What evidence-based interventions are recommended to alleviate hyperthermia associated with Malignant Hyperthermia?

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Background:

The most important treatment of Malignant Hyperthermia (MH) is discontinuing MH triggering agents, hyperventilation, and timely administration of dantrolene. However, prolonged hyperthermia worsens patients' outcomes[1] and should also be treated when occurs.

Many cooling strategies are available, but in practice it is impossible to implement all of them simultaneously without distracting from the key tasks of administering dantrolene and treating the patient's metabolic and respiratory abnormalities.

Many experts believe that hyperthermia is a sign of inadequate physiological treatment and clinicians' priority should be to stop MH with dantrolene and adequately treat hypercarbia and acidosis before focusing time and efforts on thermal management (personal communication, Dr. Daniel Sessler). It is therefore important to prioritize cooling approaches based on efficiency, ease of use, and safety.

Discussion:

Thermal management can be divided into three categories: pharmacologic, noninvasive, and invasive. *Pharmacologic* treatment of hyperthermia includes dantrolene, acetaminophen, and nonsteroidal anti-inflammatory drugs. Dantrolene is the only clinically available specific treatment for MH and, after discontinuation of triggering agents, should always be the initial treatment for any suspected MH episode. The recommended initial dose of dantrolene is 2.5 mg/kg bolus with repeated boluses as needed until hypermetabolism is controlled.

Acetaminophen, especially now that it is available intravenously, is increasingly used for analgesia and treatment of fever. However, its effectiveness in treating hyperthermia caused by MH has not been determined. Similarly, the role of nonsteroidal anti-inflammatory drugs as antipyretics during MH remains unknown. Nonetheless, the high body temperature associated with MH is due to excessive heat production by skeletal muscle; there is thus no theoretical basis, much less evidence, to suggest that antipyretic drugs will help control hyperthermia during MH episode.

Noninvasive treatments of hyperthermia include strategic ice packing, forced air cooling, circulating cool water blankets, cold intravenous fluids, and ice-water immersion. Cold intravenous fluid is effective: in healthy volunteers, 40 mL/kg infusion of 4°C or 20°C fluid, core temperature transiently decreased 2.5 ± 0.4°C and 1.4 ± 0.2°C, respectively.[2] Cold fluids should be kept available and should typically be the initial cooling measure during an MH crisis, especially since hydration is usually appropriate to limit the risk of renal injury from myoglobinemia. The method is limited by the amount of intravenous fluid that can be safely administered, typically about three liters in adults.

Ice packing (neck, groins and axillae) is effective, although prolonged direct skin exposure may provoke tissue injury. Convective cooling with forced air at ambient temperature is easy to implement and essentially risk-free. However, the method is nearly ineffective and little better than simply removing all covers and exposing the patient to ambient air. Ambient air temperature should be lowered to the extent practical.

Circulating cool water blankets set to low temperatures such as 4°C absorb considerable heat,[3] but are not available in all operating rooms and positioning water blankets or mattresses during an MH crisis may be complicated and distracting. As with any surface cooling method, efficacy is a linear function of surface area used. Some temperature management systems use circulating water with pads that feature thin hydrogel coating. They are more effective blankets than conventional circulating-water because they contact the skin well and have low thermal resistance.

Ice water immersion is by far the most effective external cooling method,[4] but is limited by the equipment required and need to move patients. In practice, immersion is not an approach that can be organized and implemented safely in the midst of an MH crisis.

Invasive strategies include bladder, rectal, gastric or peritoneal lavages, esophageal heat exchangers, intravascular heat exchange devices, and cardiopulmonary bypass. Gastric lavage is neither effective nor safe due to low return of aspiration of the injected fluids.[4] Bladder lavage is ineffective due to small contact surface area and a relatively low bladder perfusion.[4] Although not studied, rectal lavage may have similar limitations. Peritoneal lavage is highly effective because the peritoneum has a large contact surface area and is highly perfused. However, it should be noted that this method is invasive and requires special apparatus and skills (often available in emergency departments).

An esophageal heat exchanger is a new device which is inserted much like a standard orogastric tube. It has additional connectors designed for standard water blanket chillers/heaters. The device provides heat exchange via the blood circulation surrounding the esophagus. The system extracts about 50 watts which is relatively small compared to potential heat production during a severe MH crisis.[5] Furthermore, the device is not yet commonly available. Lastly, cardiopulmonary bypass is by far the most effective cooling device, but its invasiveness and technical challenges are an obvious deterrent to recommending its application during an MH crisis unless bypass is required to treat hyperkalemic cardiac arrest. Furthermore, the degree of cooling is very rarely required.

Conclusions:

Cooling should never distract from dantrolene administration and hyperventilation. Most patients treated promptly with dantrolene and hyperventilation do not become seriously hyperthermic or necessitate active cooling. Active cooling should be used with care since there can be a substantial after-drop, depending on the cooling technique, duration of application, and body heat distribution; cooling should thus be discontinued when core temperature decreases to 38°C.

External cooling methods such as circulating-water mattresses or ice packs should be considered first. If external cooling is insufficient, an easy, effective, and safe next cooling strategy is to infuse 20 mL/kg of refrigerated intravenous fluid. Other treatments should rarely be necessary, but peritoneal lavage is probably the safest and most effective of the invasive approaches if the peritoneum is already open or the patient is in an emergency department with the requisite equipment and skills.

References

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