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Review

Clinical and translational aspects of hypothermia in major trauma patients: From pathophysiology to prevention, prognosis and potential preservation

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ABSTRACT

The human body strives at maintaining homeostasis within fairly tight regulated mechanisms that control vital regulators such as core body temperature, mechanisms of metabolism and endocrine function. While a wide range of medical conditions can influence thermoregulation the most common source of temperature loss in trauma patients includes: exposure (environmental, as well as cavitary), the administration of i.v. fluids, and anaesthesia/loss of shivering mechanisms, and blood loss per se. Loss of temperature can be classified either according to the aetiology (i.e. accidental/spontaneous versus trauma/haemorrhage-induced temperature loss), or according to an unintended, accidental induction in contrast to a medically intended therapeutic hypothermia. Hypothermia occurs infrequently (prevalence < 10% of all injured), but more often (30–50%) in the severely injured. Hypothermia usually come together with and may aggravate acidosis and coagulopathy (the "lethal triad of trauma"), which again may be associated with a high mortality. However, recent studies disagree in the independent predictive role of hypothermia and mortality. Prevention of hypothermia is imperative through all phases of trauma care and must be an interest among all team members. Hypothermia in the trauma setting has attracted focus in the past from a pathophysiological, preventive and prognostic perspective; yet recent focus has shifted towards the potential for using hypothermia for pre-emptive and cellular protective purposes. This paper gives a brief update on some of the clinically relevant aspects of hypothermia in the injured patient.

Contents

Introduction

The human body strives at maintaining homeostasis within fairly tight regulated mechanisms that control vital regulators such as core body temperature, mechanisms of metabolism and endocrine functions. These essential functions may demonstrate

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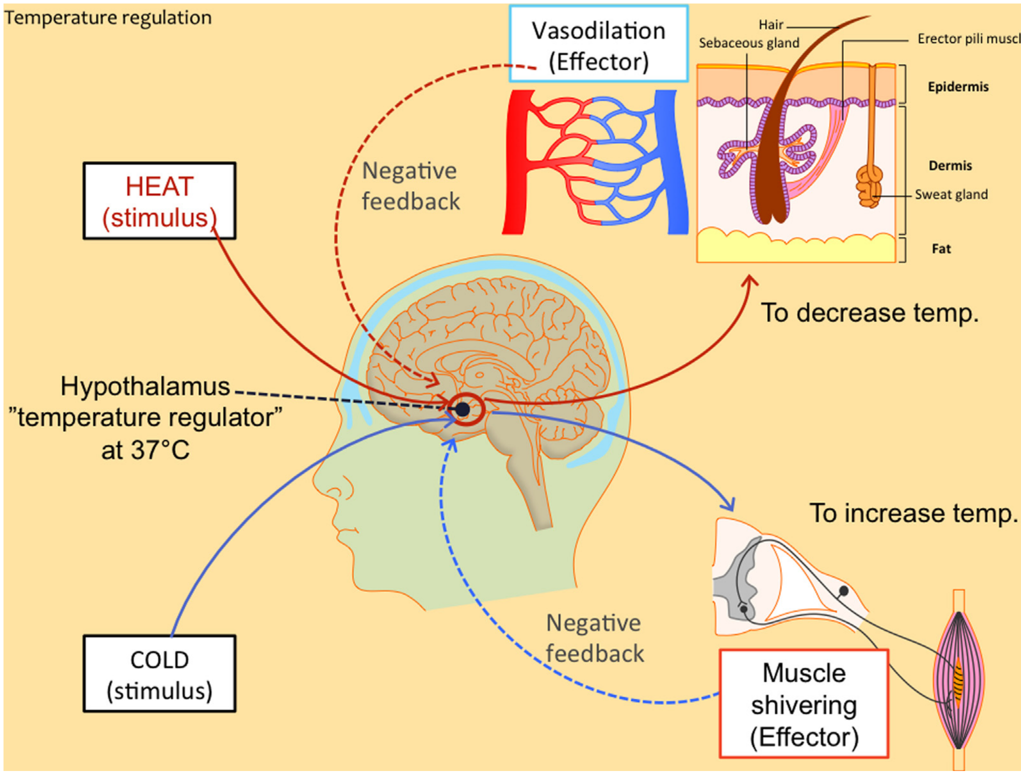

Fig. 1. Schematic depiction of thermoregulation. The hypothalamus works as the central thermoregulator and reacts upon a stimulus (i.e. cold) by a response (i.e. muscle shivering) to increase the temperature. When normothermia is reached a negative feedback loop regulates the stimulus so as not to overgenerate heat. The response may be blunted, e.g. in an unconscious patient or a patient receiving neuromuscular blockade during anaesthesia.

just slight circadian oscillation under normal circumstances,[1] such as temperature oscillation maintained between 2 and 4 °C on a circadian basis. Regulation of temperature follows through a stimulus–feedback system that ensures either generation of heat (through muscle shivering) if temperature falls, or the removal of excess heat through generation of sweat and vasodilation (see mechanisms in Fig. 1). However, any disruption of the homeostatic mechanisms may blunt these otherwise tightly controlled mechanisms (e.g. bacterial infection leading to fever; or loss of consciousness leading to heat loss and failure to compensate through shivering). A major trauma insult on the human body is typically followed by deregulated mechanisms ranging from cellular and molecular mechanisms,[2] to altered human physiology and single or multi-organ dysfunction. For severely injured bleeding patients the extreme form may be characterised as the "lethal triad of trauma" with acidosis, hypothermia and coagulopathy with a very high mortality even in the modern era of trauma management.[3] Hypothermia in the trauma setting has attracted interest in the past from a pathophysiological, preventive and prognostic perspective, yet recent focus has shifted towards the potential for using hypothermia for pre-emptive and cellular protective purposes. This review gives an overview on current findings and results reported for hypothermia in trauma victims.

Definition, measurements and classification

Hypothermia is usually considered to be present in trauma patients with a body core temperature < 35 °C. However, as no globally agreed classification of hypothermia exists, various cut-off values have been used for the definition of hypothermia, but most studies refer to hypothermia as either <35 °C or ≤35 °C.[4–9] In 2008, the ATLS redefined hypothermia parameters for trauma – for injured patients it is now <36 °C – for patients exposed such as in submersion injury, it remains <35 °C.

Notably, while recording body temperature is perceived as an everyday procedure and one of the most used ways of evaluating the general health condition, it may be associated with a considerable larger uncertainty than probably perceived by most clinicians. Temperature can be measured and monitored either by invasive means (by a pulmonary catheter, by probes in the oesophagus or bladder or by rectal probes) or by non-invasive techniques (oral, axillary, temporal artery and ear-based measurements). A number of factors may influence temperature measurements and interpretation, including human factors such as patients age and gender,[10–12] choice of technique and location, measurement errors on the side of the user, or equipment errors based on technical or calibration issues.[10,12–14] Considerable variation exists in measurement accuracy, but pulmonary artery measurements and rectal temperature appears to be fairly accurate and demonstrating good correlation for estimating core body temperature, usually with as little as ±0.1 °C in variation.[11,15,16] Probes inserted in the urinary bladder may also be an alternative, with temporal artery reading and axillary measurements being less reliable – with up to ±1 °C in difference from invasively recorded measurements – although widely used in clinical practice. As novel and improved techniques develop it is hoped that more standardised and reliable measurements can be obtained.[13]

Loss of temperature can be classified either according to the aetiology (i.e. accidental/spontaneous versus trauma-induced), or the mode of induction, such as an accidental drop of temperature in contrast to that of a medically intended use of therapeutic hypothermia. Usually one would consider hypothermia as either *spontaneous or accidental* when caused by an accident or insult per se (such as cold exposure) or *therapeutic* when used as a therapeutic means. While trauma-induced hypothermia may include an accidental component (exposure to cold weather) it is important to make clinical distinction between isolated accidental/spontaneous hypothermia and that of trauma-induced