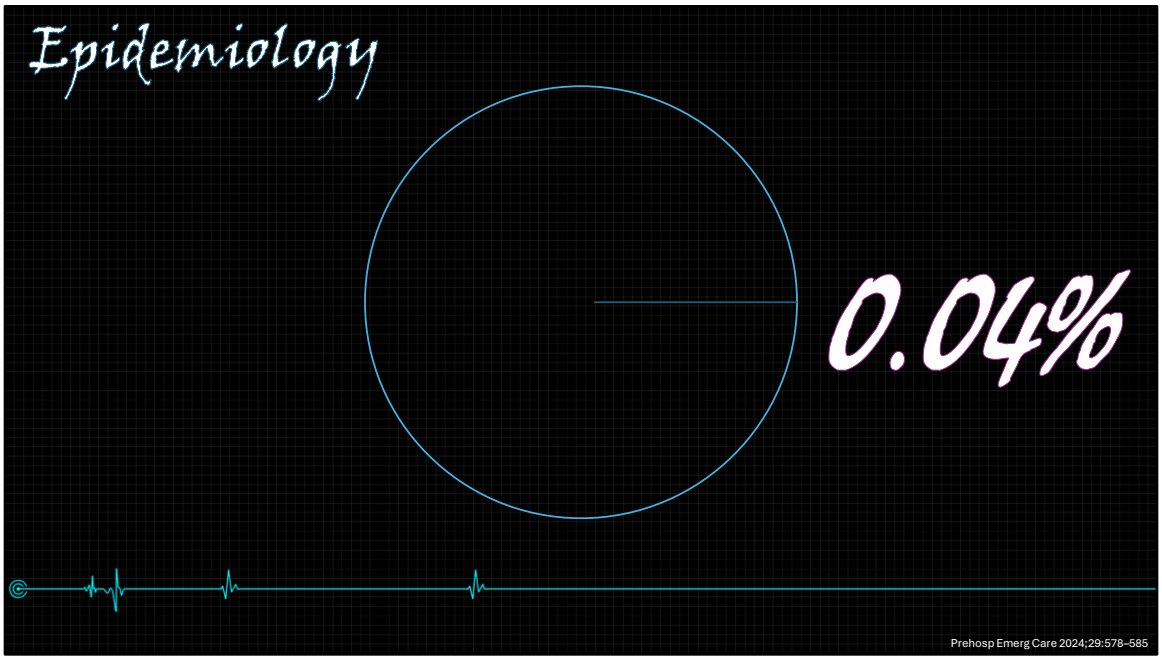
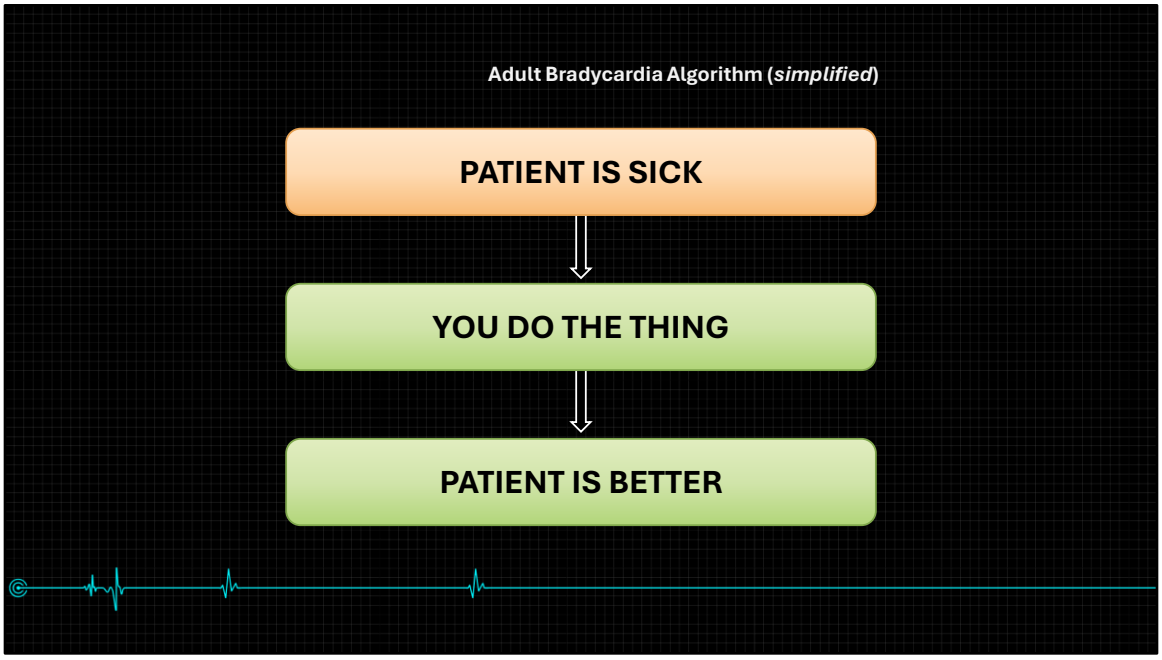
Disclaimers:
This presentation is for educational purposes only.
Know and follow your local protocols and manufacturer guidelines.
Seek expert consultation when indicated.



Although paramedics are universally taught the skill of transcutaneous pacing (TCP), the reality is this is an *exceedingly* rare intervention.

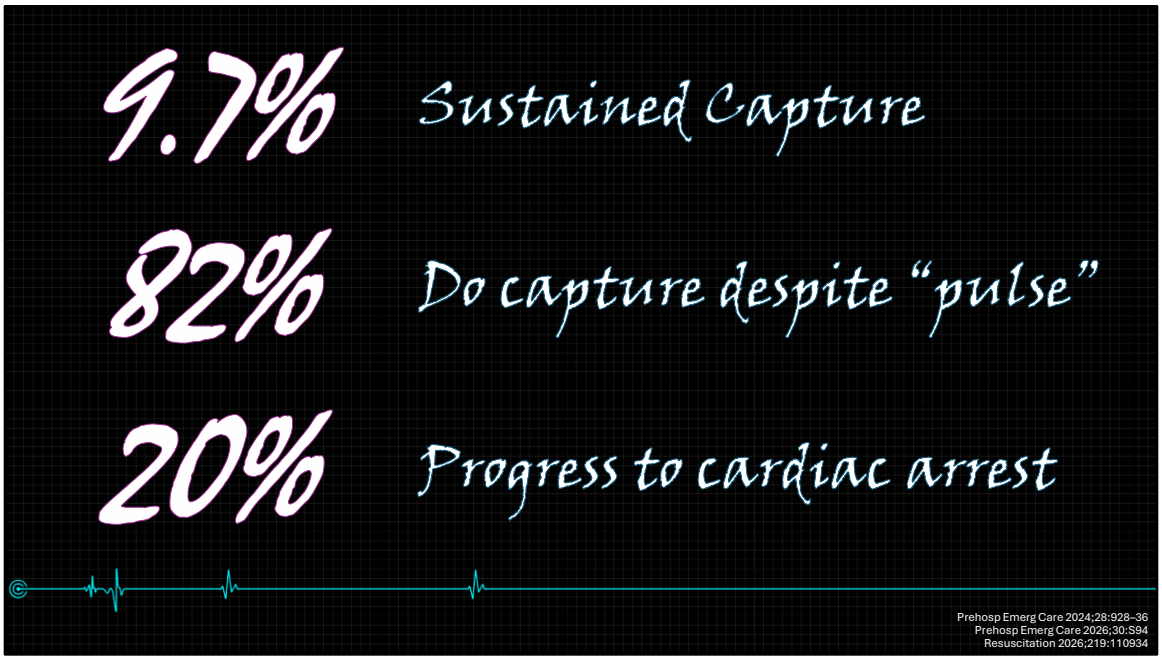
A recent NEMSIS-based study found the incidence of TCP to be only around 0.04% across over 31 million EMS encounters.

This means, MOST of our “experience” with TCP comes from rhythm generators and simulators, if at all.



In an ideal world, when we encounter a patient with severe/symptomatic bradycardia, we will employ our skills (i.e., initiate standard ACLS interventions, including TCP) and the patient will improve.

The reality is, nearly universally: **we absolutely <u>SUCK</u> at this**!

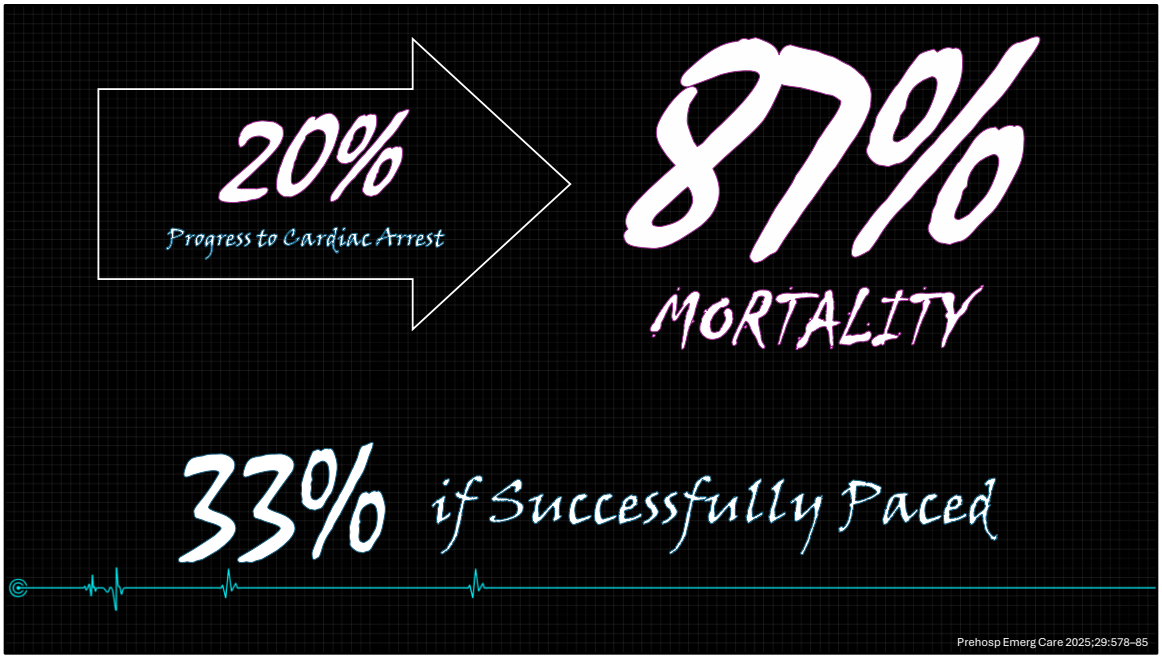


The reality is quite different than what we imagine is happening:

Fewer than 1 in 10 patients with TCP attempted actually achieve sustained *electrical* capture (and basic cardiac physiology holds that you cannot have mechanical capture without electrical capture).

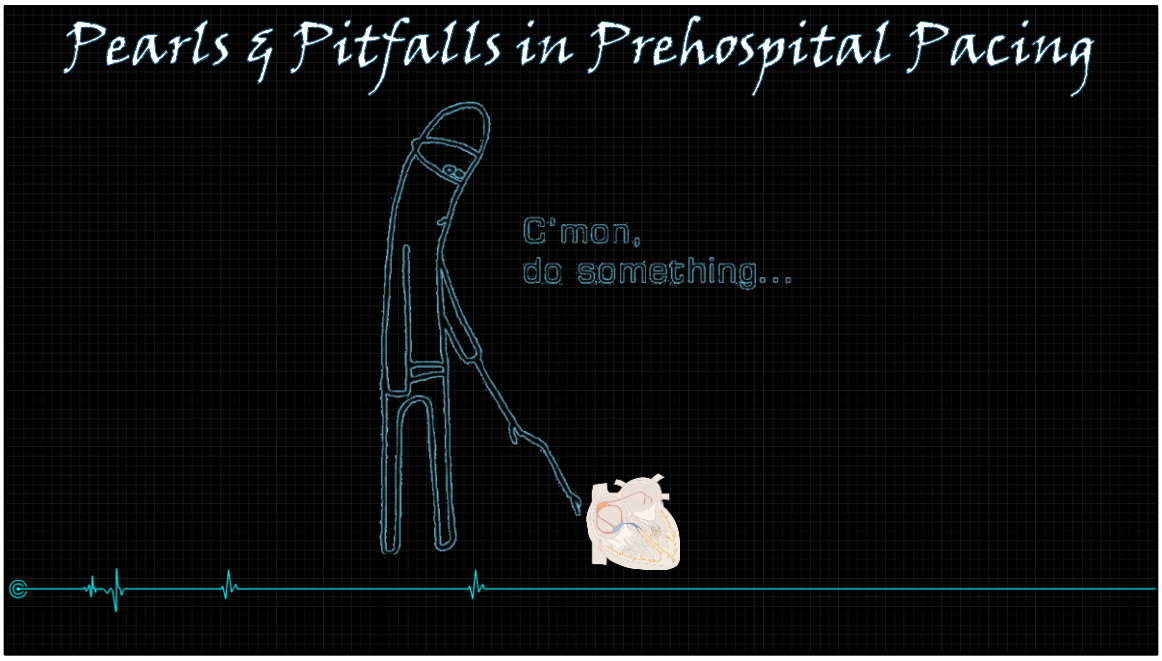
Over 80% of patients were determined to have NO capture despite clinicians documenting the presence of a "pulse" (i.e., we're EXCEEDINGLY high with our false-positive rate for pulse palpation).

Around 20% of patients with TCP attempted will devolve into cardiac arrest.



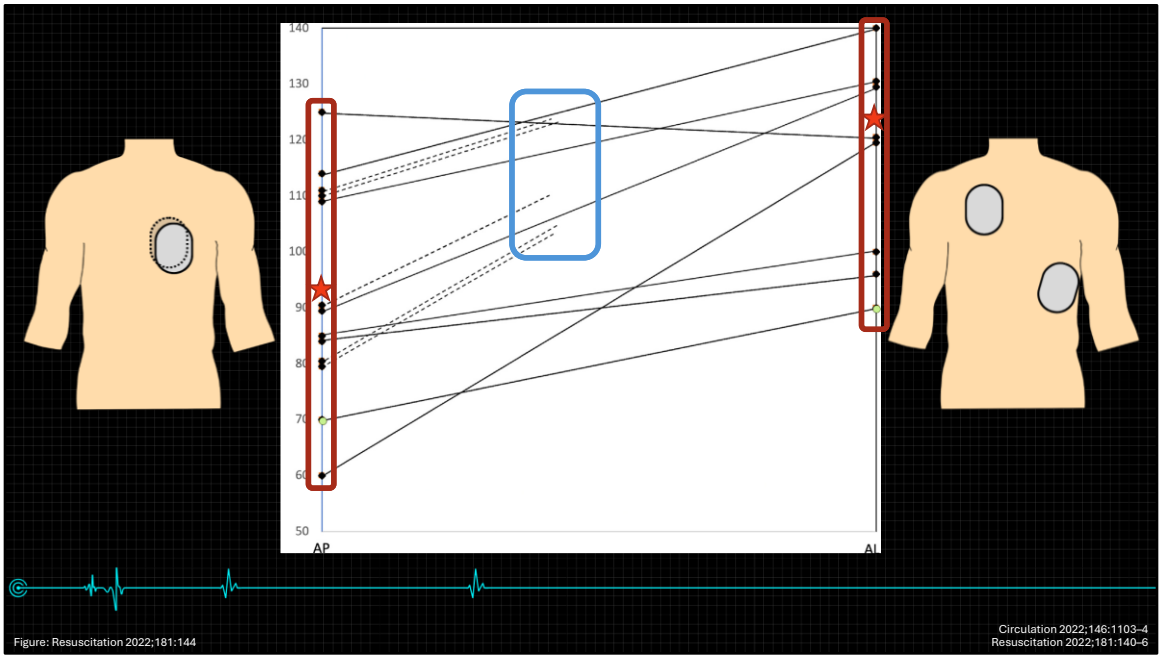
Patients that progress to **cardiac arrest** during their bradycardia episode have an astonishingly high mortality rate at nearly 9 in 10 patients.

This is compared with only 1 in 3 patients dying if they are successfully paced through their prehospital timeline and avoid arresting in the field.
To be fair, this is still a relatively high mortality rate (as one might expect from being sick enough to need an external source to keep your heart beating at a “normal” rate), but not nearly as high as the patients that arrest in the field with or without successful TCP initiation.



So, the first question we need to ask is:

HOW DO I PACE MY PATIENT in a way that optimizes my chances of success?



This was a **small** study (*N*=20, with *n*=13 paired sets of data) of **reasonably healthy** volunteers undergoing anesthesia (procedural sedation) for elective cardioversion of atrial fibrillation or flutter, who consented to receive TCP (once anesthetized) in **both** the AP and AL positioning. Essentially, each patient was his/her own control for the two pad placement strategies.

Average BMI was around 28 in this group – so not exceedingly obese.

The **first** notable finding:

- Only **76%** of patients (13/17) actually achieved capture in EITHER placement position, meaning **a quarter of patients, in the controlled EP lab, paced by trained electrophysiologists, were NEVER successfully paced.**

Other important findings:

- Of the patients achieving capture, ALL were able to be paced in the AP (anterior-posterior) position
- 5 patients were paced in AP but COULD NOT be paced (never achieved capture) in the AL (anterior-lateral) position [*BLUE box above*, showing dashed lines with no corresponding AL threshold]
- It took, on average, LESS energy to pace patients in the AP position [*RED boxes above*]; average required current was 93 mA for AP versus 126 mA for AL [*RED stars above*]
- The higher energy required in AL positioning held true in all but one patient, as seen in the matched energy lines from left to right on the above figure.

But importantly, “LOWER” energy does not mean “LOW” energy.

A theme seen across multiple published studies now is that the *average* current required to achieve successful electrical capture is **consistently >90 mA**.

Unfortunately, many of us were taught to “start low” and titrate upward. The cardiac monitor I regularly use at work defaults to a starting current of 30 mA – that’s *much* lower than what is likely to be successful (and I can’t find a way to change the default current in the back menus on the device, either, like I can with the defibrillation setting).

So, now that we've optimized our chances for success, the *next* question to ask is:

HOW DO I <u>KNOW</u> I'M PACING MY PATIENT?

Surely, an ECG waveform will confirm electrical capture, right!
….*right?*

Here, we see what LOOKS LIKE successful electrical capture.

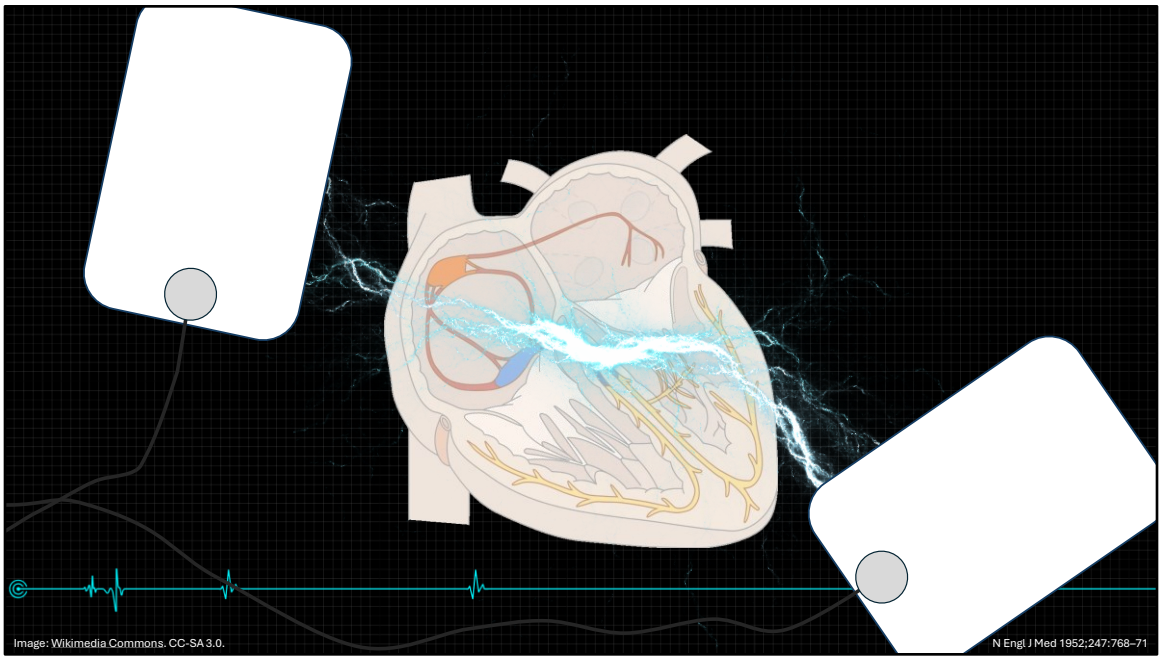
Looking at the BLUE arrows on this strip, we see a pacer spike, followed by what appears to be a QRS complex, complete with an oppositely-deflected T-wave. It's big and a little wide (which is completely expected, since we're stimulating the ventricles directly, so we know this will look like a "PVC").

In fact, when I practice this in skill stations, this is almost what the "capture" looks like on my simulator or rhythm generator!

BUT LOOK CLOSER:
The first suggestion that true electrical capture hasn't been obtained is the ***breakthrough QRS complexes*** [RED boxes] that can be seen between the "paced" rhythm.

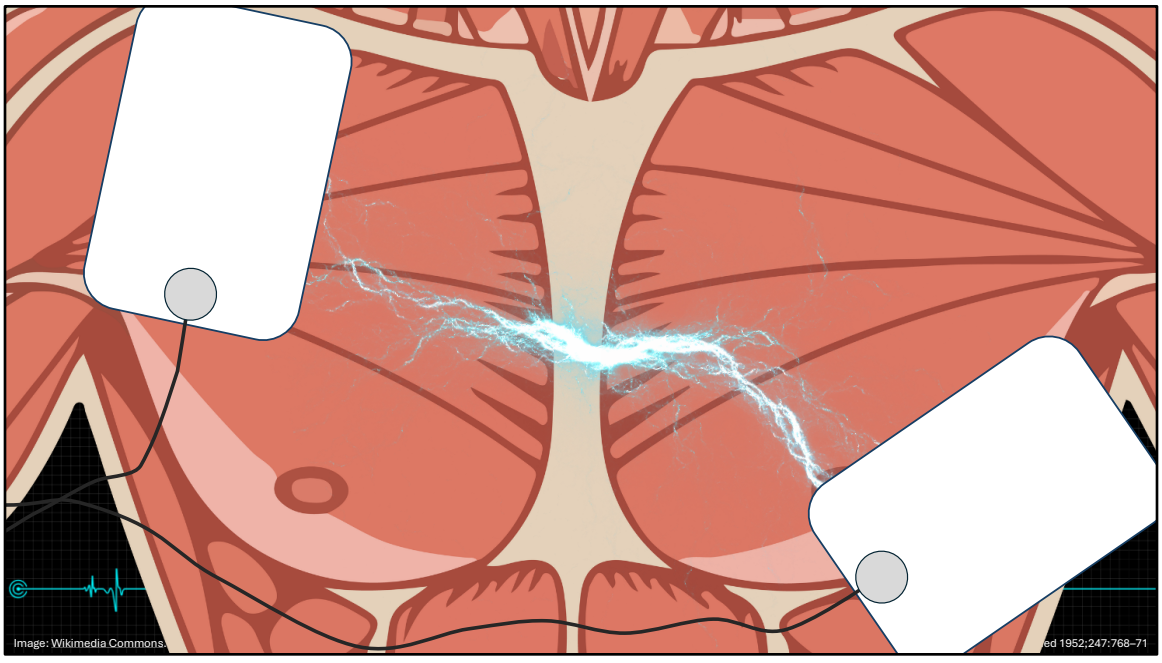
Here, they are narrow-complex, but these will generally be the same rate and morphology as the patient's underlying, pre-paced rhythm (**because the patient isn't actually being paced!**)

So, what's happening?



When we apply transcutaneous pacing to our patient, we expect that we're sending a current through the heart (i.e., depolarizing the cardiac muscle) to cause a contraction and increase heart rate, and therefore cardiac output.

And that's exactly what we're trying to do!



BUT – we also have to keep in mind that in addition to the **cardiac** muscle, we are also sending the SAME current though a bunch of skeletal muscle, depolarizing it, and causing fasciculation and muscle contractions! (basically, think of your cardiac monitor as a supercharged TENS unit).

Think of how you can see artifact on a regular 4-lead (or 12-lead) when your patient voluntarily moves their arm – because that muscle is being (electrically) depolarized move move from point A to point B, and your ECG leads are picking that up. Now, take that to a considerably higher level with your TCP energy setting, that will conveniently correspond to the exact rate that you've set your pacer.

This means: Your electrodes are not only seeing paced cardiac activity (if you're truly successful at obtaining capture), they're ALSO seeing a TON of artifact from the skeletal muscle being depolarized (and subsequently repolarizing).

And this can **EASILY** be mistaken for "electrical capture"

A couple ways you can possibly tell that you have ***false*** *capture*:

- As noted previously, if you can see the patient's underlying rhythm "through" your pacing, it's highly unlikely you've captured
- Secondly, if the size of the "QRS complex" gets bigger as you increase the energy, it's probably artifact and not actual capture. The size (amplitude) of the *cardiac* QRS complex will remain constant regardless of pacing energy required to stimulate it.

Here, we have the previous ECG strip on top, and a subsequent ECG strip with **<u>actual</u>** electrical capture below.

Admittedly, the two look **VERY** similar, and in a high-stress situation (you know, like a patient actively trying to die of severe bradycardia, and you needing to do a skill that is only done on less than one percent of one percent of EMS runs), it can be easy to mistake one for the other.

In the bottom strip, the TRUE capture can be seen with the RED boxes. We see a pacer spike followed by a true QRS complex and an actual T-wave (the T wave is better seen in the last couple complexes under the larger red box).

But, again, LOOK CLOSER. Although we do have true electrical capture - - *most of the time* - - this is not sustained capture. Again, in the areas between and just before the red boxes on the bottom strip, you can again see a loss of electrical capture and escape beats from the patient's underlying native heart rhythm (the narrow QRS complexes after paced beat #3 and after the second paced beat between the sets of red boxes).

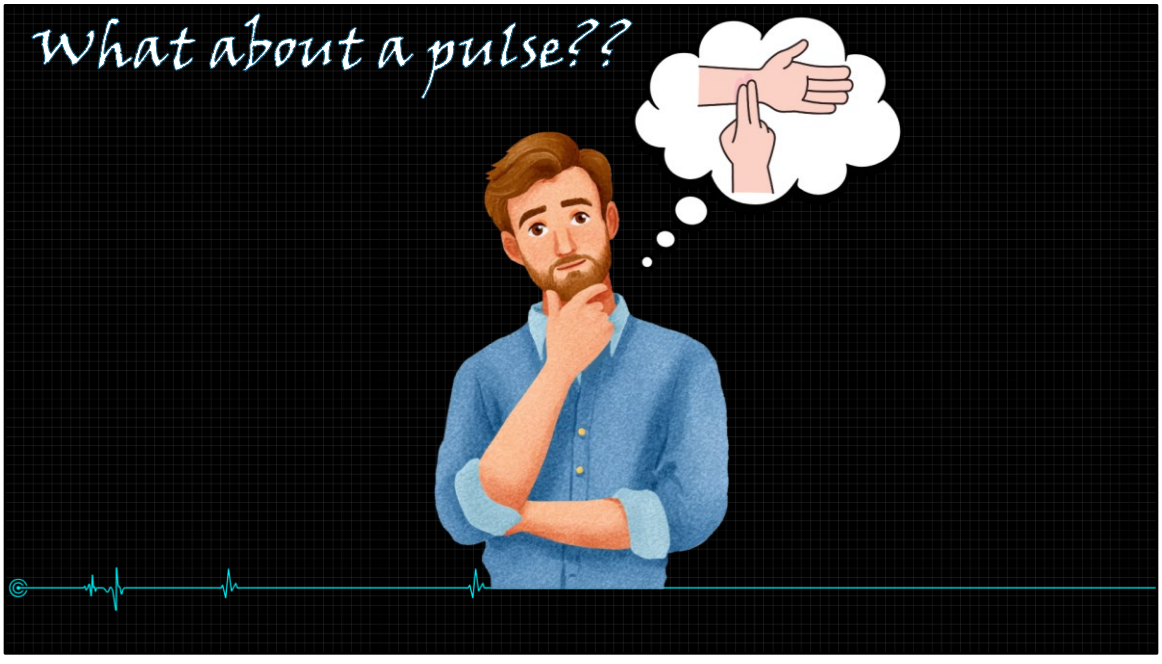
Personally, I would increase the energy level at least one more step if there's room to go up to try to obtain more consistent capture.

That said, I have a better (perhaps controversial) thought on this:

- If I'm pacing someone, they're likely in extremis (i.e., actively trying to die)
- In that case, knowing it could require a high degree of energy to capture, I have an idea…

Remember how we used to do escalating energy levels for defibrillation, then AHA said "stop doing that, just use the maximum energy level the first time you defibrillate, since it's most likely to be effective….

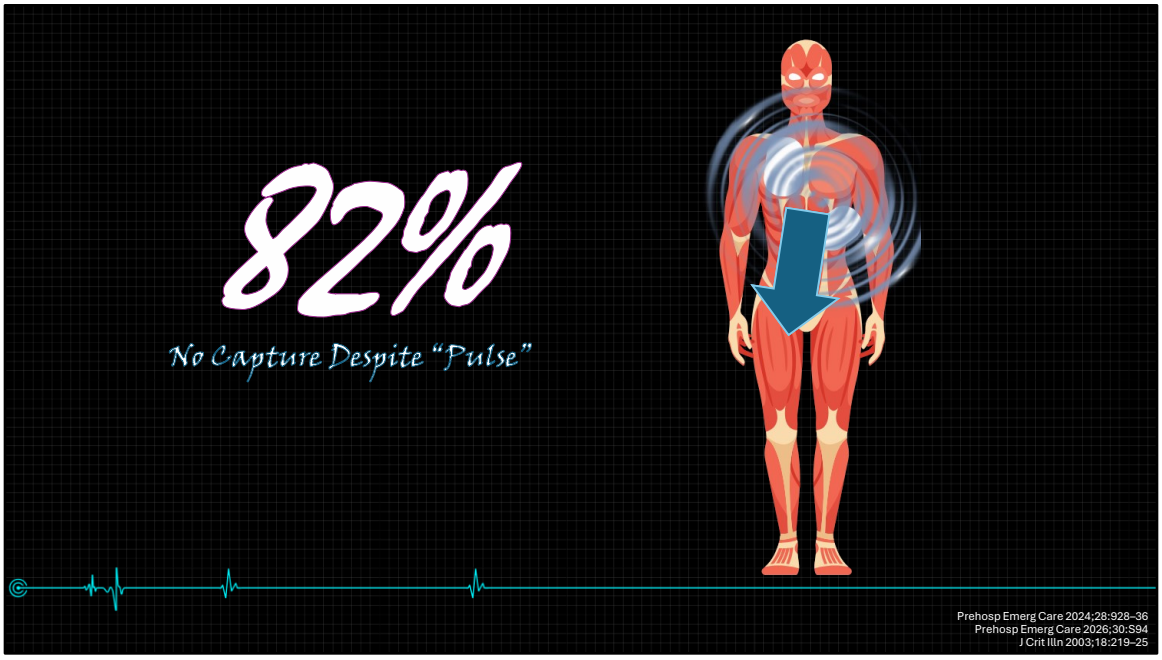
- MY ***personal practice*** is to just **maximize the TCP energy when I start pacing** (*see also:* J Crit Illn, 2003). Once we get to a hospital with transvenous pacer capabilities, 47 extra sets of hands, and an EP lab – they can wean that energy down and risk losing capture. But I'm going to maximize my chances of success, create a binary situation (it's going to either work, or not – no room for "should I go up a little more?), and expedite my ability to make the next decision in patient management.
    - THIS IS WHERE I HAVE TO ONCE AGAIN DISCLAIM AND REMIND: KNOW AND FOLLOW YOUR LOCAL PROTOCOLS, AND/OR CONTACT MEDICAL CONTROL OR EXPERT CONSULTATION IF THIS IS NOT STANDARD PRACTICE.



So, *assuming* we think we have *electrical* capture, the *last* question to ask is:

HOW DO I LIKE *REALLY KNOW* I'M ACTUALLY PACING MY PATIENT?

If I have capture, I'll get a pulse, right!
.....*right?*

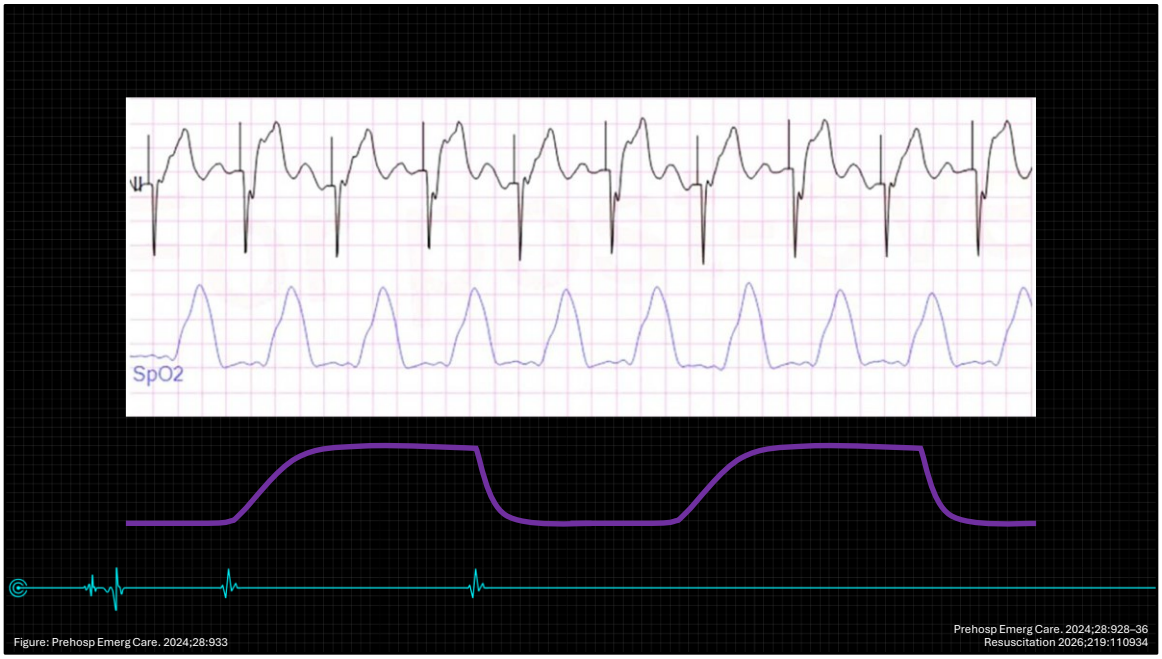


Remember what was brought up previously: Although these were only small sample studies (fewer than 30 patients each), two **separate** studies found false-positive documentation of pulses in over 80% of patients (meaning, over 80% of the time, EMS documented pulses corresponding to pacing, when there was clearly no true electrical capture).

This is likely because when the TCP generator depolarizes skeletal muscle, it leads to jerking, which can cause the perception of a "pulse beat" as the muscles move in response to each delivery of pacing current.

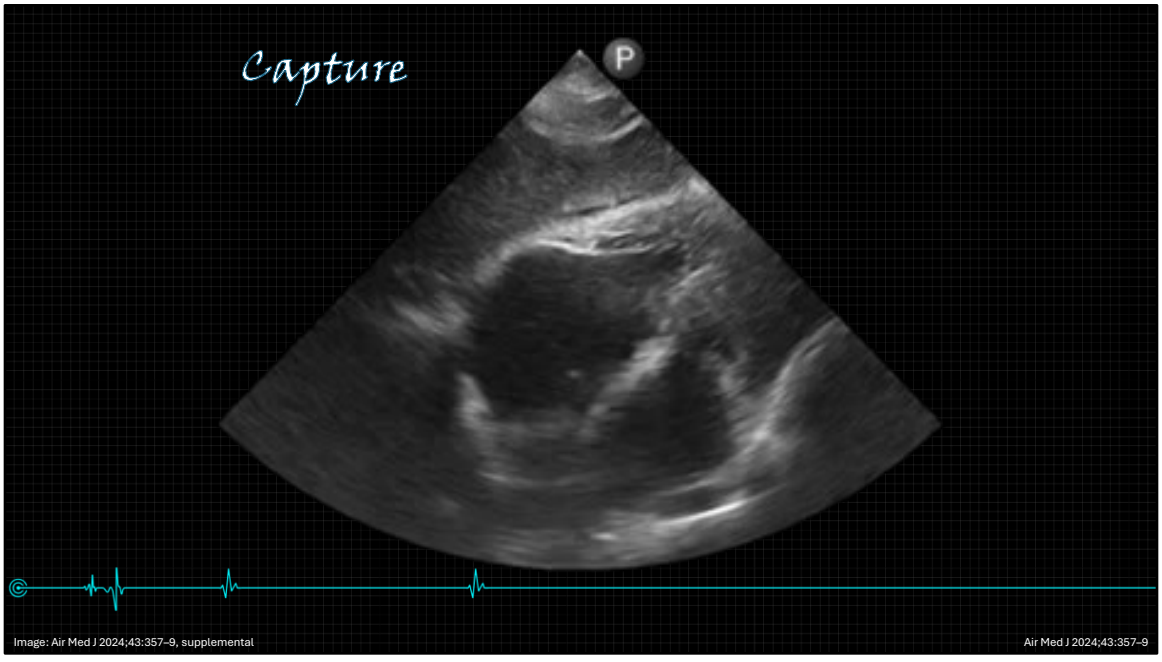
IF you choose to palpate a pulse, it may be preferred to palpate the femoral pulse, as this is a large central pulse and reasonably far away from the thoracic muscles stimulated by TCP current, so *less likely* (but not impossible) to be affected by muscle artifact.

I would definitely avoid carotid pulse palpation, as the sternocleidomastoids are likely to be affected by energy current and may lead to the false perception of a pulse with pacing current.
(*This was an AHA recommendation at one point [to avoid carotid pulses in TCP patients], but I can't seem to find it in their more-recently published guidelines*).



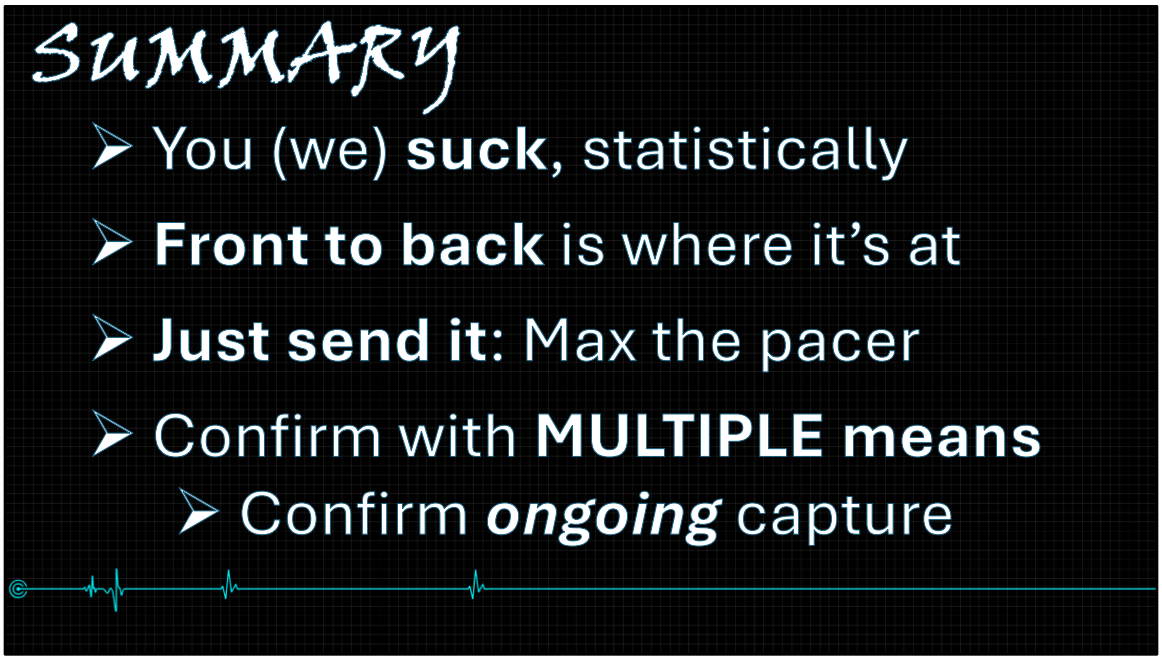
Better options for confirming mechanical capture that should be available to ALL EMS clinicians include:

- Use of **waveform pulse oximetry**
    - Keep in mind, though, this *might* be affected by motion artifact (I've literally seen the sheet on an empty stretcher generate an SpO2 waveform and reading before… creepy….)
    - There has been *at least one known case* of FALSE CAPTURE depicted by a *perfectly matched* SpO_2 waveform despite NO mechanical capture on ultrasound (reported on EMCrit: https://emcrit.org/emcrit/tcp-pulse-ox-fail/)
- Improved **end-tidal CO2**
    - Truly increasing HR (i.e., true electrical/mechanical capture) should increase cardiac output, and therefore should result in a sustained rise in EtCO2. Similar to how you're likely to see a sudden and sustained rise in EtCO2 when obtaining ROSC in a cardiac arrest patient, you should be able to expect similar when successfully pacing your patient – although this is surprisingly not well reported in the literature.
    - One recent study in Resuscitation found that, on average, **EtCO2 increased only about 2 mmHg with successful pacing** (versus an average ***decrease*** of 2-3 mmHg with no capture) – so the trend might be subtle, but you *should* see a sustained rise.
- Improved blood pressure
    - In nearly all case series of TCP attempts, true capture was associated with an improved blood pressure (versus and average of "no change" in those with no true capture).
    - I worry a little about motion artifact interfering with NIBP readings on an automated cuff, so if feasible this might be better determined with a manual BP, although I suspect the majority of BPs documented across the published literature were probably automated NIBP cuffs



Other more advanced options may include:

- Point-of-care **echocardiography**
    - True mechanical capture will generate clearly visible ventricular contraction on point-of-care TTE. This image is an example of a subxiphoid window of a patient receiving TCP during air medical transport.
- **Arterial line** waveform
    - If transport teams have the ability to place an arterial line, this may also be a more reliable way to differentiate true electrical/mechanical capture from false capture, and provides a more consistent monitoring of capture than intermittent POCUS TTE.



In summary:

- Statistically speaking, we suck at pacing. If you think you have capture, you're probably wrong (remember, only about a 9.7% rate of true, sustained capture in the prehospital literature). It's incumbent upon you to PROVE you're right.

- AP is probably more likely to achieve capture, and at a lower energy level, than anterolateral.

- Especially if your patient is in extremis and/or actively decompensating, consider just maximizing the pacer energy from the start. It will work, or it won't, but you'll know sooner and can move on to next-line therapies sooner.

- Tandem to point #1 - make sure you CONFIRM capture early and often using as many means as possible. Don't settle for just "positive pulse" (remember, statistically, we're wrong on that front over 80% of the time, too) – you should see improved EtCO2, improved BP, corresponding SpO2 waveform, and (if you have it) ventricular contraction on POCUS and/or a corresponding waveform on arterial line placement.

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