Abstract

Infrared cameras are becoming increasingly popular in clinics. Current practices, however, often overlook the importance of emissivity when taking thermal measurements. The consensus is that human skin has an emissivity of 0.98, but this varies between individuals, areas examined and whether the skin is damaged.

This research investigated the emissivity variation of chronic wounds and its effect on thermal measurements. A reflectance-based method was used which alternated shades at different temperatures over the region of interest. Based on the change in the thermal images, emissivity was calculated at each pixel. It was found that wound emissivity was slightly higher than intact skin emissivity. Correcting for emissivity resulted in an average temperature difference of 0.83% in the thermal images. The difference between the original thermal image and the emissivity corrected thermal image in some cases was substantial. These differences could prove significant in clinical evaluations, indicating the need to incorporate emissivity measurement into standard protocol to ensure utmost accuracy.

1. Introduction

Infrared Thermography (IRT) maps surface temperature distributions and offers numerous advantages over conventional clinical thermometers; it is fast, non-contact and has no harmful effects. Based on the principle that abnormal heat distribution indicates illness, IRT can be applied in the prediction, diagnosis and monitoring of conditions [1].

However, to ensure these temperature measurements are accurate, the emissivity of an object must be known. An emissivity variation of only 5% over the skin surface can alter temperature measurements by 1°C [2]. Human skin is reported to have an almost constant emissivity of 0.98 ± 0.01 between 2 and 14 μm [3] and this value is often used for clinical measurements. However, there is some disagreement amongst researchers on the emissivity of skin as different methodologies yield different results. In addition, emissivity has been shown to vary from person to person and some researchers have found different values for wounded tissue. The literature suggests further research needs to be conducted on the variation of emissivity across wounds.

Results

Emissivity of wounds and surrounding skin was measured using a reflectance-based method in a clinical setting. The change in the temperature of skin, when two shades at different temperatures were alternated above the region of interest, was used to calculate the point to point emissivity. The results were used to investigate any trends in emissivity and temperature variation across wounds, and to investigate the effect of correcting for emissivity in the thermal image.

2. Methods

Emissivity of wounds and surrounding skin was measured using a reflectance-based method in a clinical setting. The change in the temperature of skin, when two shades at different temperatures were alternated above the region of interest, was used to calculate the point to point emissivity. The results were used to investigate any trends in emissivity and temperature variation across wounds, and to investigate the effect of correcting for emissivity in the thermal image.

3. Results and Discussion

The overall intact skin emissivity was found to be 0.96 ± 0.03. Emissivity was slightly lower at wound edges than at wound centres for both diabetic and non-diabetic wounds. Values ranged from 0.91 – 1, with an average of 0.97 ± 0.03 in the centre and between 0.82 – 1, averaging at 0.91 ± 0.03, for the edge. In the centre of wounds with an eschar, emissivity was similar to intact skin while for wounds with no eschar, the emissivity was similar or higher than intact skin.

For wounds investigated daily over three weeks, emissivity was initially higher and approached values of intact skin over time. The difference in emissivity became less as time went on, but the emissivity of the wounds was always either greater or equal to that of the nearby skin. The initial increased emissivity of wounds could be due to the increased blood flow during inflammation. This would lead to more light absorption, as water in the blood absorbs infrared radiation strongly. This increased absorption would increase emissivity. When the region is no longer inflamed, the blood flow should return to normal and emissivity should approach that of intact skin.

The original and emissivity-adjusted thermal images differed by 0.3 °C on average for all images. A substantial difference in temperature (an average of 1 °C) was found in the cotton bandages, which were used as...
fiducial markers, after adjusting for their emissivity. This was evident from the bandages becoming transparent in the adjusted image (see Figures 3-4).

Thus, when the setting used for emissivity on the infrared camera is much different from the true value, the effect on the thermal image is important and must not be neglected. When the difference between these values is small (± 0.03), the effect on the thermal image is subtler, but can still be significant and should not be overlooked. This discrepancy could lead to inaccuracies in many clinical applications such as assessment of inflammatory diseases, wounds and could even lead to misdiagnosis. In particular, it would affect key clinical decision making. Thus, it is vital to ensure utmost accuracy of thermal measurements.

4. Conclusions

The emissivity of wounds was generally similar to intact skin, with lower values found at wound edges. The emissivity of a fresh wound approached values of intact skin as it healed over three weeks.

The original (using emissivity of 1 at each pixel) and emissivity-adjusted (using calculated emissivity at each pixel) thermal images differed for all images. Correcting for emissivity for thin bandages covering the skin resulted in the bandage almost disappearing in the adjusted image. As the skin beneath the bandage should be the same temperature as the skin around the bandage, this shows that the emissivity corrected image is more accurate. In other emissivity-corrected images, the wounded areas appeared to be more inflamed than indicated in the original images. In clinics, this discrepancy would be important and could affect key clinical decision making.

In conclusion, emissivity has an important effect on the thermal images and should be incorporated into standard protocol to ensure utmost accuracy.

5. References