Pacemakers for Anesthesiologists Made Incredibly Simple

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What do pacemakers do?
   a. Pace the heart
   b. Sense the heart

How do you pace the heart? You send an electrical current to the heart. The current is small and it is measured in milliamps (ma).

How do you sense the heart? The pacemaker measures the voltage produced by the heart when it contracts. The voltage is small, and is it measured in millivolts (mv).

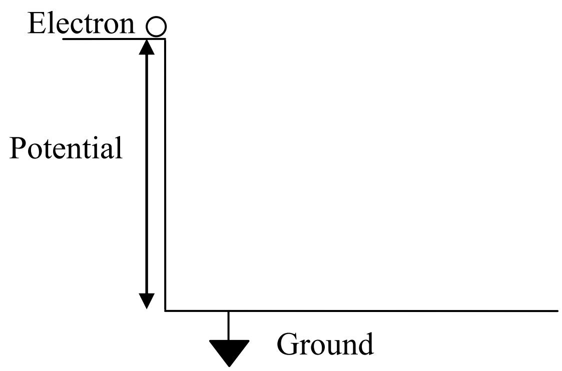
What is an electric current? An electric current is the flow of electrons. The pacemaker is a drug delivery device. The drug delivered is electrons. The current is the dose of electrons per second.

A milliamp is a small current. When you start your car you use tens to hundreds of amps. The current the pacemaker is delivering is one thousandth as big as the current to start your car.

What is a voltage? Remember when you were in high school and there was a smart kid who sat around doing nothing? Teachers would say things like. “He has a lot of potential.” Electrical voltage is the same thing. Voltage is the potential to do something. It doesn’t have to do anything, but it could, if it felt like it. You can have a battery with 1.5 volts, or 12 volts, or some other voltage. It can just sit there waiting to do something.

Current implies the delivery of electrons (the dose per second). Voltage is simply the potential of those electrons if you bothered to deliver them. The electron in the diagram below has a potential relative to ground. But it doesn’t have to do anything. The symbol for the ground is the little triangle with the line hooked to it.

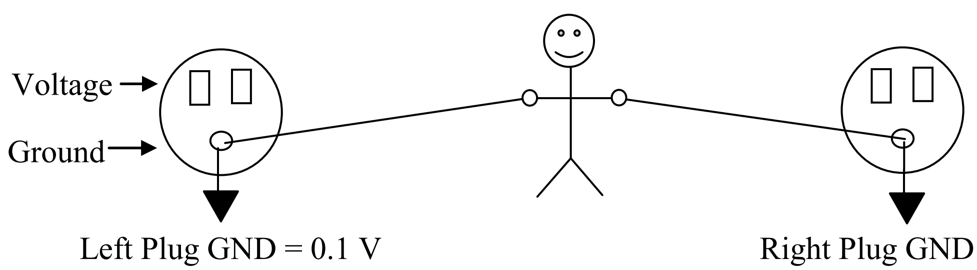
What is a ground? It is the earth. If you go outside your house to the power meter and you look at the ground near the power meter, there will be a bare copper wire that is screwed onto a copper post shoved in the ground. Your house is attached electrically to the ground with this wire and metal post. This is essentially the sewer for spare electrons from your house. The ground is the electron dump.



<u>So what is the big deal about this voltage – current stuff?</u> Well, remember Ohm's Law? You remember from physics class that V=IR, but before we go over Ohm's Law let me make this clear. Don't ever violate a LAW of physics. When you do, the penalties are severe. Physics theories - OK. Physics LAWs - don't do it.

<u>Ohms Law</u>: V=IR V: Voltage I: Current R: Resistance

What this law says is that the current depends on the voltage and the resistance. Let's do a little experiment. Here are two plugs. I attach wires to a patient, like ECG leads. I hook the wires to the ground of two separate electrical plugs. Can I hurt the patient with this set up?



Let's make an assumption. The ground on the left is not really 0. It is at, say, 0.1 volts. And the ground on the right is slightly different, let's say 0.2 volts. That's pretty close to zero. Sounds fine, right? The resistance of our wires will be low. Let's make the math easy and say we purchase really, really good wire with a resistance of 0 ohms.

Let's take Ohm's Law: V = IR. We rearrange it to make I = V/R

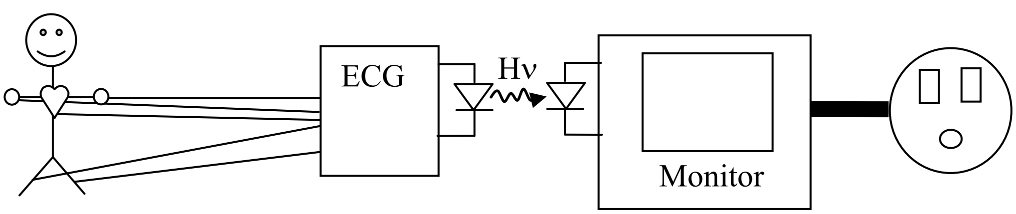
$$I = \frac{V_1 - V_2}{R}$$

$$I = \frac{0.2 - 0.1}{0} = \infty$$

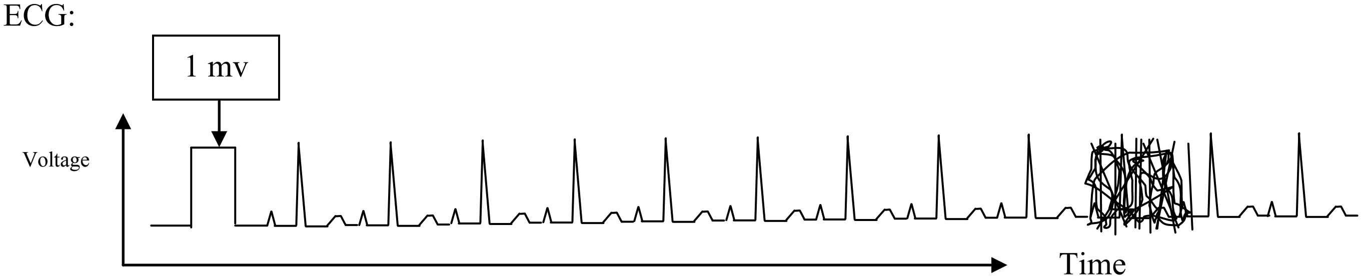
Remember that something divided by zero is infinity. And infinity is a very, very big number. When infinity is the current sent through your body, strange things happen, like smoke, charring, burns, and ultimately transfer to the eternal care unit. This is called a ground loop. The electrical equipment in your operating room is specially designed to prevent ground loops. For example, none of the ECG wires that you hook to patients is really connected to the wall. They are electrically isolated from the power in the wall. The wall power is electrically isolated from the electric company. The electricity in the OR is Special ED Electricity to prevent this type of injury. But when you put a wire on a patient, or a wire into a patient's heart (which is what a pacemaker really is) make sure you don't do something to overcome the protections built into the electrical isolation.

Special ED Electricity and the OR

Electrical Isolation is designed to make it more difficult to burn, electrocute, or incinerate stuff (patients) in the OR. Do not attempt to bypass the special systems or electrical isolation monitors or checking done by bioengineering. The ECG wires are not physically connected to the monitor. They are optically isolated from the monitor, which means they send a light signal, hν (photons), to the monitor. The electrons from the power company can't get into the patient through the monitor.



ECG:

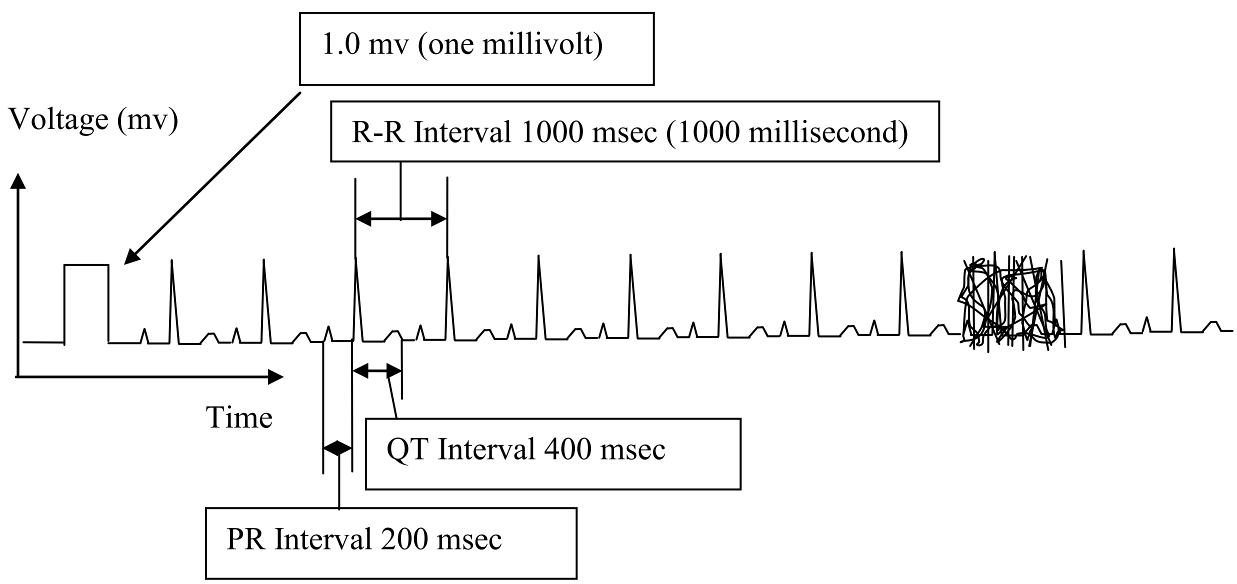


Ok, so what is that? It is a plot of Voltage on the Vertical axis (vertical is up and down) and time on the Horizontal axis (left and right).

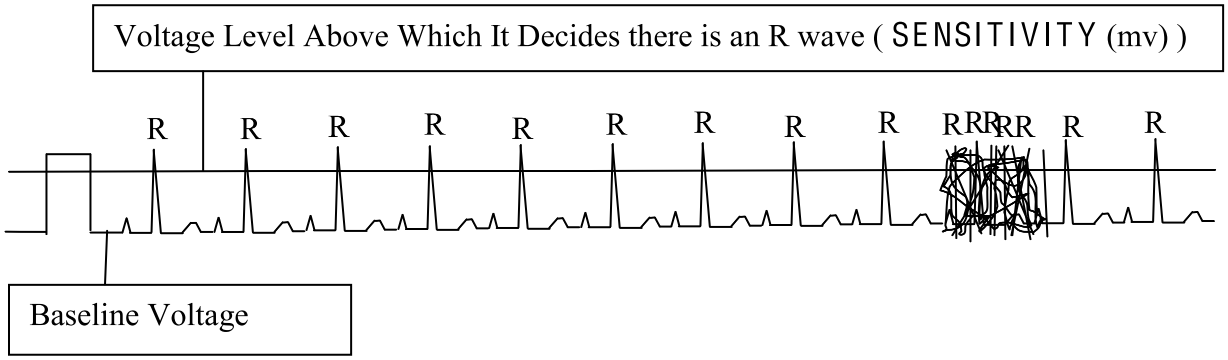
What is that little box on the far left? How big is that? First, the units. The little box is measured in millivolts. It is 1 millivolt (1 mv) high. So the QRS complexes are approximately 1 millivolt in amplitude (height).

If I tell you that the heart rate is 60 beats a minute, how many seconds is it between beats?

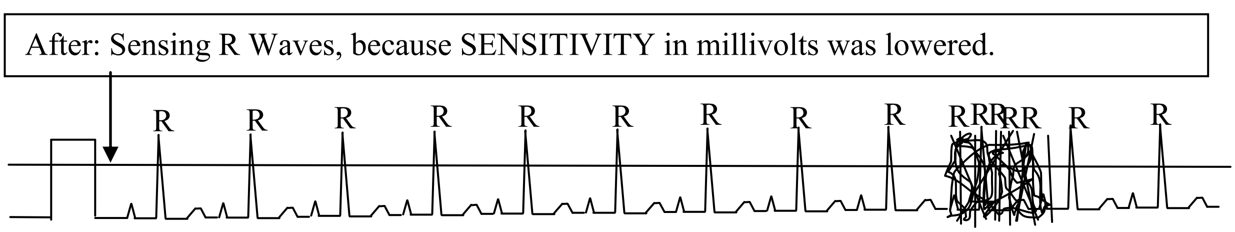
Um, um, well 60 divided by 60 would be 1… Yes, that's right. It is one second between heart beats if the heart rate is 60. Ok, so the R-R interval, the time between QRS complexes, is 1 second if the heart rate is 60. How many milliseconds is that? Correct, 1000 milliseconds is equal to 1 second. Now, how long is the PR interval? Less than 200 milliseconds if the patient does not have first degree heart block. How long is the QT interval? Right, it is approximately 400 milliseconds.



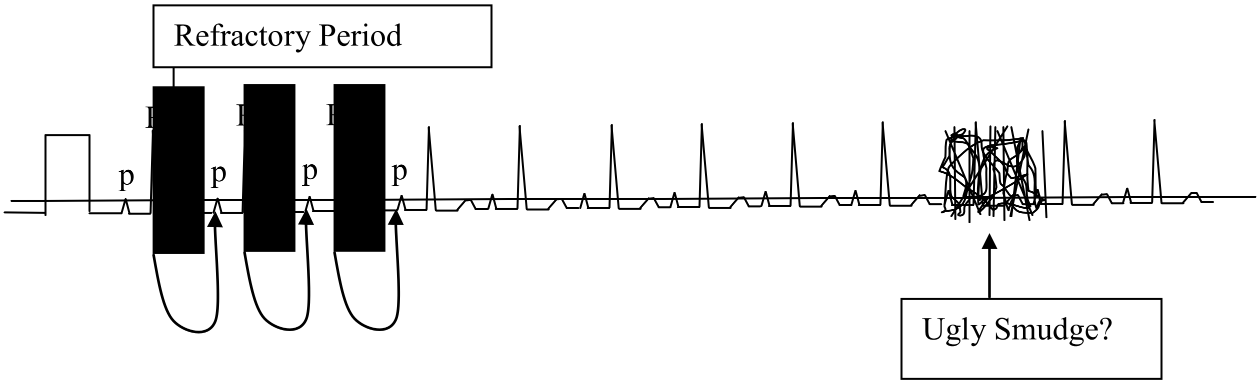
<u>How does the pacemaker detect an R wave?</u> It detects the baseline. Then it sets a level, a voltage level above which it says there is an R wave. If the voltage of the ECG exceeds that level, it is an R wave. Normally this voltage level would be called a threshold. The problem is the word "threshold" is reserved in pacemaker terminology for the minimum current to pace the atrium or ventricle. So, the term THRESHOLD is a current. It refers to the minimum current to pace the ventricle. You can't use the word THRESHOLD to describe this voltage level. So in pacemaker lingo, the word SENSITIVITY is used. SENSITIVITY is the voltage level that must be exceeded to detect an R wave or a P wave.



Now here is a little problem. You have a patient with a pacemaker. The pacemaker is not detecting the R waves. You decide to make the pacemaker MORE sensitive, so that it will detect the R waves. What do you do? You lower the SENSITIVITY in millivolts, to make the pacemaker MORE sensitive. Should I say that again? It makes sense if you think about it in voltages. *To make the pacemaker more sensitive, LOWER the voltage of the SENSITIVITY.*

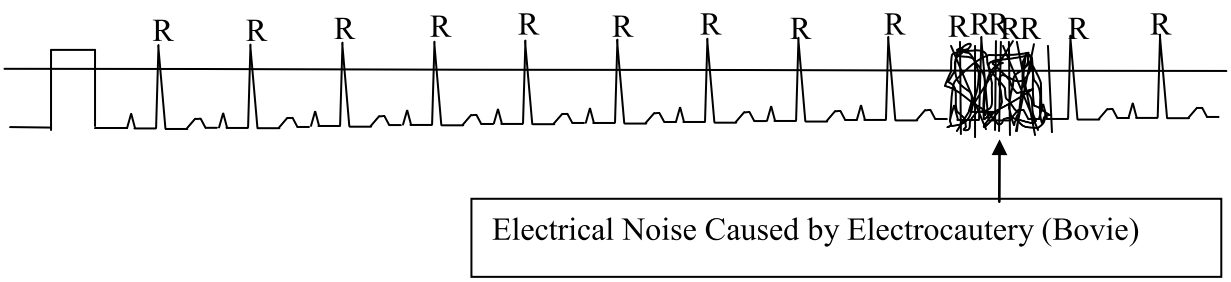


<u>How do I detect a P wave?</u> Same concept. Establish a baseline. Determine a level called the Atrial SENSITIVITY. If the voltage exceeds the level, it is a P wave? No, that won't work, because there are also T waves. What do I do about the T waves? Find an R wave, wait a refractory period, and the next thing along is a P wave.



That works. Now, what is that smudge on the ECG above? Am I a spaz? Or just a lousy artist? What is that smudge?

The ugly smudge is noise: Electrical Noise. In the OR, the noise is usually from the electrocautery, also known as the bovie. What does the pacemaker do when it sees electrical noise such as the bovie?



<u>The pacemaker is inhibited by electrocautery (the bovie).</u> The pacemaker measures voltages. It thinks that smudge is electrical activity from the heart. When it detects electrical activity from the heart, it is programmed to NOT PACE. The word INHIBITED in pacemaker land has nothing to do with the sexual proclivities or abilities of the pacemaker. The word INHIBITED in pacemaker lingo means, DOES NOT PACE. If the pacemaker is INHIBITED it just sits there doing nothing. The word inhibited does NOT imply that the pacemaker can inhibit the heart. The pacemaker paces. The pacemaker does not inhibit. The pacemaker can only make the heart go FASTER. The pacemaker can not make the heart go slower. The pacemaker CAN be inhibited by electrical activity of the heart. The word INHIBITED refers to the pacemaker NOT the heart.

Let's consider a case. You have a patient with 3rd degree heart block (the conduction system in the patient's heart doesn't work). The patient has a DDD pacemaker in place. The first D in DDD is the area PACED. The D stands for DUAL, so this pacemaker, paces both the atrium and the ventricle. The second letter stands for Area SENSED, so this pacemaker senses both the atrium and the ventricle. The third letter stands for what it does, and the D stands for Dual inhibited. This pacemaker can be INHIBITED by electrical activity from an atrial contraction and it will not pace the atrium. Or, it can be INHIBITED by the electrical activity of a ventricular contraction, and not pace the ventricle, or both. It has a lot of inhibitions. So, you take the patient in the operating room and the surgeons starts to use electrocautery. They use the electrocautery continuously. What is the heart rate and the blood pressure of the patient?

Well, the pacemaker detects the electrical noise from the electrocautery. It thinks there is an R wave. The pacemaker is inhibited, so it doesn't pace. If the pacemaker doesn't pace, the heart doesn't beat. That would make the heart rate, zero. Which would make the blood pressure, zero. Many experts agree that chronic beating of the heart is good, and a blood pressure of zero is bad, but these finding have not been confirmed in prospective randomized trials.

So, if a heart rate of zero is BAD, what do you do?

Right, you set the pacemaker to DOO. The first letter is the area paced. So, Dual pacing would pace the atrium and the ventricle. The second letter is the area sensed, so the O means it doesn't sense or it has NO SENSE. The third letter is the INHIBITIONS. This pacemaker has NO INHIBITIONS. DOO stands for DUAL pacing with NO SENSE and NO INHIBITIONS. It sounds a bit like Paris Hilton.

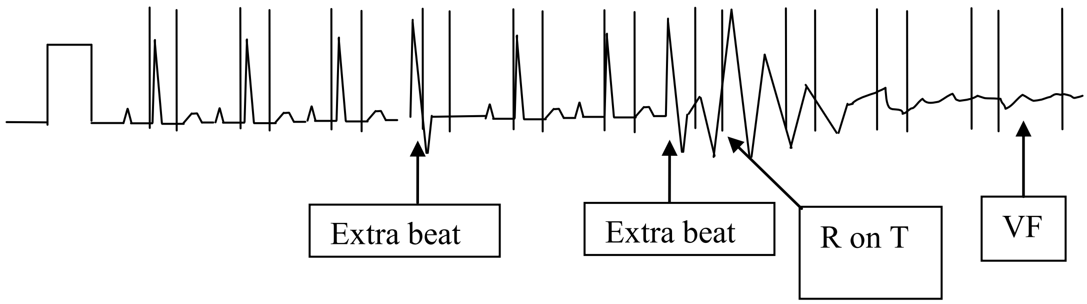
DOO and VOO
NO SENSE
NO INHIBITIONS

The Paris Hilton of Pacing Modes.

Now the pacemaker completely ignores the electrocautery. The pacemaker paces and the heart beats. The blood pressure returns. The case finishes. You send the patient to the intensive care unit. About an hour later, the patient is awake, He warms up a bit. And you hear this on the monitor.

Beep, Beep, Beep, Beep, Beep, BeBeep,,, Beep, Beep, Beep, Beep, Beep, BeBeep,,, The rhythm isn't quite right. There is an extra beep in there.

You look up at the monitor and this is what you see.



As you begin doing CPR and calling for the defibrillator, you think, what did I do wrong? Well, You heard the extra beat. The rhythm was not beep, beep, beep, beep, beep, It had an extra beat in there. That extra beat occurred earlier than expected and the pacemaker then paced on the T wave of the extra beat causing an R on T. The R on T caused ventricular tachycardia (VT) and then ventricular fibrillation (VF). Ooops!!!!!!!!

The entire point of a pacemaker sensing is to avoid R-on-T. When you select an asynchronous pacing mode such as VOO or DOO, you are the sensor. The pacemaker is NOT sensing the electrical activity of the heart. You are responsible for sensing. If you detect extra beats, turn the pacing mode to one that senses such as DDD or VVI. DO NOT LEAVE THE PACEMAKER IN DOO or VOO when you are not in an OR with electrocautery that is actually causing a problem with the pacemaker.

Never leave a patient in DOO or VOO.

Now, here is a trivia question. Have you ever seen a James Bond Movie? What is James Bond's code number? 007. What does the double 00 in 007 stand for?

LICENSED TO KILL. When you leave a patient in DOO or VOO, it is LICENCE TO KILL. DO NOT LEAVE A PATIENT IN DOO OR VOO mode.

When you leave a patient in the ICU, check the pacing mode on the pacemaker and record it on your anesthesia record. If you forget to write it down there is a problem. An hour later someone may change the pacing mode to VOO or DOO. Then when the patient has VT and VF, you will be blamed. If you write the mode down, you won't forget, then you won't be blamed for leaving it in VOO or DOO.

DO NOT LEAVE A PATIENT IN DOO or VOO.

The OO modes are only for use in the operating room when there is electrocautery that interferes with the pacemaker.

What does the Magnet do?

Medtronic Dumb Magnet

Medtronic Smart Magnet

Before we get into Magnets, there are a few baseline questions.

Question 1: Are Magnets Magic?

It is important to ask this because it's not uncommon in pacemaker-land to hear, "Oh, don't worry about the pacemaker. Just put a magnet on it." or "If there is a problem, I'll put a magnet on it." When you hear this magical thinking, the next thing you should ask is, if magnets magically solve all pacemaker problems, why don't they just put a magnet permanently on the pacemaker? Or better yet, sell a magnet with each pacemaker and have the patient wear the magnet in a special shirt pocket magically precluding all pacemaker problems?

The magnet is NOT MAGICAL. The magnet simply throws a programmable switch in the pacemaker. It changes it from one mode to another. The magnet mode depends on the brand of pacemaker, the type of device, whether magnet mode is turned on, and it may even depend on the level of battery charge in the device. In some implantable devices the magnet mode may shut off the device. In others it may make the device listen for information from a radio frequency controller. It may change modes to another type of function. The magnet throws a programmable switch. It may or may not be what you want.

Question 2: Suppose you had a computer where the patient's life depended on the function of the computer. If the computer malfunctions, the patient dies. Would you go up to the computer keyboard and randomly punch keys to see what would happen?

Of course not!!!! No one in their right mind would randomly punch buttons on a computer that a patient's life depended on.

Question 3: Should you randomly throw a switch in an implantable device without knowing what the switch does?

The magnet throws a switch. If the implantable device is a pacemaker it frequently will put the device in DOO at 99. If the implantable device is an implantable cardiac defibrillator (ICD), it may shut off the defibrillation functions. If the device is a deep brain stimulator, it will do something else. If it is a vagal nerve stimulator, something else will happen. If it is a dorsal column stimulator, it will be yet something else. If it is a bladder stimulator, the patient may pee on your shoes. The point is simply that the magnet throws a switch and you should know what the device is and what the magnet does before you randomly throw it.

There was a study done at a large Midwestern hospital system where they used the "hope for the best and if that fails put a magnet on it" approach to pacemakers. There was a 3% operative mortality associated with pacemaker function. They started interrogating all pacemakers prior to surgery and found that 10% were not functioning properly. They then began interrogating *all* pacemakers prior to surgery and completely eliminated perioperative pacemaker associated mortality.

I went to a code for an elderly gentleman admitted to the medicine service with congestive heart failure. I looked at this very short of breath man and there was a blob under the skin inferior to his left clavicle. I pointed to the blob under the skin and asked the medical resident, "What's that?" The response was "We think it is a pacemaker." I responded, "The patient has been in the hospital for two days with congestive heart failure and you don't know what that device is? Did you get a chest x-ray on this admission?" "Oh yes, definitely" "And what did it show?" "Infiltrates, curly B lines, cardiomegaly." "Could you see the blob under the skin?" "Ugh?" "Was there a lead to the atrium and a second lead to the ventricle?" "Ugh?" "Were the leads broken?" "Ugh?" "Did you have cardiology interrogate the pacemaker?" "Ugh?" "Is it functional?" "Ugh?"

The blob under the skin was a pacemaker, it was malfunctioning, and unfortunately the patient arrested and died prior to us being able to correct the pacemaker malfunction. Pacemakers are just electronic devices situated in a hot, salt water filled environment, with motion. This environment is NOT compatible with electronics. Despite the hostile environment they work pretty well but NOT perfectly. If you have a question about a patient, interrogate the pacemaker and figure out if it is working. It may not be functioning properly.

The next thing that drives me nuts is physicians who take a patient in the operating room without knowing the brand, model, function or magnet mode of the pacemaker, when it was last checked, who controls it, whether the hospital has a programmer for this make and model of pacemaker, whether there someone who can run the programmer, and what the indications are for the pacemaker. They will say something like "Oh, it was an emergency, and if there was a problem, we would put a magnet on it." This is magical thinking. The magnet simply changes mode. If the new mode is better than the mode you are in, great, if not…

It takes about five minutes to find out everything there is to know about a pacemaker. Patients carry a card in their wallet that gives a lot of information. If you can't find the card you can get an X-ray of the device and see the make on the circuit board. Moreover, you can see the leads and tell what the device is. The easiest way to find out what the device is, is to call Medtronic Bradyarrhythmia Products at 800-505-4636. The phone number is on the web at http://www.medtronic.com under the physician section for electrophysiology. They are open 24/7/365. If you call and identify the patient, they will tell you if the device is a Medtronic device. If it isn't, they may even give you the phone number for the other manufacturers such as Guidant, etc. These companies want to help you. They want to solve the problem quickly. They make a lot of money on these devices and they want you to be pleased with their service. If there is a question with a pacemaker or defibrillator they will send a rep. The rep is usually one of the most intelligent, beautiful reps you will meet and even better, they may bring donuts. If in doubt just call them and they will help you, and they may bring donuts.

What you need to know:

a. What is the device?
b. What brand and model?
c. Who controls it?
d. Does your hospital have a programmer for this make and model?
e. What is the magnet mode?
f. Why does the patient have a pacemaker? This is important because if the patient has it for third degree block, you should treat the device as if the patient's life depends on the device, because it does.
g. What rhythm does the patient have when the pacemaker is shut off? If the rhythm is asystole, treat the device with a certain respect and caution. If you plan to replace the device, you may want to place a temporary wire to pace while the implantable pacemaker is not functional.

One approach to finding out about pacemakers is to go to the electrophysiology clinic (EP) that controls the pacemaker and ask about it. You should be careful though. When you say something like "What does the magnet do?" They will say, "Oh, it always goes to DOO at 99." My response is usually, "Is this true?" They will then look at you quizzically and say "I don't know." The reason for this confusion is few things are always true and the DOO at 99 for magnet mode is NOT ALWAYS true. Let me give you an example.

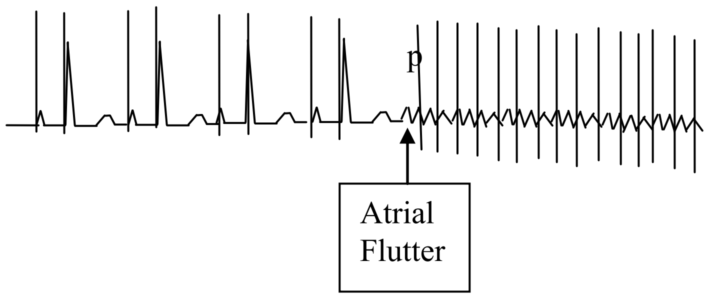
When a pacemaker's battery runs down it goes into something called END OF LIFE MODE. This is a very poorly worded mode. It really should be called END OF BATTERY LIFE MODE, but END OF LIFE MODE is what they call it. When a pacemaker's battery runs down, it tries to save power, so in some devices the MAGNET mode for END OF LIFE MODE is DOO at 50. What happens to a patient that has an intrinsic heart rate of, say, normal sinus rhythm at 70, when you pace DOO at 50? That's right, you get VT then VF then END OF LIFE MODE. Be careful with the magnet, it throws a switch, It is NOT MAGICALLY, SPECIALLY, WONDERFUL - it simply throws a switch.

Intrinsic Heart Rate	Pacemaker Rate	Pacemaker Mode	Result
80	50	DDD	80
50	80	DDD	80
50	80	DOO	80
80	50	DOO	VF (This is BAD)

This is a really important chart. Pacemakers accelerate the heart. They don't ever slow it down. You should think of the pacemaker as poking the heart. You can only speed it up by poking. You don't slow it down by poking. If the pacemaker is in a mode that inhibits such as DDD or VVI, the pacemaker can sense the heart's intrinsic rhythm, and it will avoid pacing on a T wave. If the pacemaker is in DOO or VOO mode, it does not SENSE, it does not INHIBIT. It just paces. If the intrinsic heart rate is lower than the paced rate, the pace maker will speed up the heart, and every thing will be OK. If the pacemaker is slower than the intrinsic heart rate, the pacemaker will pace on a T wave and you will get VT and/or VF and this is BAD. DO NOT PACE WITH DOO or VOO unless you have electrocautery that interferes with the pacemaker. In DOO or VOO mode, YOU are the sensor.

<u>Which is a safe pacing mode: DDD or DVI?</u>

Let's think about this. DDD is Dual pacing, dual sensing, dual inhibitions. DVI is dual pacing, only senses the ventricle, is only inhibited by the ventricle. DVI ignores the atrial contraction? Hmmmm. I don't know.



1. Detect p Wave
2. Wait 200 msec (PR interval)
3. If no QRS, pace
4. Repeat

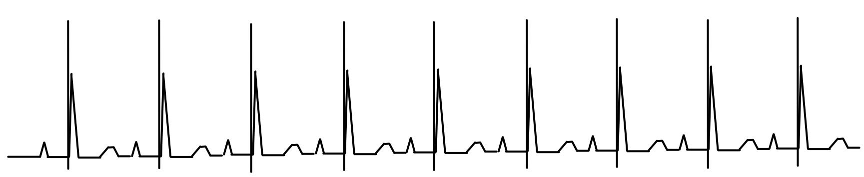
If the R-R interval is 200 msec, the HR = 300 and the blood pressure = 0.

DDD tracks atrial rates. There is a MAXIMUM RATE setting to prevent 1:1 conduction of supraventricular tachycardias.

If a pacemaker is in DDD mode, it tries to follow the atrial rhythm. If the atrial rate accelerates, the pacemaker will track it. If the atrial rate becomes too high, there is a MAXIMAL RATE to prevent 1:1 conduction of supraventricular tachycardias which would have rates that would preclude ventricular filling. 1:1 conduction of atrial flutter at a rate of 300 would give a heart rate of 300 and a blood pressure of zero. DVI mode is useful in situations where there are frequent supraventricular tachycardias or in situations where the patient should not track the atrial rhythm.

CASE: You are called to the ICU to see a patient with a pacemaker. The nurse is very concerned because the pacemaker appears to not be functioning. The nurse has set the pacemaker to DDD at 50 but you see the following on the monitor.

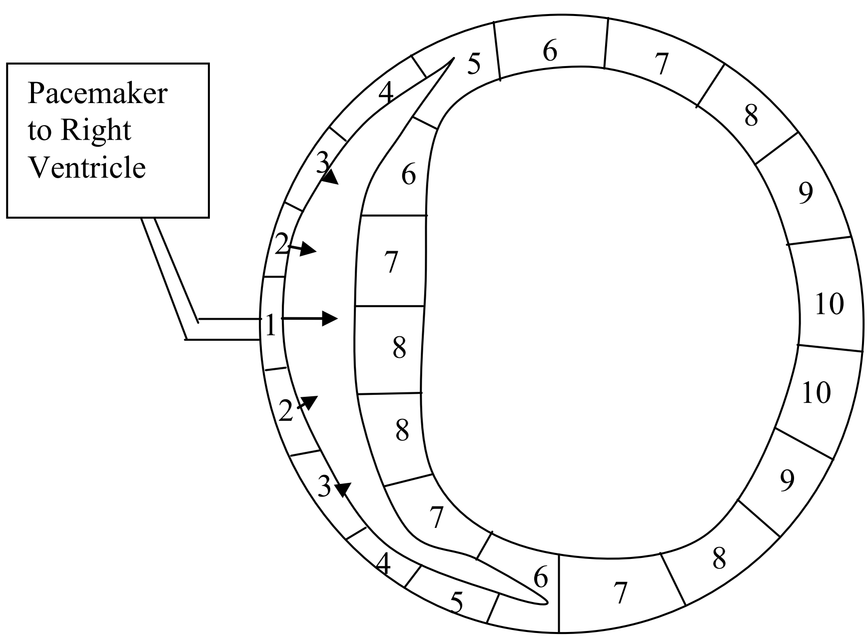
HR = 110



The pacemaker is set at DDD at a rate of 50. The monitor says the heart rate is 110. It looks like 110. The pulse oximeter reads a rate of 110. The arterial line gives a rate of 110. You put your finger on the pulse and it reads 110. You look at the monitor and, sure enough, there is a pacing spike on every QRS and the pacemaker is pacing at a rate of 110. Is the pacemaker working?

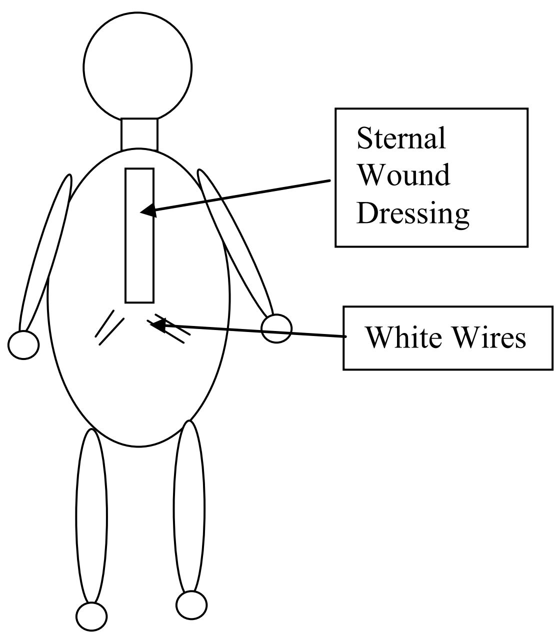
Yes. The pacemaker is working perfectly. The pacemaker is detecting the P waves caused by sinus tachycardia. The pacemaker then waits the set PR interval, let’s say 200 msec. If there is first degree AV block and no QRS occurs spontaneously within the 200 msec, then the pacemaker paces. It then waits for the next P wave, waits 200 msec, if no QRS, it paces. It is following sinus tachycardia perfectly. If you want the heart rate to slow down, you don’t set the pacemaker slower, you give a drug like a beta blocker, or pain medication like fentanyl, or something that will slow the sinus tachycardia. The pacemaker is doing exactly what it is programmed to do (DDD). It is following the atrial contraction.

Which pacing mode is most efficient? Before you answer, let me define efficiency as the highest cardiac output. One more caveat, the conduction system is intact, and the sinus heart rate is too slow.

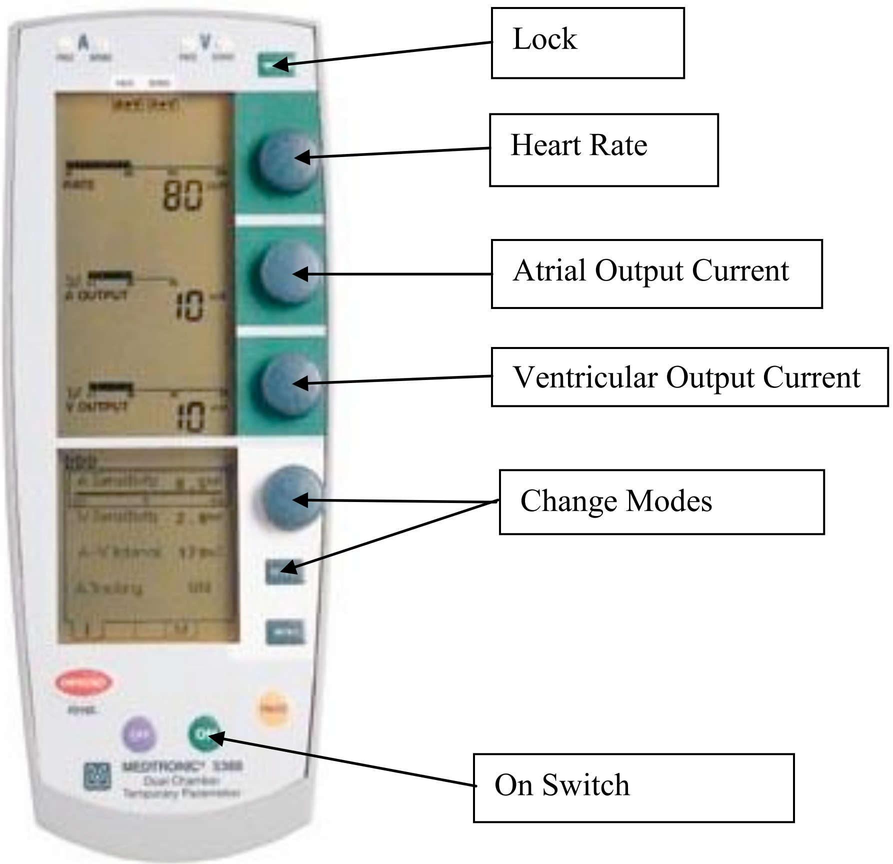


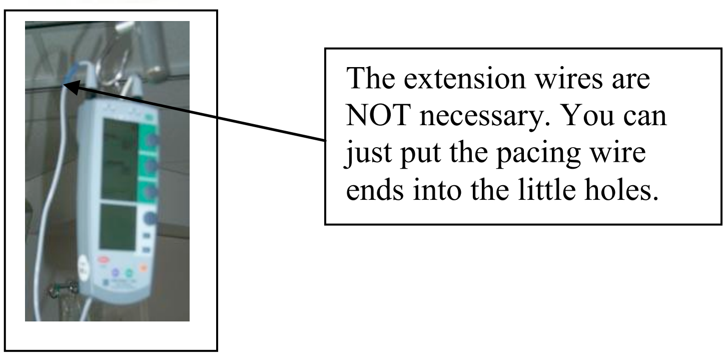
The answer is AAI. Lowly atrial pacing, atrial sensing, inhibition by pacing. AAI has no chance of pacing the ventricle on a ventricular T wave, reducing risk. But the most important point is that AAI mode relies on the normal ventricular conduction system, so the conduction is synchronous across the ventricular wall. In the above diagram the right ventricular free wall is paced. The contraction passes slowly through the right ventricular free wall to the septum and finally to the left ventricular free wall. The contraction is not synchronous. The right ventricular free wall contracts prior to the septum and long before the left ventricular lateral wall. The ventricle is less efficient by 10-15%. The reason that paced QRS complexes are wider than normally conducted QRS complexes is because the contraction is less synchronous. The reason that bi-ventricular pacing leads sometimes help patients with congestive heart failure pacing with two leads, one in the right ventricle and one passed through the coronary sinus towards the lateral wall, is that the contraction is more synchronous and more concentric and more efficient. In a patient with good ventricular function, 10-15% doesn't matter. But in patients with low cardiac output states, 10% is a lot. When your cardiac index is lousy, 10% may make the difference between needing inotropes and not, or needing a balloon pump and not. 10% matters when you are desperate to improve cardiac output.

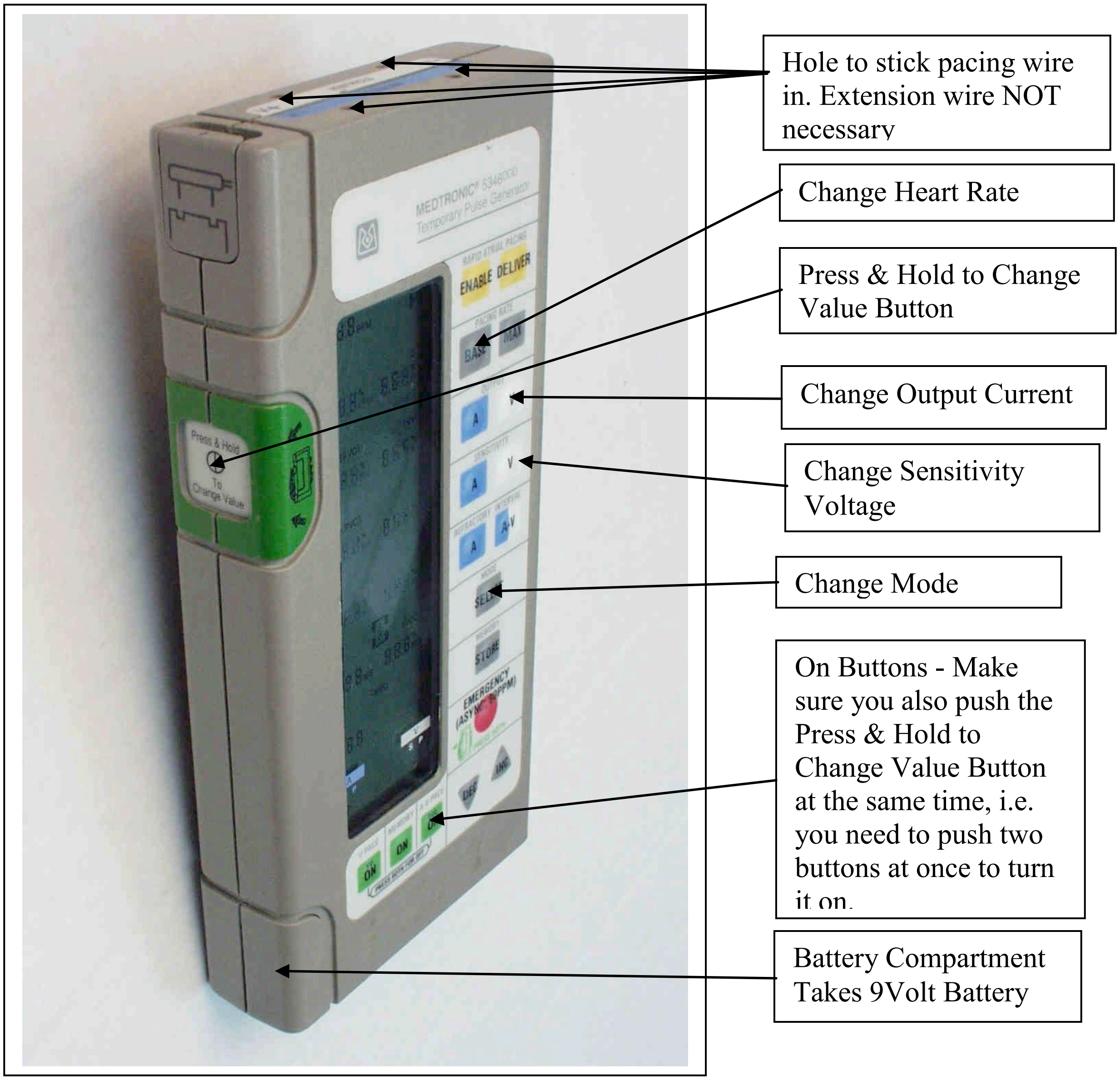
CLINICAL CASE: You are called to the transitional care unit for a CODE BLUE. You find a patient in the bed in asystole. They have a dressing on their chest from a sternotomy wound and there are four little white wires coming out of the skin just lateral to the inferior edge of the sternotomy scar. You begin CPR, ventilate, oxygenate, give epinephrine & atropine, and intubate. What next?



What to do? The white wires are pacing wires. The ones on the patient's right go to the right atrium. The ones on the patient's left go to the ventricle. Hook the pacing wires to the external pacer and turn it on. "What if I don't remember which is which?", you might ask. Hook up the wires and turn it on. Prior to doing this the patient is DEAD in ASYSTOLE. If you don't hook up the wires the patient may remain DEAD. Hook up the wires. "I don't have the extension cords!!!!", you might say. So what? Just take the metal lead at the end of the little white wire and put it in the little hole at the top of the external pacemaker and turn it on. The extension wires are NOT necessary to make it work.


Lock
Heart Rate
Atrial Output Current
Ventricular Output Current
Change Modes
On Switch


The extension wires are NOT necessary. You can just put the pacing wire ends into the little holes.

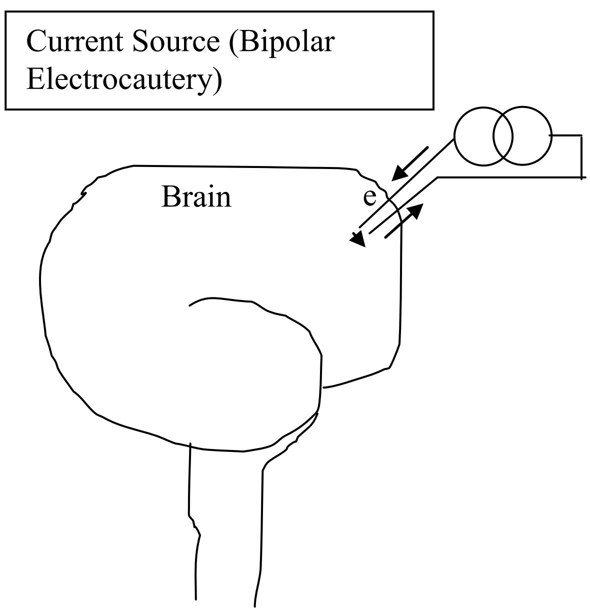


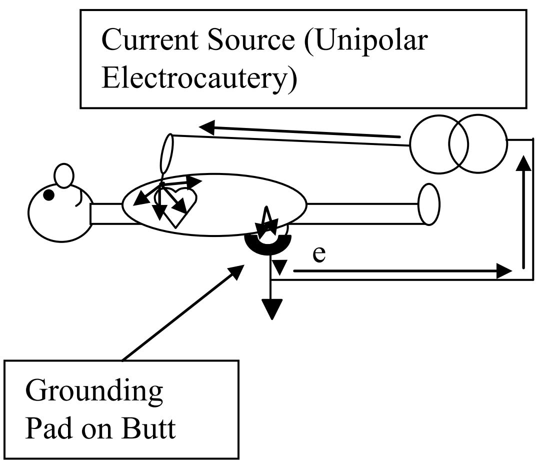
Medtronic 5346 DDD Temporary Pulse Generator is an older model. It is not the easiest device to use. There are a few points which will make it much easier to use. Hold the device in your left hand. Put your thumb on the magic secret button marked Press & Hold to Change Value. There is actually a diagram of your fingers and thumb on the front to remind you. PUSH AND HOLD the Press & Hold to Change Value Button any time you want to change a value. Then push the button for the thing you want to change. Then use the up and down arrows to make it change. If you don't push and hold the Press & Hold to Change Value Button, nothing will work. It is like a clutch in a car. To change gears push in the clutch (magic secret green button). You should play with this device prior to using it in an emergency to get the concept of how to change values. The screen only displays the values that matter in the mode you are in when you are in a mode. For example in AOO mode only the heart rate and atrial output current will display. In DDD mode everything displays. It is a good device, it just takes a couple of minutes to figure out.

Bipolar Versus Unipolar

What is an electric circuit? What is bipolar? What is unipolar?
When you think about medical devices a big deal is made of unipolar versus bipolar. Is there some fundamental difference? No, they are not really different. They use the same electrons. They use the same physics. Bipolar devices put the ground near the source. Unipolar electronic put the ground somewhere else.

Electrons are electrons. There is only one type. The basic concept of electronic circuits can be described as ELECTRONS are SHY. If an electron cannot find its way home from the party, it won't go. Electrons want a return path, they want a circuit. They only buy round trip tickets. You try to sell them a one way ticket, they will not go. So, if you want an electron to do something you need a return path, you need a circuit!





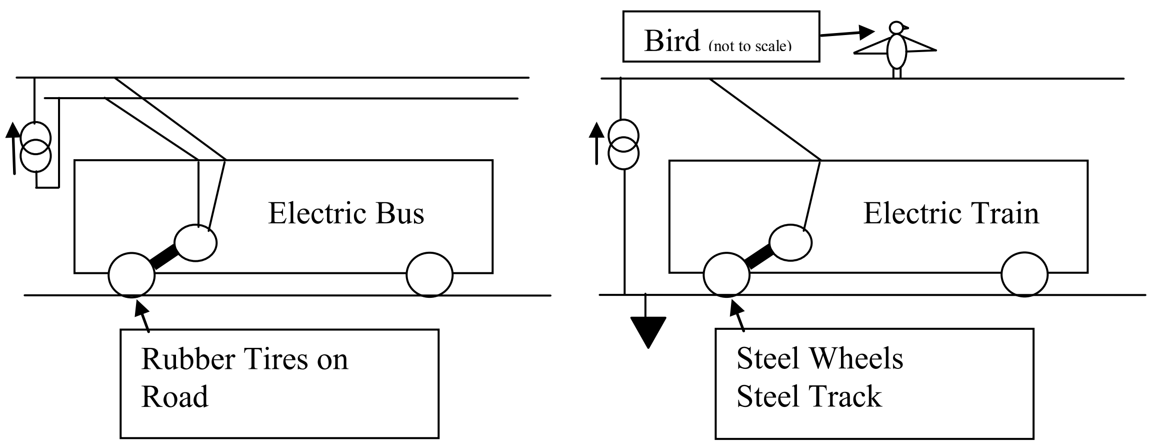
Why do the neurosurgeons use a bipolar bovie and the rest of surgeons use unipolar bovie? The neurosurgeons want to control the current path. They do not want to use the brain stem as a ground. The bipolar electrocautery gives the return path to the electrons so that they don't use the brain stem, or the spinal cord for a return path. Unipolar bovie might cause injury or a seizure.

Why do the neurosurgeons drip saline on the bovie? They are trying to dissipate the current even more. They just want to coagulate between the tips of the forceps.

In a unipolar bovie, why doesn't the ground pad on the butt cause a burn? The area of the bovie point is very small. The area of the grounding pad is large. The current density on the bovie tip is high, causing heating and coagulation. On the grounding pad the current density is low, preventing burning. The nurses check the grounding pad to make sure it lies flat and has good contact throughout to prevent high current density and burns.

Why doesn't the bovie stop the heart? The current in the electrocautery is many, many amps, like 10 amps. The voltage in the electrocautery is high, like enough volts to cause a spark (10,000). The electrons go through the heart. In fact you can bovie on the heart and not cause VT or VF. How could that be?

The frequency of the heart is 1 to 2 hertz. 1 Hertz is 1 cycle per second which would be a heart rate of once per second or 60 times a minute. 2 Hertz would be a heart rate of 120 beats a minute. The frequency of the electrocautery is 1,000,000 hertz (1 MHZ) (one megahertz). The bovie doesn't hurt your heart because it uses MEGAHURTS. It is too high a frequency for the heart to track and have VT or VF. If you turned the frequency of the bovie down to 1 kilohertz (1,000 hertz) it would cause VT, VF, and death immediately.



Why does an electric bus have two wires and an electric train just have one wire?

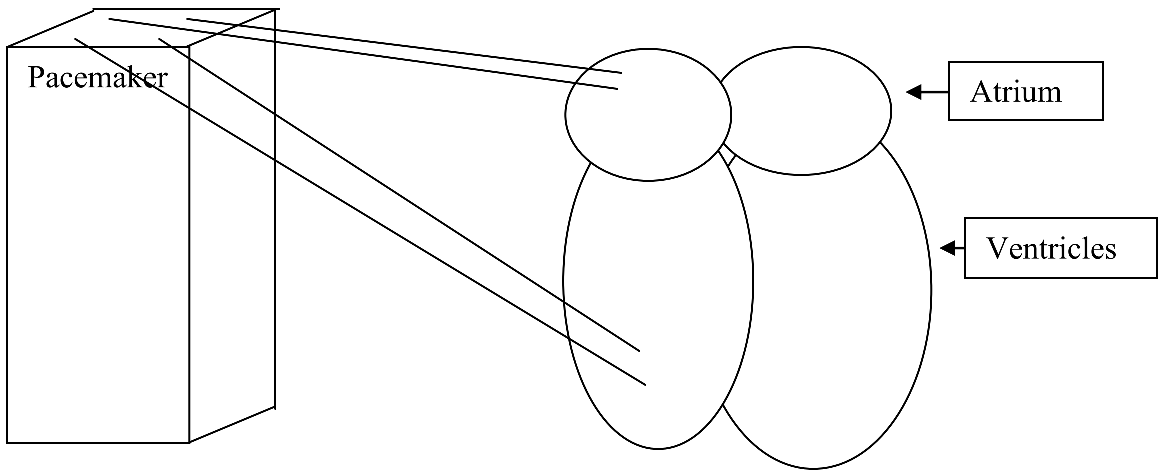
The electric bus has rubber tires. The electrons can't get off the bus because the tires insulate. Electrons need a way back to the power station. The bus must have TWO wires to work.

The electric train has one wire because it uses the track as the ground. The electrons go from the power source to the wire to the train motor to the steel wheels to the track back to the power source to make a circuit.

What would happen if I touched the electric train track? (NOT THE THIRD RAIL ON A SUBWAY). Nothing. Because the track is grounded. You are grounded. There is no voltage potential.

What would happen if a bird landed on the overhead wire? Would we get Kentucky Fried Birdy? Nope. The bird would be fine. He has no voltage potential difference. He is at the voltage of the wire, but there is nowhere for the electrons to go, so he is fine. If the bird peed on the ground and made a circuit, then you get crispy bird. But just sitting on the wire, he is fine. I want you to do some homework. The next time you are near an electric train or bus look under the wire and see if there is a pile of crispy fried birds and squirrels. I bet you won't find a single one. No potential difference, no flow of electrons, no current, no crispy fried bird.

Now that you understand electronic circuits please study the following diagram.



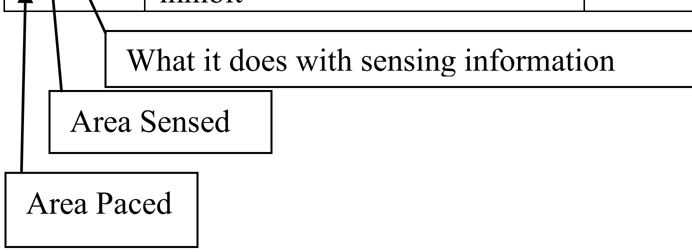
You are in the OR at the end of a cardiac case. The patient is in third degree heart block and the pacer is set to DDD. The resident removes the drapes and the ioban and one of the ventricular pacing leads is pulled out. The heart rate is zero, the blood pressure is zero, you begin CPR. Now what?

a. Continue CPR until I figure out what to do.
b. Put on external pacing pads and hope they work.
c. Start isoproterenol if I can find the drug and remember the dose and whether it actually works.
d. Call cardiology, hope they are in the hospital, and have them place a temporary wire.
e. Stick a pacing wire into the patient's skin somewhere. The heart will pace. Then open up the sternum and replace the pacing wire.

The answer is e. If you stick a pacing wire into the patient's skin, the electrons will find the wire and complete the circuit. Electrons may be dumb, but they travel at close to the speed of light and they can find the wire. You may need to turn up the ventricular current. Alternatively, you could borrow an atrial lead as the ground until you have a new wire. Or you could jumper across the grounds to use the atrial ground for both atrium and ventricle.

OK, last but not least, the code. <u>You now get to learn the secret code</u>.

Code	What is it?	Who gets it?
AOO	Atrial pace, no sense, no inhibitions	Sick sinus syndrome with intact conduction in the operating room with bovie. Ie Cardiac case, in OR, with bovie, with heart rate low from narcotics.
AAI	Atrial pace, atrial sense, inhibited by atrium	Sick sinus syndrome with intact conduction system.
VOO	Ventricular pace, no sense, no inhibit	Third degree heart block in OR with atrial fibrillation. Why atrial fibrillation? Because you can't effectively pace the atrium if it is fibrillating.
VVI	Ventricular pace, ventricular sense, ventricular inhibit	Third degree heart block with atrial fibrillation.
DOO	Dual pace, no sense, no inhibitions	Third degree heart block in OR with bovie.
DVI	Dual pace, ventricular sense, ventricular inhibit	Third degree heart block with supraventricular tachycardias
DDD	Dual pace, dual sense, dual inhibit	Third degree heart block.



<u>How do I remember the code?</u> The code is for a PACEMAKER. The first letter is the area PACED. Why? Because it is a PACEMAKER. Suppose you saw a code ODO? Have you ever seen a code ODO on a PACEMAKER? Well, what would an ODO be? It would be a machine that just sensed and did nothing. An ODO is an ECG machine. The first letter is the area paced. The second letter is the area sensed. The third letter is whether is inhibited or not. O is do nothing.

DOO and VOO modes are ONLY FOR USE IN THE OR WITH BOVIE! They are the Paris Hilton of pacing modes: no sense, and no inhibitions.

I hope you learned something. If you have questions or are confused or find an error please send me an email.

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