British Journal of Anaesthesia **105** (4): 417–20 (2010)
doi:10.1093/bja/aeq243

BJA

Recognizing and managing a malignant hyperthermia crisis: guidelines from the European Malignant Hyperthermia Group

K. P. E. Glahn[1]*, F. R. Ellis[2], P. J. Halsall[3], C. R. Müller[4], M. M. J. Snoeck[5], A. Urwyler[6] and F. Wappler[7]

[1] Danish Malignant Hyperthermia Centre, Department of Anaesthesia, University Hospital Herlev, Copenhagen, Denmark
[2] University of Leeds, Leeds, UK
[3] MH Investigation Unit, St James University Hospital, Leeds, UK
[4] Department of Human Genetics, University of Würzburg, Germany
[5] MH Investigation Unit, Nijmegen, The Netherlands
[6] Department of Anaesthesia and Research, University of Basel, Switzerland
[7] Department of Anaesthesiology and Intensive Care Medicine, Hospital Cologne-Merheim, University Witten-Herdecke, Cologne, Germany

* Corresponding author. E-mail: kpeg@dadlnet.dk

Key points

- MH is rare, but its incidence may be increasing.
- Prompt recognition is the key to a safe outcome.
- These guidelines provide a template for diagnosis and treatment.
- Suspected cases and their relatives should be followed up and investigated for MH.

Survival from a malignant hyperthermia (MH) crisis is highly dependent on early recognition and prompt action. MH crises are very rare and an increasing use of total i.v. anaesthesia is likely to make it even rarer, leading to the potential risk of reduced awareness of MH. In addition, dantrolene, the cornerstone of successful MH treatment, is unavailable in large areas around the world thereby increasing the risk of MH fatalities in these areas. The European Malignant Hyperthermia Group collected and reviewed all guidelines available from the various MH centres in order to provide a consensus document. The guidelines consist of two textboxes: Box 1 on recognizing MH and Box 2 on the treatment of an MH crisis.

Keywords: complications, malignant hyperthermia; European Malignant Hyperthermia Group; malignant hyperpyrexia; safety

Accepted for publication: 5 July 2010

The first known case of malignant hyperthermia (MH) survived because the anaesthetist quickly stopped anaesthesia and surgery when he observed a set of strange clinical signs. However, he was already alerted to a potential problem because of a preoperative history of several anaesthesia-related deaths in the patient's family.[1] The key lesson learnt from this event is as relevant today as it was back in 1960: survival from an MH crisis is highly dependent on early recognition and prompt action.

MH crises are very rare and an increasing use of total i.v. anaesthesia (TIVA) using non-triggering agents in many Western European countries is likely to make it even rarer, leading to the potential risk of reduced awareness of MH among anaesthetists and theatre staff. However, recent reports showed that the frequency of MH episodes has increased, and due to the autosomal-dominant inheritance in humans, prevalence of MH can be estimated up to 1:3000.[2] In addition, dantrolene, the cornerstone of successful MH treatment, is unavailable in many institutions in Eastern European countries and in large areas around the world due to its cost, thereby increasing the risk of MH fatalities in these areas.

The European Malignant Hyperthermia Group (EMHG), a leading international society working on MH, has therefore decided to publish guidelines for the detection and handling of an MH crisis. Many institutions have drawn up local guidelines and most countries with an MH Investigation Unit have developed national guidelines. The EMHG Executive committee collected and reviewed all guidelines available from the various MH centres in order to provide a consensus document. It is hoped that this will be helpful, especially for countries having no MH centre and therefore no national guidelines.

While recognizing that it is impossible to stipulate the exact set-up for dealing with MH for each institution worldwide, we are, nevertheless, convinced that the EMHG guidelines will provide a sound basis to help anaesthetists and theatre staff in Europe and around the world ensure that best practice is followed and enable them to plan ahead.

The guidelines consist of two textboxes: Box 1 on recognizing MH and Box 2 on the treatment of an MH crisis.

Box 1 EMHG Guidelines: **Recognizing an MH crisis**

Early recognition of an impending MH crisis and its immediate treatment is essential for the patient's survival. As the clinical signs associated with MH are not unique, anaesthetists must be able to recognize a pattern of signs in order to make a rapid diagnosis.

Any patient may develop MH during or shortly after an anaesthetic where trigger agents are used—this can occur even in patients who have had uneventful general anaesthesia previously.

Trigger agents are

- all volatile (inhalation) anaesthetic agents;
- succinylcholine.

Clinical signs

Early signs

Metabolic

- Inappropriately elevated CO_2 production (raised end-tidal CO_2 on capnography, tachypnoea if breathing spontaneously).
- Increased O_2 consumption.
- Mixed metabolic and respiratory acidosis.
- Profuse sweating.
- Mottling of skin.

Cardiovascular

- Inappropriate tachycardia.
- Cardiac arrhythmias (especially ectopic ventricular beats and ventricular bigemini).
- Unstable arterial pressure.

Muscle

- Masseter spasm if succinylcholine has been used.
- Generalized muscle rigidity.

Later signs

- Hyperkalaemia.
- Rapid increase in core body temperature.
- Grossly elevated blood creatine phosphokinase levels.
- Grossly elevated blood myoglobin levels.
- Dark-coloured urine due to myoglobinuria.
- Severe cardiac arrhythmias and cardiac arrest.
- Disseminated intravascular coagulation.

Differential diagnosis

- Insufficient anaesthesia, analgesia, or both.
- Infection or septicaemia.
- Insufficient ventilation or fresh gas flow.
- Anaesthetic machine malfunction.
- Anaphylactic reaction.
- Phaeochromocytoma.
- Thyroid crisis.
- Cerebral ischaemia.
- Neuromuscular disorders.
- Elevated end-tidal CO_2 due to laparoscopic surgery.
- Ecstasy or other dangerous recreational drugs.
- Malignant neuroleptic syndrome.

Box 2 EMHG Guidelines: **Managing an MH Crisis**

Start treatment as soon as an MH crisis is suspected.
The clinical presentation of MH varies and treatment should be modified accordingly.

Treatment

Immediately

- Stop all trigger agents.
- Hyperventilate (use a minute volume 2–3 times normal) with 100% O_2 at high flow.
- Declare an emergency and call for help.
- Change to non-trigger anaesthesia (TIVA).
- Inform the surgeon and ask for termination/postponement of surgery.
- Disconnect the vaporizer—do not waste time changing the circuit/anaesthetic machine.

Dantrolene

- Give dantrolene 2 mg kg^{-1} i.v. (ampoules of 20 mg are mixed with 60 ml sterile water).
- Obtain dantrolene from other sources, for example, pharmacy/nearby hospitals—at least 36–50 ampoules may be needed for an adult patient.
- Dantrolene infusions should be repeated until the cardiac and respiratory systems stabilize.
- The maximum dose (10 mg kg^{-1}) may need to be exceeded.

Monitoring

- Continue routine anaesthetic monitoring (Sa_{O_2}, ECG, NIAP, E'_{CO_2}).
- Measure core temperature.
- Establish good i.v. lines with wide-bore cannulas.
- Consider inserting an arterial and central venous line, and a urinary catheter.
- Obtain samples for measurement of K^+, CK, arterial blood gases, myoglobin, and glucose.
- Check renal and hepatic function and coagulation.
- Check for signs of compartment syndrome.
- Monitor the patient for a minimum of 24 h (ICU, HDU, or in a recovery unit).

Symptomatic treatment

Treat hyperthermia

- 2000–3000 ml of chilled (4°C) 0.9% saline at i.v.
- Surface cooling: wet, cold sheets, fans, and ice packs placed in the axillae and groin.
- Other cooling devices if available.
- Stop cooling once temperature <38.5°C

Treat hyperkalaemia

- Dextrose: 50%, 50 ml with 50 IU insulin (adult dose).
- $CaCl_2$: 0.1 mmol kg^{-1} i.v. (e.g. 7 mmol=10 ml for a 70 kg adult).
- Dialysis may be required.

Treat acidosis

- Hyperventilate to normocapnoea.
- Give sodium bicarbonate i.v. if pH < 7.2.

Treat arrhythmias

- Amiodarone: 300 mg for an adult (3 mg kg^{-1} i.v.).
- β-blockers (e.g. propranolol/metoprolol/esmolol)—if tachycardia persists.

Maintain urinary output >2 ml kg^{-1} h^{-1}

- Furosemide 0.5–1 mg kg^{-1}.
- Mannitol 1 g kg^{-1}.
- Fluids: crystalloids (e.g. lactated Ringer's solution or 0.9% saline) i.v.

Consult your local Malignant Hyperthermia Investigation Unit about the case
Patients suspected of being MH-susceptible should undergo diagnostic testing using *in vitro contracture testing* (IVCT) at a designated MH-laboratory (www.emhg.org).

Action cards adapted for local conditions and resources can be extremely helpful in dealing with an MH crisis. Such a system, designed by the Australian and New Zealand MH group (MHANZ),[3] has proved to be a success in full-scale simulation and can save valuable time.

It is important that once a case of MH is suspected, either because of a full-blown MH crisis or a set of symptoms suggestive of MH which resolved on stopping any trigger agents, the patient and their relatives should always be referred to a regional or national MH centre for further investigation wherever possible. The EMHG has previously published guidelines for diagnosing MH susceptibility using the IVCT test and genetic testing when indicated.[4 5]

Conflict of interest

None declared.

References

1 Denborough M. Malignant hyperthermia. *Lancet* 1998; **352**: 1131–6

2 Rosero EB, Adesanya AO, Timaran CH, Joshi GP. Trends and outcome of malignant hyperthermia on the United States, 2000 to 2005. *Anesthesiology* 2009; **110**: 89–94

3 Available from www.malignanthyperthermia.com.au/mhanz_mh_resource_kit.htm

4 European MH Group. A protocol for the investigation of malignant hyperpyrexia (MH) susceptibility. *Br J Anaesth* 1984; **56**: 1267–9

5 Urwyler A, Deufel T, McCarthy T, West S, for the European Malignant Hyperthermia Group. Guidelines for molecular genetic detection of susceptibility to malignant hyperthermia. *Br J Anaesth* 2001; **86**: 283–7