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REVISIONES

Body temperature and heating temperature in major burns patients care

Temperatura corporal y temperatura de calentamiento en el cuidado de pacientes grandes quemados.

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ABSTRACT:

Objectives: To describe the heating methods and their application to maintain body temperature in majors burn patients.
Methodology: Bibliographic review carried out between September 2019 and February 2020 about the thermoregulation and heating of the burn patient in the CINHAL, CUIDEN, PUBMED, MEDES and WOS databases in Spanish and English, documents from the last 10 years, from which 26 were analyzed.
Results: Hypermetabolic response and hypothalamic reprogramming cause an increase in basal temperature in burn patients between 37 and 38.5ºC without infectious origin. To decrease the energy expenditure at rest and the hypermetabolic response, it is possible to act through a high ambient temperature between 28 and 32ºC as passive external heating.
Discussion: Other external heating methods can achieve this goal such as convective air blankets, heating plates, or surface systems.
Conclusions: The recommendation of warming by means of high ambient temperature, which creates hostile environments for workers and patients, should be reviewed through the study of the inclusion of active external warming methods.

Key words: Burn patient; Body Temperature Regulation; Heating; Energy metabolism; Nursing Care.

RESUMEN:

Objetivos: El objetivo es describir los métodos de calentamiento y su aplicación para el mantenimiento de la temperatura corporal en el paciente gran quemado.
Metodología: Revisión bibliográfica realizada entre septiembre de 2019 y febrero de 2020 acerca de la termorregulación y calentamiento del paciente quemado en las bases de datos CINAHL, CUIDEN, PUBMED, MEDES y WOS en español e inglés, de los últimos 10 años, de los cuales fueron analizados 24 documentos.
Resultados: La respuesta hipermetabólica y la reprogramación hipotalámica provocan un aumento de la temperatura basal en los pacientes quemados, entre 37 y 38,5ºC sin origen infeccioso. Para disminuir

el gasto energético en reposo y la repuesta hipermetabólica se puede aplicar una temperatura ambiental elevada, como calentamiento externo pasivo, entre 28 y 32ºC.
Discusión: Existen otros métodos de calentamiento externo activo que pueden conseguir el mismo objetivo como las mantas de aire convectivo, placas térmicas o sistemas de superficie.
Conclusión: Debe revisarse la recomendación de calentamiento mediante temperatura ambiental elevada, que crea ambientes hostiles para los trabajadores y los pacientes, a través del estudio de la inclusión de métodos de calentamiento externo activo.

Palabras clave: Quemados; Regulación de la Temperatura Corporal; Calentadores; Metabolismo energético; Atención de Enfermería.

INTRODUCTION

The skin is the largest organ of the body, performs functions of homeostasis maintenance and thermal regulation. Loss of skin from a burn will require temporary replacement of these functions until recovery. WHO defines burns as a global health problem, with a prevalence 7 times higher in developing countries, mainly occurring domestically, with prevention being the intervention that can most reduce mortality [(1)].

In Spain, there were 1,757 deaths from accidents of fire, smoke and hot substances, in the last decade, 1996-2016, with an upward trend since 2011. In 2017, 9,186 burn income was recorded with an incidence was 7 cases per 100,000 inhabitants and a total of 39,170 hospital stays. The European Burns Association (EBA) describes that 14 out of 100,000 people will need hospital care for burns per year [(2)].

These patients usually develop hypothermia after burning and when transferred to a burn unit they receive more specialized care [(3)]. Burns with an extension greater than 20% Total Burn Surface Area (TBSA), advanced age, and other morbidities increase your risk of hypothermia.

Between 40-80 % of patients suffering severe burns have hypothermia during the acute phase [(3,5,6)], directly related to the extent of the burn. Hypothermia has higher prevalence in older age, burns greater than 40% TBSA and female [(5-7)]. In addition, the presence of hypothermia is described as an independent factor that can increase the mortality of these patients by up to 5% [(5)].

Since the accident that causes the burn, begins the process of care of major burn patient. The nurse has the competence to issue the hypothermia diagnosis or risk of hypothermia, establishing a care plan, and defines normothermia as its target. The heating mechanisms must be adjusted to achieve the target temperature, achieving a balance between production, gain and heat loss.

The aim is to describe the heating methods and their application for maintaining body temperature in major burn patient.

MATERIAL AND METHODS

A bibliographic review was conducted between September 2019 and February 2020, about thermal regulation, warming in hypothermia and metabolic control in burns patients with search terms, DeCS and MeSH: Burns - Burns, Burns, Burns - Burns patient, Hypothermia - Hypothermia, Body Temperature, Body Temperature, Body Temperature Regulation- Body Temperature Regulation, Heating – Heating, Heaters-

Heaters, Energy Metabolism - Energy Metabolism , Energy Consumption - Energy Consumption, Basal Metabolism - Basal Metabolism, Physiological Stress - Stress,Physiological, Ambient Temperature Temperature Temperature, Body Temperature - Body Temperature, Nursing Care - Nursing Care, , Nurse – Nurses, Nursing - Nursing, Burn units-Burn Units, Thermal Comfort- Thermal Comfort, in databases: CINHAL, CUIDEN, PUBMED, MEDES, the Web Of Sciencie Metasearcher (WOS), in the secondary databases: Cochrane library, Joanna Briggs Connect, UptoDate, GuiaHealth; and on the referral pages of international patient care societies with ISBI, ABA and EBA burns. Also included was the search for grey literature, doctoral theses in TESEO and other related reference documents. Articles in Spanish and English, published since 2009, were included, a range necessary for the proper definition of the concepts that are reviewed of adult patients with thermal burns, and content related to patient care with burns, heating, thermoregulation or metabolism. Documents of small burns, chemical or electrical burns, inhalation injury, out-of-hospital care or post-acute phase were excluded.

RESULTS

3536 articles were found, according to the databases and search engines consulted, applying search filters with the terms defined above were obtained 199, after screening and selection for further evaluation and analysis resulted in 24 documents. The background and review of the research topic below are set out as categorized by sections.

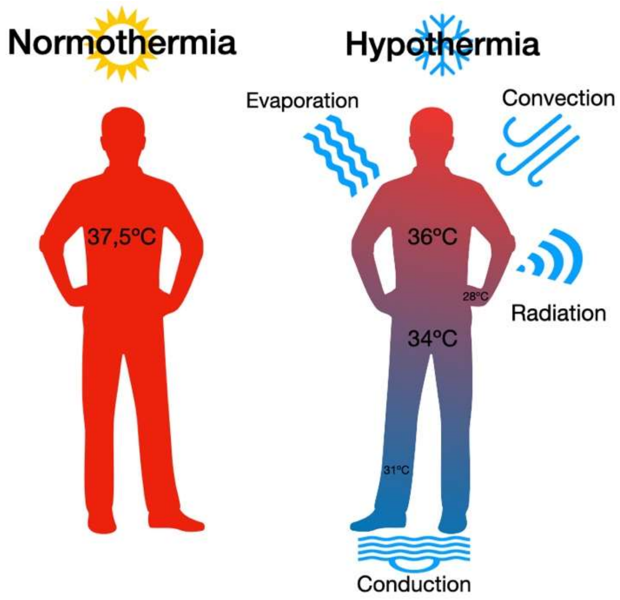
Body temperature in major burn patient

The loss of the surface of the skin by a burn leads directly to the loss of its functions resulting in an alteration in thermoregulation, alteration of sweat regulation (heat losses by evaporation) and alteration of the regulation of blood flow (heat losses by radiation and convection) [8].

Heat losses of the burn patient are presented by conduction, convection, radiation and evaporation [9]. Control of driving losses shall be carried out by acting on the surface that is positioned to the patient either the transport table, bed or surgical table. Treatment on convection losses shall be performed by monitoring environmental temperature and humidity and protecting from air currents. Radiation losses will be losses to the environment, so the patient's body exposure should be limited. And in the face of evaporation losses, contact with wet dressings and sweat control [9]. Heating and temperature maintenance measures will be applied to alleviate these losses.

The loss of heat and water through the burn causes an increase in central temperature, reprogramming the hypothalamic regulation, so patients are expected to have a higher temperature of up to 2ºC without infectious focus being around 38,5ºC [10]. A body temperature of less than 35ºC [11] should be avoided because of its unwanted effects and despite not knowing the optimal target temperature, it should be greater than 37,5ºC [4].

Figure 1: Heat loss of the burn patient. Own elaboration.



Hypothermia in burn patients may increase vasoconstriction lesions, cause clotting disturbances, decreased enzymatic activity, impaired breathing, may cause arrhythmias and death (11-13). The centralized care offered in a large burn unit provides a controlled and standardized environment indispensable for the survival of these critical and immunocompromised patients (14).

Pre-hospital action and implementation of established recommendations for burn cooling, monitoring the risk of hypothermia and applying heat loss control measures, will determine the progression of hypothermia and the need for faster warming of patients with extensive burns (3,6).

Once stabilized and for the first few hours after the injury, the patient will need to be covered with clean, dry blankets to prevent or limit hypothermia. Measures to maintain body temperature include occlusive dressing to prevent heat loss, local infection and promote healing. The barrier effect of dressings ensures thermal insulation and moisture maintenance, allowing gas exchange. Along with the limitation and control of body exposure, they are relevant factors to avoid decreased body temperature (12).

It is called critical temperature, at the temperature that triggers a thermogenic cell response. As the severity of the burn increases, the critical temperature decreases. While the critical temperature and time to reach it may vary between patients, hypermetabolic response can be controlled by high ambient temperature, minimizing heat losses, improving coagulation and reducing morbidity and mortality (4).

The target temperature range of patients in a study in US burn units was between 36 – 38ºC (15). Despite the absence of a clear definition of the target temperature, there is a relationship between higher body temperature and lower metabolic expenditure. shall be considered in the burn patient (Table 1).

Table 1: Body temperature in major burn patients

Authors	Methodology / Sample	Event	Recommendation
Sommerhalder et al, 2020	Review current problems in burn hypermetabolism	Based on Corallo's study, there is no clinical guide on temperature management	Maintain a temperature around 37.5ºC
Alonso-Fernández et al, 2019	Retrospective observational temperature study in 58 patients in the first 72 hours	Entry into Burn Unit in hypothermia, less than 35ºC Reach normothermia after 16 hours.	Increased effort in overheating. Average temperature of 37ºC, increase warming measures
Pahm et al, 2018	Review of treatment guidelines in patients burned in initial care	In case of hypothermia and Do not start overheating limbs until reaching 35ºC of central temperature to avoid a drop in temperature	Avoid temperature less than 35ºC
Gaickwad, 2016	Systematic review	Heat loss of the burn patient by conduction, convection, radiation and evaporation	Limit the patient's body exposure to avoid hypothermia.
Weaver et al, 2014	Descriptive retrospective income study of 2270 burn patients	Income temperature of 36.7ºC, 3.5% with temperature less than 35ºC	Definition of hypothermia between 34ºC, 35ºC and 36ºC. Increase efforts to increase body temperature to income.
Hostler et al, 2013	Retrospective descriptive study of 12097 patients with burns	Hypothermia associated with burns greater than 20% TBSA, elderly. High body mass index protective of hypothermia	Defines hypothermia temperature less than 36.5ºC
Bishop et al, 2012	Burns Critical care review, 7 references	Central base temperature in major burn patients burned 38.5ºC	Seek temperature greater than 37.5ºC. Temperature of 37ºC is considered relative hypothermia
Willmore et al, 1975	Case and control study, 8 burns patients, 4 control cases	Metabolic rate calculated by consumption of O_2 exhaled, insensitive losses of H_2O at 25ºC and 33ºC	Temperature greater than 1.7ºC – 2ºC in burn patients.

*REE Resting Energy Expenditure, ** TBSA Total Burn Surface Area

In the care of the burn patient, it should be noted that the baseline temperature of these patients is 38.5ºC, and that a temperature below 37ºC can be considered as relatively hypothermia [16].

Energy metabolism in burn patients

Two phases are considered in the metabolic response of the burn patient, the acute phase ranging from the accident to 72 hours, and the hypermetabolic phase. The hypermetabolic state developed by the burn patient after the acute phase increases energy consumption. Several actions are needed to decrease the effects of hypermetabolism to reduce caloric expenditure, at least so that there is no increase in metabolism [17].

Burns greater than 20% TBSA will develop a hypermetabolic, inflammatory and stress response in a similar way to that developed with burns greater than 40% TBSA [18]. It`s recommended to act on hypermetabolism, as its decrease will improve the healing of burns. The early and appropriate nutritional contribution to the patient will intervene on the catabolic state by decreasing energy demand [19].

During the acute phase after burning, the patient has a severe loss of lean body mass, free radical imbalance in relation to antioxidant defense mechanisms and impaired immune function. Intervention through adequate nutritional support and early onset of enteral nutrition will meet the energy demands of proteins, fats, lipids and micronutrients. In addition, the supplement of micronutrients such as glutamine, will contribute to the recovery of lean mass [20].

The metabolic expenditure of burned patients in the study of Stanojcic et al [18] was 1,4 ± 0,2 times the basal metabolic expenditure, while in the study of Leung et al [21] was 1,43 ± 0,32 times the BMR in patients with burns less than 40%.

Water losses of up to 4 l/m2 of burn surface area per day are found [22]. The evaporation body fluid losses quantified are 3 to 4 times greater than in healthy skin depending on deep second-degree and third-degree burns. It can be assessed by the Trans Epidermal Water Loss index (TEWL), measuring the amount of water in grams that passes through the skin to the surrounding atmosphere, per hour and skin area, being according to the depth of the burn from 50 to 62 gr/m^2 per hour [23] (Table 2).

Table 2: Thermoregulation in major burn patients

	Authors	Methodology / Sample	Event	Conclusion
Water losses	Busche et al, 2016	Water loss study in 28 patients	50 to 62 gr/m^2 per hour. You have differences between burns, donor areas, and coverage with biosynthetic substitutes.	Lost water 3 times greater in deep burns and 4 times greater on surface burns
Water losses	Zacwaki et al, 1970	Study of 20 patients from O_2 consumption and insensitive water losses	Losses of 4 l/m^2. Burn exposure losses of 0.5ºF.	Hypermetabolism increases water losses. Decreased body exposure decreases losses
Energy expenditure	Sommerhalder et al, 2020	Review current problems in burn hypermetabolism	The higher TBSA since the 20% increase in GMB	Progressive increase in environmental temperature-dependent GMB, based on Kelemen study
Energy expenditure	Leung et al, 2019	Retrospective observational study. Energy Expenditure Measure in 29 Patients	They presented a REE ratio of 1.43 ± 0.32 Difference between 4 GMB predictive scales. Does not include temperature in the studio	Recommendation of the use of indirect calorimetry to calculate Resting Energy Expenditure for the control of the hypermetabolism of the burn patient.
Energy expenditure	Stanojcic et al, 2018	Retrospective study of metabolic expenditure in 1288 patients	They presented a ratio of REE 1.4 ± 0.2 calculated using a metabolic exchanger. Doesn't consider body temperature	Control of increased hypermetabolism, inflammatory response and stress in burns with more than 20% TBSA

*REE Resting Energy Expenditure ** TBSA Total Burn Surface Area ***BMR Basal Metabolic Rate

Heating methods

Measures to alleviate heat losses should act in heating and maintaining the patient's body temperature through active internal heating methods such as intravenous hot liquid administration and other heating and extern methods that will be passive and/or active. An analysis of the use of heating methods, in US burn units, declared in relation to total cases: 94.2% increase in ambient temperature, followed by 88.5% forced air appliances, 82.7% tempered intravenous liquids, 38.5% conductive heating pads and temperature-regulated intravascular catheter 21.6%[15] (Table 3).

Passive external heating: Ambient temperature

As a passive external heating method a high ambient temperature is used, the recommendations place it between 28 and 33º [11]. This increase in ambient temperature can reduce Resting Energy Expenditure from 2.0 times to 1.4 times in patients with burns greater than 40% TBSA.

This measure serves to minimize the increase in basal metabolic rate caused by heat generation and water loss by evaporation. It is a Grade B recommendation of evidence by Joanna Briggs Institute [24] providing a warm room with an ambient temperature of 28–32ºC, to prevent hypothermia.

Pruskowski et al [15] observed that the increase in ambient temperature was the most commonly used heating in burn units, using a wide temperature arc of 24 to 35ºC.

Table 3: Environmental temperature in the care of major burn patients

Authors	Type of study / Sample	Variables	Results
Sommerhalder et al, 2020	Expert recommendation	Kelemen study, REE decrease by 22ºC with ambient temperature 30ºC brakes at 22ºC.	Room temperature UCI 28 – 30ºC
Pruskowski et al, 2018	Descriptive observational study of 52 burn units	Temperature in the Resuscitation phase	67.3% ICU at 75-80ºF 38.5% ICU at 90-95ºF
		Room Temperature	67,3%. ICU's at 75-80 ºF 40.3% ICU at 85-90 ºF
		Ambient temperature During cures	63.5% ICU at 75-80 ºF 42.3% UCI's at 85.- 90 ºF
Kelemen et al, 1996	Case and control study with 44 burn patients and 4 controls	Negative correlation between temperature from 22 to 32ºC and REE/BMR rate. It states that the environmental temperature-dependent reduction ranges from 2.25 to 1.5 REE/BMR rate	The control group found no significant differences in the REE/BMR ratio at different temperatures
	Calculation of metabolic expenditure by indirect calorimetry at 22, 28, 32 and 35ºC		The lowest REE/BMR rate was shown at an ambient temperature of 32ºC
James et al, 2017	Systematic review 4 studies	Recommendation Level 5, expert opinion, based on Bishop and Latenser studies	Prevention of hypothermia by ICU room at 28-32ºC, hot fluids, hot blankets and hot inspired air
Rizzo et al, 2017	Systematic review 15 studies from 1972 to 2013	Temperatures from 22 to 40ºC in the care of burns patients in ICU and operating room	Need to update the heating and environmental temperature studies. Moderate hypothermia studies needed

*REE Metabolic Energy Expenditure, **BMR Basal Metabolic Rate, *** TBSA Total Burn Surface Area

To decrease hypermetabolic response, such as non-pharmacological measures, it can be acted by raising the ambient temperature. Kelemen et al [25] found that the ambient temperature range from 30ºC to 32ºC would reduce hypermetabolism in patients with burns from 20% TBSA, reaching a 22% decrease in energy demand compared to an ambient temperature of 22ºC. Environmental temperatures above 32ºC would no longer provide this benefit. There is a relationship between higher burn body surface area and higher temperature demand [25].

Active external heating

Active external heating is obtained by directly applying heat to the surface of the body. The use of convective air as an active external heating method has been studied mainly in the surgical and care field of critical patients [26]. This application is effective to achieve normothermia starting from a body temperature of 32ºC. The application of convective air achieves a higher rate of 1ºC of heating compared to other methods [27].

DISCUSSION

The burn patient needs to maintain a higher body temperature due to increased energy expenditure. Maintaining a high ambient temperature decreases hyper-metabolic response and therefore energy consumption. The current recommendations are based on Wilmore's research, which studied the metabolic impact of high ambient temperature applied as a passive external overheating method.

As shown in *Table 1,* there is a temperature range considered safe, but there is no exact delimitation of an optimal reference temperature for the burn patient. At the same time, in secondary assessment, it is necessary to estimate the effects of external warming in relation to factors such as anxiety, pain or disconfort.

It was observed in a Burn Unit that the average temperature of patients at the end of the acute phase was around 37ºC, when temperatures close to 38ºC are expected, a fact that makes it necessary to reflect on warming measures, and whether the body temperature of non-infectious origin is the best reference value for the maintenance of such measures [5] .In contrast, it has been observed that in patients of pediatric age, this hyperthermal response does not develop as in adults[28].

High ambient temperature has unfavorable effects, such as increased proliferation and growth of microorganisms [29] or heat stress. Maintaining normothermia only by passive external overheating at high temperatures creates harsh working environments. Intervention would be required through the combination of passive external heating methods that could lower the room's ambient temperature and decrease the patient and workers' disconfort.

Several authors and guides recommend the joint use of heating measures such as inspired hot air or hot blankets [9,12,16,27] but there are not precise specifications on the use of an active external heating type, plus there is variability in terms of the time of application and its availability. This method is of limited use in burn patients, as while skin care actions are performed, it cannot be applied comfortably or effectively.

There are experiences with active internal heating methods such as the use of an intravascular catheter intended for thermoregulation as it produces a rapid response in both patient warming and cooling against other methods. Its use is limited in time due to the risk of intravascular thrombosis [30], so treatment cannot be extended more than 72 hours.

An active external heating method that employs heating and cooling rates and range by applying skin gel patches such as Articsun 5000®, the application of which is contraindicated on skin with ulcers, wounds or burns, which prevents its use in the case of patients with extensive burns.

Active external heating methods can improve temperature maintenance and heat loss without creating adverse environments for healthcare professionals during care, further optimizing the thermal regulation of the burn patient. The adequacy of the heating methods could achieve an improvement of the thermal comfort of the patient and the workers in the Burn Unit reaching a decrease in the high ambient temperature.

CONCLUSIONS

The major burn patient needs a body temperature greater than 37 – 37.5ºC reached 38.5ºC, to avoid critical temperature and decrease energy expenditure, controlling hypercatablic state.

The recommended ambient temperature in large burn units is between 28 and 33ºC. The application of high environmental temperatures creates severe environments for workers and patients, so their effective application in these units is variable and requires an adaptation and balance between the needs of the patient and the conditions of the workers.

The recommendation of high ambient temperature heating should be reviewed through the study of the inclusion of active external heating methods in burn patients.

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