively.

Ventricular wires are more crucial than atrial wires. There is an old saying that 'V wires may save your patient's life but A wires may take your patient's life', a reference to how wires can cause bleeding when removed. Most surgeons do use ventricular wires in every cardiac case. If you do not put V wires on the heart in every case, you must place them at least in every valve case because heart block can exist after these cases. You should also place ventricular wires on every 'sick heart', including during left ventricular assist device insertions and transplants, because you want to have complete control of the electrical state of the heart in these cases. You should also strongly consider using ventricular wires on a coronary bypass case when you have had to lift and twist the heart (such as to do a lateral wall bypass graft), as this type of intraoperative positioning can sometimes lead to temporary heart block. Finally, you should always place pacing wires when an intra-aortic balloon pump is being used. Again, most cardiac surgeons place ventricular wires on every heart case, though some do not use atrial wires in all cases.

You must be sure to stitch the wires to the skin securely at their exit sites so that they don't get 'caught on door knobs' and get pulled out. The wires should be tied into a simple loop prior to securing them with a skin stitch. This loop will significantly lessen the chance that the wires will be pulled out inadvertently in the postoperative period.

Finally, if you have gone to the trouble of placing ventricular wires, they should be hooked up to a pacer at the end of the case, at least for the trip to the intensive care unit, as this early postoperative period is, potentially, the most unstable time for the patient. Furthermore, you should always test the wires before closing the chest to be sure that they will actually work and capture (pace) the left ventricle. Occasionally, they will not capture, and you will need to reposition them, put in an additional wire, or switch the polarity of the wires. Testing the wires is absolutely vital if there is any question at all about heart block or concern about decreased ventricular function. It is worth noting that the negative pole of the pacer is the 'output' pole. (A way of remembering this fact is that, with direct current, electrons, which are negatively charged, are moving from the pacer to the heart through the pacing wires).

One trick, when testing the wires, is to have the pacer set on asynchronous pacing, as occasionally something will suppress a pacer set in the demand mode in the operating room, such as atrial activity or, especially, the use of electrocautery. Using the 'asynch' mode is particularly important for atrial pacing. There is some theoretical issue with asynch pacing of the ventricle, as one wants to avoid the so called 'R on T' pacing, which could cause ventricular fibrillation, though this rarely happens. A practical way to deal with this issue is to avoid leaving the pacer pacing the ventricle asynchronously after getting the pacemaker set up in the operating room (OR) and, rather, shifting to the 'demand' pacing mode for the V wires. Also, when testing your pacing setup, you should do so, or at least start, with the output of the pacer turned all the way up. You can turn the output down later. Most of the time you want the pacer output to be twice what is necessary to 'capture' the heart. Higher pacer outputs are thought by some to make the wires not work as long in the postoperative period.

It is worth noting that the ventricular wires will occasionally appear to not be functioning correctly when initiating pacing immediately after removing the aortic cross clamp. This situation can be due to the wires shorting out on the diaphragm and can be resolved by placing a sponge between the wires and the diaphragm, while finishing up the operation.

Be sure to check the pacing wires sites on the heart when you're ready to close, because occasionally those sites will start bleeding after seeming to have been hemostatic at first. One last point about V wires is that ventricular wires can be used to overdrive pace ventricular tachycardia or to suppress premature ventricular contractions in the early postoperative period.

Atrial Pacing Wires

Atrial wires are less necessary than ventricular wires, as ventricular wires can 'save the patient' if heart block develops for any reason, including when an air bubble goes down the right coronary artery and lodges in the artery that supplies the atrioventricular (AV) node, if air is ejected from the heart as one comes off bypass. However, optimal atrial pacing can add significantly to the cardiac output, both by increasing the heart rate and by optimizing ventricular filling. Though estimates vary, the contribution of the atrial output to overall cardiac output is at least 20%, and can be up to 30%, depending on the physiological circumstances [5].

There are two priorities in the placement and use of atrial pacing wires, which are that you should make sure that they work, if you have gone to the trouble of attaching them, and that they must not cause harm, especially when they are being removed. To attach the atrial wires, you should take the curved needles off and strip the insulation off of the wires, so that you will have enough surface area on the wire for adequate contact with the atrial tissue. When stripping the ends of the wires, you can use a scalpel blade and hold the wire against something solid and flat like the sternal retractor. The wires must have significant contact with atrial tissue, and they cannot be in contact with each other, since they will 'short out' if they are touching.

Atrial wires can be used not only to pace the atrium but can also be used to diagnose arrhythmias. Sometimes atrial wires, hooked up to an EKG machine, can differentiate ventricular tachycardia from an atrial arrhythmia with aberrancy. Furthermore, one can use atrial wires to overdrive a patient out of atrial flutter. And, of course, atrial wires are necessary for A-V sequential pacing. One should never pace a heart with just the ventricular wires if the atrial wires are in place, as you would be failing to take advantage of the atrial 'kick'. Furthermore, if the atrial wires will capture and pace and there is no heart block, the heart will work considerably better if only atrial pacing is used, as the atrial impulse will travel into the ventricles through the normal conduction system, which will allow normal simultaneous depolarization of both ventricles and, thus, optimize cardiac function. This concept is an important one to consider. We recommend placing atrial wires in any patient who has right or left ventricular dysfunction or who has a need for pacing due to heart block or bradycardia, since these patients tend not to tolerate ventricular pacing alone very well. In addition, all heart transplant recipients should have atrial wires placed to keep the heart rate up postoperatively, which will help support the function of the right ventricle in the early postoperative period.

Atrial wires are usually placed later in the operation than are ventricular wires, as it is fairly easy to get them positioned on the atrium with the heart beating. Furthermore, the atrial wires are more likely to get pulled out inadvertently while decannulating or doing the other chores needed to finish up the case, such as positioning chest drains. Again, you should not to put the atrial wires too far posterior on the right atrium because they can pace the right phrenic nerve when they are too close to it, which is painful for the patient (When the phrenic is being paced, it is as though the patient has the hiccups, with a hiccup rate of 80 to 100 times a minute!).

Optimal contact of each wire with the right atrium requires that the wires not be attached to fat nor to an area that is or will become ischemic. What area on the atrium might become ischemic? The tissue 'outside' or above a pursestring (like the right atrial cannulation site) can become relatively underperfused once the atrial pursestring is tied. Atrial wires placed into this tissue will work for a while but may fairly quickly become unusable, because the tissue 'above' the pursestring may not be well perfused (Still, some surgeons do like to attach A wires to sites like this because there is theoretically less chance of causing bleeding when they're pulled.).

So, to get good contact, you can consider creating a trough for the stripped wire to lie in. This strategy is analogous to a Witzel Stitch, as shown in Fig. 2:

The optimal way to place these stitches is to take a bite with a 5-0 Prolene in one area of the right atrium with some laxity and then to take a bite just far enough away from that spot to create a tunnel over the wire when the suture is tied, as shown in Fig. 3:

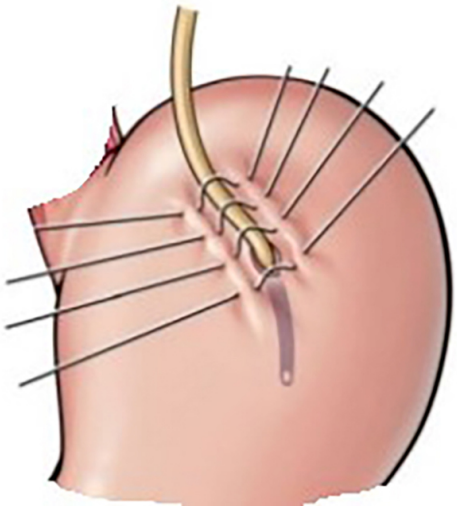

Fig. 2. Using a Witzel Stitch for the Pacing Wire.

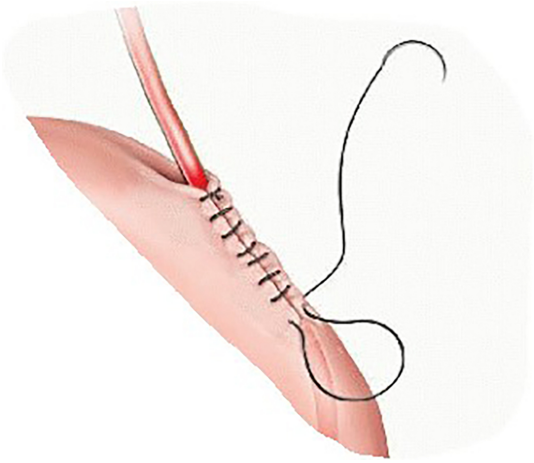

Fig. 3. Using a Witzel Stitch to Provide Optimal Contact of the Atrial Tissue to the Pacing Wire.

When the suture is tied, the atrial tissue will come together over the top of the wire, and the amount of tissue in

contact with the wire will be optimized. Furthermore, the wire will slide right out when the wires are pulled later. It does help to kink the end of the A wires a bit to help keep the wire in this groove. A small amount of kinking of the wire tip will not cause trauma to the atrium when the wire is pulled out and may make the wire a bit more secure in the position you have chosen to place it.

It may be best to avoid using the tissue in a pursestring that has been used for a retrograde cardioplegia cannula for an A wire site, though some surgeons do use this technique. One reason to avoid using this technique is that one may need to repair that cannulation site later, in which case, the wire could become trapped by the repair stitch. You should also avoid having an atrial wire near the sinus node (at the junction of the superior vena cava and the right atrium), as your stitches may interfere with its proper function or with its blood supply. Furthermore, you should be sure that the atrial wires will end up lying away from any coronary graft that is running along the right side of the heart. You definitely do not want an atrial wire and a coronary graft to become too intimate! Again, you do not want to make these wires too long as they may end up getting caught on instruments or fingers while finishing up the case. Finally, you should always test these pacing wires, both for assurance that they are ready to work and to help the anesthesiologist set up the pacemaker correctly, since they may be unfamiliar with temporary cardiac pacing.

Passing the Wires out of the Chest

When you are ready to pass the wires out to the surface of the upper abdomen, the properitoneal fat should be dissected away from the back of the rectus muscles on both sides. This dissection of the properitoneal fat is actually best done at the beginning of the case, but if it has not already been done, this is the time to do it. Dissecting this properitoneal fat makes all of the following easier:

- Passing the pacing wires out through the skin.
- Passing the chest drains out of the chest.
- Closing the fascia of the upper abdomen accurately and without fat getting between the fascial edges, which can impair healing.

This dissection also minimizes the risk of passing wires or mediastinal tubes through the peritoneal cavity where they might injure the stomach or bowel, which can, most certainly, happen. As an old saying goes, this is not a good place for a colostomy!

The long straight needles on the external end of pacing wires can be tricky to handle, and people get stuck by them on occasion. These wires are also more difficult to handle in heavy patients. Sometimes, it is useful to load these needles onto a heavy needle driver to facilitate their passage out to the upper abdominal wall. It can also be helpful to press down on the skin at the intended exit site with the finger hole of a needle driver or clamp, which can help to keep your fingers out of harm's way. Remember that the convention for the orientation of these wires is that the atrial wires are led out on the right side of the upper abdominal wall, while the ventricular wires are led out on the left.

Setting up the Pacer

A problem with atrial pacing when using the current generation of temporary cardiac pacers is that the pacers are usually set in the synchronous mode. This mode is often the default mode so that the pacer can function by sensing an impulse from the sinoatrial (SA) node, which will then trigger an impulse to the ventricular leads. While this pacing strategy may seem attractive, it is virtually never necessary in the early postoperative period. However, this pacing mode can be quite useful for long-term or permanent pacing. Thus, the initial setting for pacing with atrial wires in the operating room, should be to use the asynchronous mode, which should override any intrinsic atrial activity. Conversely, pacing with the ventricular wires should be in the synchronous mode, which will avoid an R on T phenomenon and will, therefore, likely avoid inciting ventricular arrythmias.

The next pacer setting to sort out is the rate, which is generally best set at 90 to 100 beats per minute. You can adjust the rate later with guidance from echocardiography or from cardiac output as measured by a Swan Ganz catheter (especially when continuous cardiac output is being measured).

To set the pacer output, you should turn down the output until capture of the chamber being paced is lost, and then set the output to double that value. You should make this determination for both the atrium and the ventricle. Next you should check the sensing of the ventricular wires, by turning down the sensitivity until sensing is lost, and then doubling that setting. Always check to ensure that the pacing wires are securely attached to the pacer leads and that those leads are securely attached to the pacer itself. Finally, you will want to adjust the atrio-ventricular (AV) interval, as prolonging that interval may allow the ventricles to fill more completely. These adjustments are best made with guidance from transesophageal echocardiography, while still in the operating room.

A typical temporary pacer is shown in Fig. 4.

More specifically, the usual pacemaker set up for perioperative pacing is to set the atrial to ventricular interval (A-V interval) at about 150 milliseconds, to set the output for both chambers well above the minimum threshold (at first anyway), and to keep the atrial output mode in asynch (as opposed to 'demand' or 'synch'). The optimal rate for pacing in the early postop period is usually 90 to 100 beats per minute. You can read a more complete review of how to set up and use these pacers in The House Officer's Guide

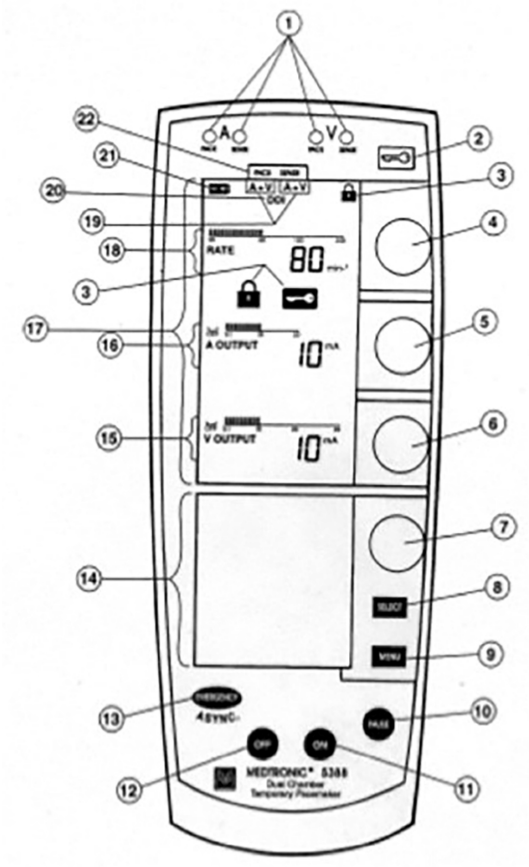

Fig. 4. A Typical Temporary Cardiac Pacer. 1- Pace & Sense LED's; 2- Lock & Unlock Key; 3- Lock Indicators; 4- Rate Dial; 5- Atrial Output Dial; 6- Ventricular Output Dial; 7- Menu Parameter Dial; 8- Parameter Selection Key; 9- Menu Selection Key; 10- Pause Key; 11- Power On Key; 12- Power Off Key; 13- Emergency/Asynchronous Key; 14- Lower Screen; 15- Ventricular Output Graphics; 16- Atrial Output Graphics; 17- Upper Screen; 18- Rate Graphics; 19- Setup Indicators; 20- DDI Indicator; 21- Low Battery Indicator; 22- Setup Labels.

to ICU Care by Dr. John Elefteriades and others [6]. There is also an excellent review of setting up a temporary pacemaker after cardiac surgery on CTS NET [7].

Again, one can use only the atrial wires (without ventricular pacing) if there is no heart block. Conduction through the intrinsic conduction system is considerably more efficient than atrioventricular (A-V) sequential pacing. A-V sequential pacing should be used only if heart block is present, which is relatively unusual in the immediate postop period [8].

Pacing wires should certainly also be placed on all patients who already have permanent pacemakers, as the permanent pacing wires could have been disrupted or the settings of a permanent pacemaker may have been affected by the use of electrocautery during the operation [9].

Once the patient has been moved to the intensive care unit (ICU), you should instruct the nurses and physicians in the unit about what you want done with the pacing wires. The safest thing to do is to have the wires hooked to a pacer but not have the pacer turned on, if it is not needed. Your ICU colleagues should ask you before turning on the pacer (especially since those who are inexperienced with temporary pacing may not be familiar with setting up the pacemaker correctly). If a Swan Ganz catheter is in place, you and the ICU team can find the optimal mode of pacing if the patient's heart seems to struggling. You can optimize the pacing strategy with echo guidance, as well. For instance, if the intrinsic heart rate is 60, and you pace at 90, you will reliably increase cardiac output by about 50%. Of course, if the patient is in chronic atrial fibrillation, there is no need to pace with the atrial wires. On the other hand, if you've done an atrial ablation (for chronic atrial fibrillation), you will want to have placed atrial as well as ventricular wires, as pacing the atrium may suppress recurrent atrial fibrillation.

Defibrillation in the OR

If the patient goes into atrial fibrillation in the OR, especially if they were not in this rhythm preoperatively, you should defibrillate them to restore normal sinus rhythm, if at all possible. Shocking the heart a few times will not cause significant cardiac injury. However, shocking repeatedly, especially with higher outputs of the defibrillator, has been shown to cause some cardiac enzyme 'leak'. It is certainly worth attempting to get the heart into the proper rhythm and paced with the proper rate after heart surgery, especially if the cardiac output is lower than you would like.

Dealing with the Wires When not in Use

The wire tips need to be capped or protected so that there is no inadvertent current applied to them, when they are not being used. However, one must always realize that, should a cardiac code occur, the wires need to be immediately accessible, so they should not be taped up or surrounded with big wads of gauze. Another 'fun fact to know and tell' is that the ground for the pacer can be an EKG pad on the skin or even a wire placed through the skin. This strategy is more commonly used in pediatric patients than it is in adults.

Use of Temporary Pacing Wires for Rhythm Analysis

While pacing wires can be used for rhythm analysis in the perioperative period, describing their use for this purpose is beyond the scope of this treatise.

Pulling the Wires

So, when can you pull the wires? Again, it's worth noting that atrial wires can harm the patient (when being pulled) while ventricular wires can save the patient (if transient heart block develops). There really is no reason to be in a hurry to get these pacing wires out postoperatively. In a certain sense, the longer they are in, the less likely they are to cause bleeding when they are pulled. And, once in a while, even late in the postoperative period, it can occasionally be useful to be able to pace the patient. It does make sense to pull the pacing wires at least a day or two prior to discharge from the hospital, to allow time for any 'untoward effects' (rare though they are) of pulling the pacing wires to become evident [10].

In addition, there is some attraction to the idea that pulling the wires while the chest tubes are still in place might at least alert you to a problem with bleeding earlier than if the tubes were not still in place. This strategy is particularly pertinent if the patient is being anticoagulated, for one reason or another. One might also consider pulling the atrial wires first, while the chest tubes are still in, leaving the V wires to be pulled later. Some surgeons cut the pacing wires at the skin when they are no longer needed, and some do this routinely. However, wires that have been cut off can later stick out against the skin, when edema subsides, and can be uncomfortable to the patient. It is worth noting that pulling the wires is usually not too uncomfortable for the patient. That is, pulling them is considerably less painful than pulling chest tubes can often be.

There has been some degree of concern about wire remnants in patients who need magnetic resonance imaging (MRI) at some point after a cardiac operation. However, this concern is unfounded, as patients can safely undergo an MRI with a lower Tesla machine, such as a 1.5 Tesla device. It is also worth noting that a patient who is actually being paced cannot undergo an MRI study because the pacer box itself is not MRI compatible [11]. Furthermore, there have been reports of retained temporary pacing wires causing significant complications and should, therefore be avoided if possible [12].

Summary

Cardiac pacing wires are an important part of managing the heart in the perioperative period. There are quite a few 'tricks of the trade' both to make these pacing wires work optimally and to make their use safe.

Author Contributions

CT and NT designed the review and wrote the manuscript. Both authors contributed to editorial changes in the manuscript. Both authors read and approved the final manuscript. Both authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

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Conflict of Interest

The authors declare no conflict of interest. CT serves as associate editor of this journal. CT declares that he was not involved in the processing of this article and has no access to information regarding its processing.

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