Novel Use of Smartphone-based Infrared Imaging in the Detection of Acute Limb Ischaemia

A. Peleki*, A. da Silva
Department of Vascular Surgery, Wrexham Maelor Hospital, Croesnewydd Rd, Wrexham LL13 7TD, UK

Introduction: Infrared thermal imaging is based on perfusion changes reflected by skin temperature variations. It is an established non-invasive diagnostic method within vascular surgery, with applications such as peripheral arterial disease assessment and prevention of diabetic foot complications. However, owing to hardware limitations or lack of resources, it is not yet widely used in clinical practice.

Report: A novel portable infrared imaging camera, easily powered via a smartphone and free App software, was used to obtain digital thermograms during the clinical evaluation of acute limb ischaemia (ALI).

Discussion: Portable infrared imaging represents a new promising tool for the assessment of tissue perfusion that can be applied at the bedside during clinical evaluation of suspected ALI.

INTRODUCTION

Infrared thermography is an imaging method able to detect temperature variations in living organisms. It was first introduced into clinical medicine during the 1950s, when a heat-sensitive imaging device was used to depict a rise in skin temperature over cancerous breast tissue. The principle of skin temperature relating to underlying tissue perfusion has since had multiple applications in various specialties, where infrared imaging has been successfully used as a noninvasive diagnostic tool.

The role of thermal imaging has already been recognised within vascular surgery, with studies investigating its diagnostic value in detecting circulation changes. Positive results have been reported in cases of chronic peripheral arterial disease, diabetic foot complications, and steal syndrome. However, this imaging method is not yet fully integrated with daily clinical practice owing to hardware limitations, as in most cases a remote recording device with relevant software analysis is required.

We hereby present a novel portable infrared camera, weighing just 16 g, attachable to a smartphone device, iPhone (Apple, Cupertino, CA, USA) or Android (Google, Mountain View, CA, USA), and powered via a free App, which can be easily downloaded through the App Store or Play Store. Although it was originally designed for non-medical purposes, we decided to investigate its use in assessing tissue perfusion in suspected cases of acute limb ischaemia (ALI).

REPORT

A 78-year-old woman presented with a painful right limb, and reduced sensation and movement. The clinical appearance of both feet was similar, and no Doppler signals were detectable on either foot (see Fig. 2). The portable infrared camera was used to obtain digital thermograms with temperature measurements of both feet, without footwear, at the time of acute presentation and post-revascularisation. The camera was activated via the App and automatically calibrated by sampling the background ambient temperature. All thermal images were captured along with temperature values following a simple screen tap (Fig. 1). Thermograms and temperature captures were compared between affected and asymptomatic limb, as well as among pre- and post-intervention on the same limb. The initial image demonstrated a marked discrepancy in thermal luminosity distribution, as well as a temperature difference of 3 °C between the two sides. Following revascularisation with popliteal embolectomy, a rise in temperature of 3 °C was noted in the affected side, while the thermal luminosity of the revascularised foot was noted to be significantly improved (Fig. 2).

DISCUSSION

Changes in blood flow such as ischaemia, inflammation-induced vasodilatation, and neovascularisation are reflected as a change in the overlying skin temperature.
Various infrared thermography-based techniques have been trialled throughout the years in an attempt to measure these changes in a quantifiable fashion.

There have been several encouraging reports of infrared imaging being used as a non-invasive diagnostic tool for perfusion abnormalities. Nevertheless, thermography methods have not yet become widely established in clinical medicine. Impractical devices, complex computer software, lack of trained personnel, or financial budgets are some of the potential limitations for their wider adoption.

However, recent advances in smartphone technology can now place a modernised digital infrared camera into any doctor’s palm. The Seek Thermal Compact XR (Santa Barbara, CA, USA) device, compatible with iPhone and Android smartphones is a state-of-the-art portable thermal camera, originally designed to detect heat loss, electrical hazards, and insulation damage, or to identify animals or intruders at night. It produces high-quality thermograms (32,136 pixels, $-40 \degree C$ to $330 \degree C$ detection), while specialist training for its use is not required. Its cost of £259 renders it a viable option for either surgical departments or individual clinicians.

We decided to test this device in a clinical context as part of the assessment of ALI during on-call in a district general hospital setting. ALI requires prompt assessment and recognition, as early intervention has been shown to reduce limb loss and mortality rates. The infrared portable camera was successfully used at the bedside at the time of acute presentation, providing us with immediate thermal imaging of the affected limb when arterial duplex or computed tomography angiography would have taken hours to become available (if during normal working hours), and considerably longer out of hours. The clear perfusion asymmetry demonstrated on the thermograms aided the diagnosis, and facilitated early treatment. Furthermore, the thermal images provided valuable baseline information on temperature and perfusion discrepancy, which was later used for evaluation and quality control of revascularisation results.

CONCLUSIONS

Smartphone-based infrared photography can provide an easy way to obtain clear and quick bedside evaluation of tissue perfusion. Further studies are required to quantify the diagnostic value of this noninvasive tool in the clinical context of ALI assessment, as well as to explore its quality-control potential of revascularisation outcomes.

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