Transcutaneous oxygen tension in non-invasive vascular medicine

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Measurement of transcutaneous oxygen tension ($tcpO_2$) has gained worldwide acceptance as a simple and effective method of evaluating cutaneous blood flow in settings where skin viability and the adequacy of skin blood flow are of major concern.

An example of such a setting is the non-invasive vascular laboratory at the Mayo Clinic, headed by Dr Thom W. Rooke. To get insight into how $tcpO_2$ measurements can be applied as a part of the daily routine in such a setting, acutecaretesting.org has visited Dr. Rooke.

Q: Dr Rooke, how long have you been working with $tcpO_2$ measurements?

A: I have used $tcpO_2$ in the Mayo Clinic Vascular Lab since about 1982, so it is over 15 years now.

Q: What are the main applications for $tcpO_2$ here?

A: We typically use it to assess the severity of ischemia. That involves diagnosing the presence of ischemia, and trying to determine how severe it is.

Q: Can you go into a bit more detail on how you assess the degree of ischemia, and how this information is used?

A: If you know the amount of ischemia that is present, you can predict a number of things, but most importantly, whether wounds or incisions are likely to heal. This is certainly one of the most significant applications for transcutaneous oxygen measurement.

Another area where we find it extremely useful is when we want to assess the amount of small-vessel involvement.

We have a number of situations, particularly with diabetics or people with small-vessel vasculitis, where conventional tests (usually non-invasive vascular laboratory tests), do not give us the ability to assess how badly or to what degree the small vessels are obstructed. In these cases, $tcpO_2$ is very helpful.

Q: How do you typically make lower-extremity $tcpO_2$ measurements?

A: We usually take the patients and have them lie in the supine position in a quiet room where the temperature is carefully controlled. The patients are given a short period of time after entering the room that allows them to equilibrate.

We like to maximally vasodilate the skin underneath the electrodes, so we perform all our measurements with electrodes heated to a surface temperature of 45 °C. Our standard study involves placing two electrodes on the dorsum of each foot and a reference electrode on the chest wall, i.e., five electrodes in all.

We will typically allow the measurement of oxygen to take place until a steady state value is reached; and that is usually 15-20 minutes. Occasionally, it may take a bit longer.

Once we feel we have a good steady state resting supine value from all five electrode sites, we perform a provocative manoeuver to see if we can bring out degrees of arterial insufficiencies that may not have been noted in the resting study.

This is done by elevating the legs to 30 degrees (**Fig. 1**) for a period of three minutes and looking for the drop in tcpO_2 that accompanies that. After the three minutes of leg elevation, we are done.

Q: So that's why you have five tc pO_2 monitors on your chart?

A: Right. Another advantage we have with the five electrode setup is that even with a single reference chest value, we can position the other four on a single leg if we wish to do a preamputation study, to determine what the oxygen level is at multiple points on a given leg.

Q: What tcpO_2 values indicate poor tissue viability?

A: Using our tcpO_2 technique we find that values over 40 mmHg typically indicate that a wound will heal. Values below 20 mmHg typically indicate problems that can prevent successful wound healing.

In the so-called gray zone, between 20 and 40 mmHg, we find that leg elevation is the most useful thing we can do to sort out whether or not a wound is going to heal. Leg wounds that start with values between 20 and 40 mmHg, but drop by less than 10 mmHg when we elevate them, heal 80 % of the time.

Conversely, if the values drop by more than 10 mmHg upon elevation, the wound fails to heal 80 % of the time. So, using the elevation test gives us an extremely good prognostic ability.

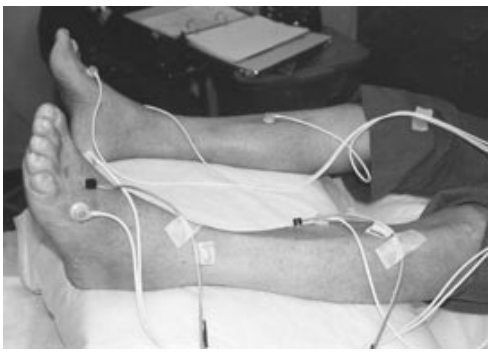

FIG. 1: tcpO_2 measurement on elevated legs (model photo).

As mentioned earlier, at the Mayo Clinic Vascular Lab tcpO_2 measurements are also used before and after revascularization and amputation. Dr Rooke was asked to expand on these important issues:

A: When we measure tcpO_2 before and after revascularization, we are always amazed by the excellent correlation between healing and change in tcpO_2. With regard to amputations, years ago the orthopedic surgeons were extremely skeptical of tcpO_2 measurements as a means of predicting amputation.

I was told by my orthopedic surgical colleagues that the only thing that made any difference was the surgeons' clinical assessment, when they were right there in the operating room looking at the freshly amputated stump and the blood flow. But in fact, surgeons have come to truly rely on preoperative tcpO_2 measurements as one of their most powerful predictors of whether or not amputation will heal at a particular level.

acutecaretesting.org also asked Dr Rooke of his

opinion on whether or not accurate prediction in wound healing and determination of amputation sites using tcpO_2 reduces cost. To this, Dr Rooke replied:

A: In my mind, absolutely. We do tcpO_2 studies almost routinely in our wound care clinic when we are confronted with patients who have nonhealing wounds and some kind of obstructive arterial disease. If the tcpO_2 values are such that we think we are not going to get healing, we immediately go to revascularization.

If we cannot revascularize, we think about some other modality such as hyperbaric oxygen, external pneumatic pumping, or even amputation. Conversely, if we feel we have adequate oxygen then we will go the whole 9 yards, as they say, to really push and try to salvage the wound.

The final issue brought up was the controversy between doctors dedicated to tcpO_2 measurements and those that insist they can get equal information by just looking at and feeling the patient.

Q: Dr Rooke, what would you say to those people?

A: They are clearly wrong. Maybe now would be the time to pull out the orthopedic surgical antidote that was actually the logic over 10 years ago with regard to amputation. Surgeons felt that there were two things wrong with bringing tcpO_2 into this picture: the first was that clinical evaluation, in their mind, was the only thing that was useful.

Secondly, there were no such things as failed amputations. Both of those statements turned out to be wrong. It was actually quite easy to convince the orthopedic surgeons in a matter of months that tcpO_2 evaluation was indeed a better way to assess the healing potential, than just the clinical evaluation. I think logic extends into all types of wound healing and all types of limb salvage situations.

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