Thermal Imaging Cameras Confirm Effectiveness of Local Anaesthetics

Loic Premartin, FLIR Advanced Thermal Solutions, Tel: +33-1-6037-0100, Email: research@flir.com

For many operations the use of local anaesthetics is preferred to general anaesthetics, since it is considered to be safer for the patient. To determine the effectiveness of local anaesthetics the patient is subjected to pin pricks. If the patient indicates a pain sensation then the local anaesthetic is considered to be ineffective. Not only is the pin prick method subjective, it is also useless if the patient is unable to communicate. Furthermore it takes approximately 30 minutes before the pin prick method can be used to reliably determine the success of a local anaesthetic. Researchers at the Erasmus University Medical Centre, Rotterdam, the Netherlands, have found thermal imaging camera to provide a new and objective tool to determine the effectiveness of the local anaesthetics.

Accurate assessment of the effectiveness of local anaesthetics (regional blocks) is of vital importance, according to Dr Ir. Sjoerd Niehof from the Anesthesiology Department of the Erasmus University Medical Centre: "Quick and accurate identification of failed blocks allows the anaesthesiologist to take appropriate action, such as administering additional anaesthetics, in an early stage.

"This will not only help to avoid unnecessary operation room delays, but will also help limiting the administration of additional anaesthetics to clinically appropriate situations. This is important because administering additional injections carries a small but definite risk of morbidity. In other words: the accurate assessment of regional blocks will help to save lives."

Niehof compared several different methods including FLIR thermal imaging cameras: "Thermal imaging provides immediate feedback. Medical personnel can use a FLIR thermal imaging camera to objectively determine the effectiveness of the local anaesthetics.
If the regional block is not effective it will clearly show in the thermal image."

Thermal Imaging Solution

The researchers initially used a FLIR SC2000 Series thermal imaging camera with an uncooled microbolometer detector that produces thermal images with a resolution of 320 x 240 pixels.

"As a response to the local anaesthetics the blood vessels dilate, a phenomenon called vasodilatation," explained Niehof. "This leads to an increased blood flow and subsequently to an increased skin temperature in the area affected. In our research we found that in case of a successful regional block the skin temperature rises with 4.5°C in about 20 minutes. In case of a non-effective block the maximum temperature difference was just 0.8°C. This difference in temperature increase can be detected and documented using a FLIR thermal imaging camera."

Finding test subjects was relatively easy, according to Niehof: "We approached patients at the University Medical Centre that were to undergo surgery on the hand or forearm and asked them to participate. Thermal imaging is a non invasive method, so it is completely safe and it doesn't cause any inconvenience for the patient, so it was easy to find patients willing to cooperate."

This resulted in a test group of 25 patients who were subjected to regional anaesthetics (mepivacaine 1.5%). The effectiveness of the anaesthetics was determined using three methods: the pin prick test, the cold sensation test or the thermal imaging test. From the moment the anaesthetics where administered the effectiveness tests were executed every five minutes for a total duration of 30 minutes. The final check was made using a surgical forceps just before surgery.

High Specificity

In medical diagnostics the terms sensitivity and specificity are used to determine the reliability of a test method. In this case sensitivity indicates the ability of a test method to correctly identify a successful regional block and specificity is the ability of the test to correctly identify a failed block. In other words: sensitivity is the percentage of people that have a successful regional block (as confirmed surgically) which have also been successfully identified as such using the test method, while specificity is the percentage of people that have a surgically confirmed failed block which have been successfully assessed using the test method.

The thermal imaging method has the best sensitivity and specificity. It reaches its maximum sensitivity of 95% at 15 minutes and maintains that for a period of 10 minutes, after which it drops to 90%. The pin prick reaches its maximum of 80% during the same time period. The cold sensation method reaches its maximum of 60% five minutes later and maintains it for a shorter duration.

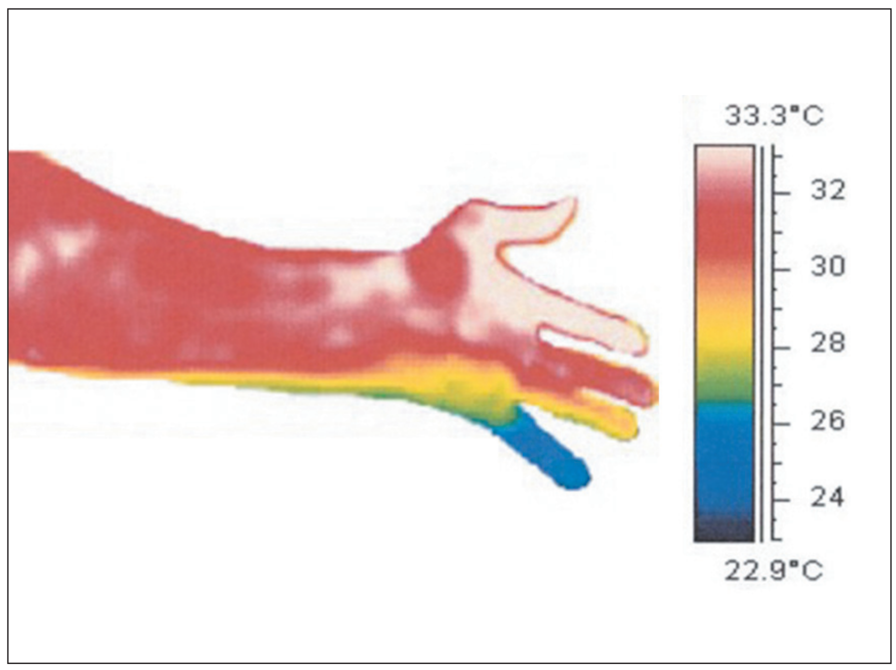
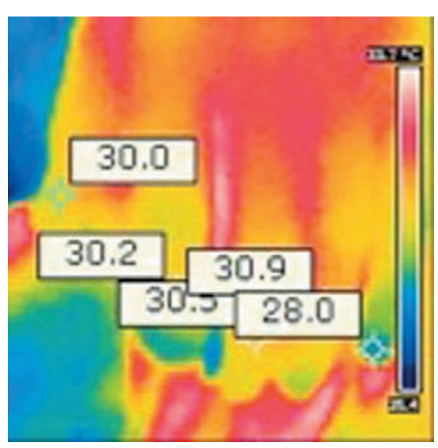


Figure 1. This figure, taken with the FLIR SC2000 Series thermal imaging camera shows a cold pink, indicating that the ulnar is not anaesthetised.

The specificity of thermal imaging reaches 100% after ten minutes, maintaining this level until the end of the 30 minutes. Both cold sensation and the pin prick methods reach their maximum much later, when 25 minutes have passed. Their maximum specificity is respectively 95 and 90%.



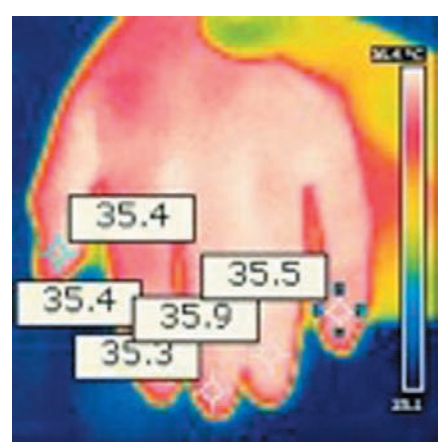


Figure 2. Two thermal images taken just before and 30 minutes after administering local anaesthetics. The rise in temperature indicates that the local anesthetic is effective.

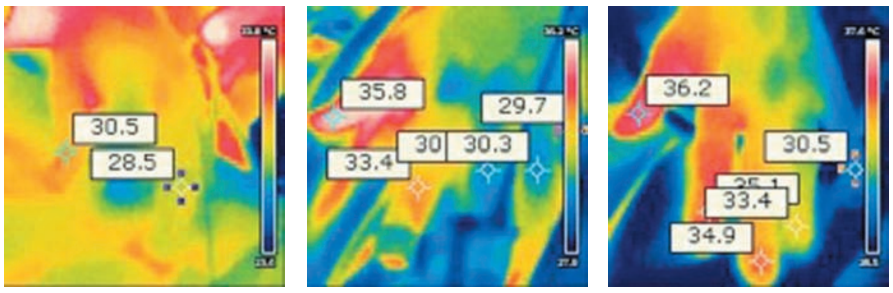


Figure 3. These thermal images show a hand after local anaesthetics were administered. The increase in temperature shows that the regional block is successful in the area that will be operated on. In this case the pink finger and the surrounding area show little to no rise in temperature, indicating that the ulnar nerve is not anaesthetized. General anaesthetics were therefore administered prior to surgery.

Results Confirm Usefulness of Method

From these results Niehof concluded that thermal imaging is the best method for regional block assessment. "Thermal imaging reaches higher accuracy values and maintains those high values for a longer period of time. And above all: it is a method that is completely objective, no patient input is required. At the same time it is extremely easy to use. All you need to do is point the FLIR thermal imaging camera and push the right button."

According to Niehof local regional blocks should be assessed by a FLIR thermal imaging camera: "I don't see why not. The price is not a limiting factor anymore. Given the fact that it will help decrease morbidity risk by avoiding unnecessary additional anaesthetics I would say that it is definitely worth the investment."

"And thermal imaging cameras can be used for more than just this particular application", continued Niehof. "Thermal imaging technology has seen use in the detection of certain infections, nerve damage and soft tissue injuries. Ongoing research is constantly revealing new and exciting ways to use thermal imaging technology as a medical monitoring and diagnostics tool."

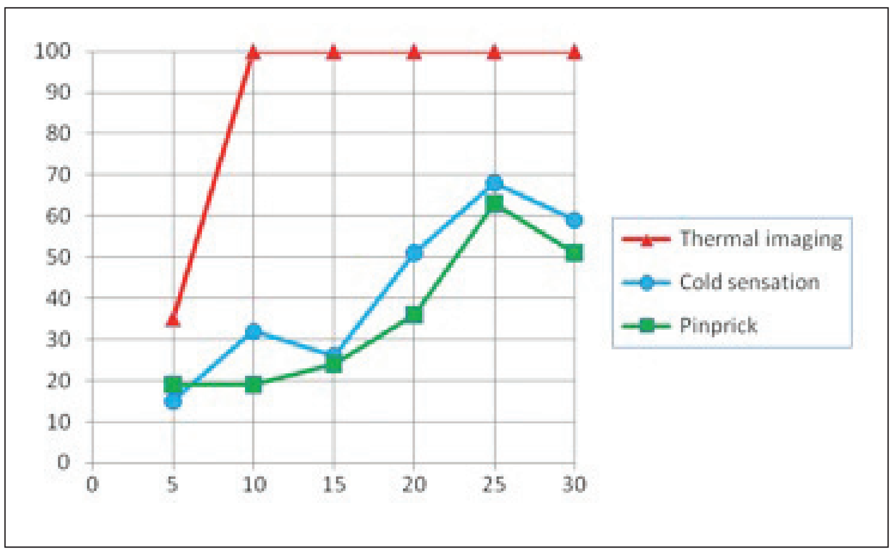


Chart 1. This chart shows the sensitivity of the thermal imaging (red), cold sensation (blue) and pin prick (green) assessment methods over time.

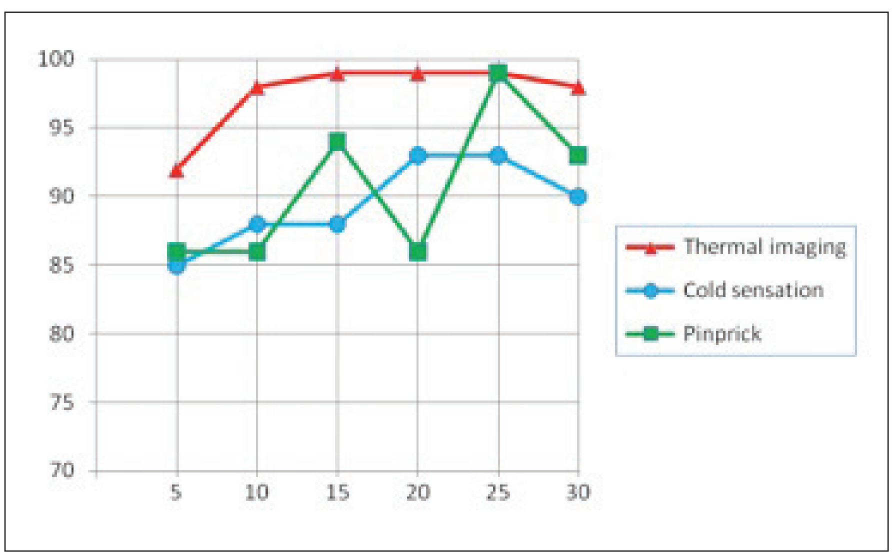


Chart 2. This chart shows the specificity of the thermal imaging (red), cold sensation (blue) and pin prick (green) assessment methods over time.

Source: Galvin, E.M, et al, Thermographic temperature measurement compared with pin prick and cold sensation in predicting the effectiveness of regional blocks. Anesth Analg, 2006. 102(2): p. 598-604.

Thermal Imaging

Thermal imaging cameras record electromagnetic radiation in the infrared spectrum, which is emitted by all matter as a function of its temperature, and those readings into a visible image. Infrared radiation lies between the visible and microwave portions of the electromagnetic spectrum (more specifically the wavelengths from 900 to 14,000 nanometers, or 0.9–14 µm). Any object that has a temperature above absolute zero (-273.15°C or 0 Kelvin) emits radiation in the infrared region. Even objects that we think of as being very cold, such as ice cubes, emit infrared radiation.

The existence of infrared was discovered in 1800 by astronomer Sir Frederick William Herschel. Curious to the thermal difference between different light colours, he directed sunlight through a glass prism to create a spectrum and then measured the temperature of each colour. He found that the temperatures of the colours increased from the violet to the red part of the spectrum. After noticing this pattern Herschel decided to measure the temperature just beyond the red portion of the spectrum in a region where no sunlight was visible. To his surprise, he found that this region had the highest temperature of all. This 'invisible light' he had discovered is now called infrared radiation.

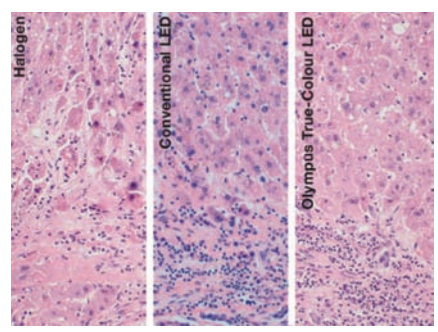
Thermal imaging cameras are very similar to regular digital video cameras. Infrared radiation coming from an object or scene is focused by the optics onto an infrared detector. The detector sends the information to sensor electronics for image processing. The electronics translate the data coming from the detector into an image that can be viewed in the view finder or on a standard video monitor or LCD screen.

Using so-called 'blackbodies', objects with a known temperature, thermal imaging cameras can be calibrated so that the recorded intensity of infrared radiation can not only be used to produce an image, but also to determine the temperature of an objects or scene within the camera's field of view. In other words: the thermal image is transformed in a thermographic image. Every pixel in the image is in fact a non-contact temperature measurement.

Thermal imaging detectors can be roughly devised in two categories: microbolometer detectors and quantum detectors. Microbolometer detectors are usually made of a metal or semiconductor material. They respond to infrared radiation in a way that causes a change of state in the bulk material (for example, resistance or capacitance), which allows for thermographic calibration. These detectors typically cost less to produce and have a broader infrared spectral response than quantum detectors, but they are influenced by incident radiant energy and are less sensitive than quantum detectors.

High-end thermal imaging cameras incorporate photon detectors, which operate on the basis of an intrinsic photoelectric effect. These materials respond to infrared by absorbing photons that elevate the material's electrons to a higher energy state, causing a change in conductivity, voltage, or current. By cooling these detectors to cryogenic temperatures, they remain practically unaffected by incident radiant energy, ensuring high sensitivity and accuracy.

Don't Fight to Get the Light Right



Olympus provides its versatile, powerful BX3 clinical microscope systems for analysis and disease diagnosis in pathology and cytology. The systems take advantage of Olympus's new true colour LED illumination technology and built in Light Intensity Manager (LIM) to create images with accurately rendered colours. Histological and cytological stains appear exactly the same under the true colour LED as they do under daylight filtered halogen, facilitating a seamless transition for labs adopting the new, more efficient LED technology. True colour LEDs offer longer lifetimes, constant colour temperature at all voltages and reduced power consumption when compared to traditional halogen bulbs. In addition, the LIM improves user workflow and maximises consistency by automatically modulating light intensity when working with different magnifications. Such advantages make the BX3 systems with true colour LED illumination the logical choice for comfortable and efficient clinical microscopy.

The Olympus true colour LED approach utilises the most advanced mixed-matrix brightfield LED technology currently available to provide a colour rendering index very similar to that of halogen illumination. Stains such as Haematoxylin, Eosin and Papanicolaou look the same when using the Olympus LED as when using halogen light sources, while similar colours can be easily differentiated. These factors maximise the accuracy and reliability of diagnosis using the Olympus true colour LED illuminator.

With a large number of clinical samples to screen, the optimisation of user workflow can significantly improve the efficiency of pathological analysis. For this reason, the Olympus true colour illumination system with LIM automatically modulates light intensity when changing objective lenses. This means that consistent illumination is maintained without the need for manual adjustment, saving a significant amount of time, while simplifying and improving the screening process. Automation is achieved using sensors mounted in the nosepiece that detect the objective lens in use and manipulate the LED intensity according to user defined preferences.

The flexible Olympus BX3 clinical microscopy systems with true colour LED illumination and LIM have been specifically developed to meet the needs of clinical microscopy, ensuring reliable diagnosis while maximising workflow efficiency.

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