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Establishing Level of Amputation in Severe Burn Wounds with Infrared Thermography.

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ABSTRACT

Thermography can evaluate the depth of the burn with a high degree of accuracy.

It can be used to assess the level of amputation in a patient who suffered severe burns in lower extremities. It represents a non-invasive imaging technique, with an interpretation in real time that can result in an early assessment in the need for surgery. A 21-year-old male patient was admitted in our hospital 6 hours after suffering a flame burn injury due to an explosion caused by a gas pipeline. Involving 50% TBSA, suffering 3rd and 4th -degree burns, affecting lower abdomen and extremities. Bilateral lower limb amputation and debridement was necessary. Before the amputation, an evaluation with infrared thermography was carried, finding significant decrease in distal extremity temperature, 10 centimeters above both knees. Making it possible to determine the level of amputation based on the decreased temperature of the lower limbs. Patients who suffered severe burns showed decrease in distal temperature (at least 6.2 °C) compared to healthy skin. It represents advantages in terms of cost, ease at use for clinicians, and because of its non-invasive feature is well accepted by patients. Thermography can inversely correlate skin temperature with burn depth, as well as reduced vascular perfusion near the wound surface. In conjunction with a proper clinical assessment, it can be a powerful auxiliary study, when trying to preserve viable tissue, compared to clinical assessment alone.

PALABRAS CLAVE

Amputation, Burn, Wounds, Thermography

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CASE REPORT

EA twenty-one-year-old male patient, admitted in ER 6 hours after suffering direct flame burn injury caused by a gas pipeline explosion. Patient suffered third and fourth degree burns involving 50% TBSA, affecting lower abdomen and lower extremities (Fig 1) On admission, resuscitative measures according to advanced trauma life support (ATLS) protocol were given, the patient was kept under intensive care with monitoring of his vital signs. (Fig. 1) Bilateral lower limb amputation and debridement were necessary. Prior to amputation, an evaluation with infrared camera was carried. Thermography of the lower limbs was assed using a FLIR T400 (FLIR Systems, Wilsonville, OR, USA) with a 320 × 240 focal plane array of uncooled micro-bolometers with a spectral detection range of 7.5–13 μm and a thermal sensitivity of 50 mK at 30°C. The patient showed a significant decrease in distal temperature 10 centimeters above both knees. This way it was possible to determine the level of amputation based on the decreased temperature of the lower limbs. (Fig. 2, 3).

Thermal imaging showed normal temperature in the right side of the abdomen with average of 31.4°C with standard deviation (SD) = 0.9, and a decreased temperature distribution over the burned skin of the lower ipsilateral extremity with an average temperature of 25.2°C with standard deviation (SD) = 1.6., and the contralateral side 31.1°C SD 2.6 and 24.9°C SD 2.5 respectively.

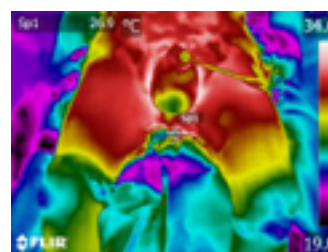


Figure 1. Burn affecting lower abdomen and lower extremities

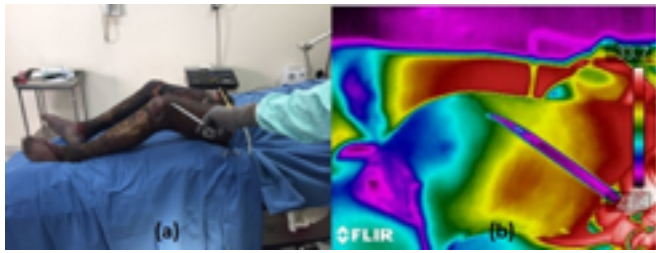


Figure 2. Bilateral lower limb amputation and debridement were necessary

After surgery, tissues of the mangled lower extremities were assessed clinically and with the use of thermography to measure the temperature and quality of soft tissue and muscles, which were viable and had adequate blood supply. (Fig. 4)



Figure 4. After surgery

DISCUSSION

Treatment consideration in a mangled lower extremity are a challenge for the surgeon. In the presented case, it was found that patients who suffered severe burns showed decreased distal temperature (at least 6.2 °C) compared to healthy skin. Our results correlate with the method carried out by Spence et al., in which above the knee amputation was performed when thermograms with a severe knee-foot longitudinal thermal gradient (LGT) was $>6^{\circ}\text{C}$.

Several scores have been developed to establish guidelines when deciding to amputate or not, however in literature there is no consensus. The most used score in literature is the MESS with a sensitivity of 79 % and a sensibility of 83 % in prediction of limb salvage. Although NISSA score is more sensitive than the MESS score (81,8 % and specificity 92,3 %)1. In another study, Kiran Kumar et al. established that MESS could predict amputation of severely injured lower limbs, having score of equal or more than 7 with 91% sensitivity and 98% specificity.

But there is no scale or instrument that defines the level of limb amputation.

New reconstructive techniques allow trying limb salvage in complex lesions that could only be treated by amputation in the past decades. As described by Fodor et al. failed attempts at limb salvage result in prolonged hospitalization, along with multiple surgical procedures, pain and psychological trauma. Patients who have undergone a lower extremity amputation may develop an unstable soft tissue envelope of the amputation stump. This envelope may result in pain that prohibits prosthetic use or may become chronically infected. Providing stable soft tissue coverage at the amputation site may provide relief from pain and prevent infections.

Additionally, a stable amputation soft tissue envelope may assist with the ability of the patient to maintain his or her existing level of ambulation, overall sense of wellness, and ability to maintain social integration, all which directly correlates with a better quality of life. Salvage of a lower extremity amputation level may significantly improve a patient's overall quality of life. Attempts to salvage an amputation level that is plagued by unstable wounds, pain, or infection are warranted in those patients who have the physiologic reserves to undergo salvage of their amputation level.

The use of thermography has proved to be consistently reliable, and represent advantages in terms of cost, ease at use for clinicians and because of its non-invasive feature is also well accepted by patients. Thermography can inversely correlate skin temperature with burn depth, as well as reduced vascular perfusion near the wound surface. The essential advantages of this technique are its noninvasive nature, simplicity, safety of examination and quickness. We consider this diagnostic tool could also be used for different traumatic or inflammatory pathologies of the extremities.

To the authors' knowledge, this is a first case report in which infrared thermography is used to assess and help establishing a level of amputation in a burned patient. Thermographic evaluation can be more accurate to preserve more tissue than clinical assessment. This study supports the surgical strategy of an early and adequate procedure for lower limb amputations, to avoid a late secondary closure and permit a good

prosthetic limb.

CONCLUSIONS

Thermography in conjunction with a proper clinical assessment can be more useful to preserve viable tissue when compared to clinical assessment alone. The presented results help establish a clear and measurable cut-off point when opting for an amputation surgery in a burned patient. Therefore, thermographic imaging can be used as a non-invasive procedure to evaluate third and fourth degree burn injury of accuracy.

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Short Running Head: Level of amputation with thermography

Consent

Written informed consent was obtained from the patient for publication on this case report and any accompanying images. A copy of the written consent is available for review by the Editor of this journal.

Declarations.

Competing interest.

The authors declare that they have no competing interest.

Authors' contributions.

GADR collected the clinical data, and drafted the manuscript, AMC, ESKM and FJG performed the statistical analysis and drafted the manuscript, MAMJ formulated the clinical treatment programs, and helped to draft the manuscript, FAG revised the manuscript for important intellectual content and the translation. All authors read and approved the final manuscript.