

NGN NCLEX 2026 · PERIOPERATIVE · PHARMACOLOGY CRISIS

Malignant *Hyperthermia*

A rare but life-threatening, autosomal-dominant skeletal muscle disorder triggered by volatile anesthetics or succinylcholine — minutes matter. Recognizing the earliest cues (rising ETCO_2 , tachycardia, masseter rigidity) and acting on the MHAUS crisis protocol before hyperthermia appears is the difference between rescue and arrest.

● ANESTHESIA EMERGENCY

● AUTOSOMAL DOMINANT · RYR1

● ANTIDOTE: DANTROLENE

● MHAUS HOTLINE 1-800-644-9737



Definition & Overview

What it is · Why it matters

WHAT IT IS

A rare, inherited (autosomal-dominant) hypermetabolic crisis of skeletal muscle caused by a defect in the ryanodine receptor (RYR1) on the sarcoplasmic reticulum. Exposure to a trigger sets off uncontrolled calcium release inside muscle cells.

WHAT TRIGGERS IT

Volatile inhaled anesthetics (halothane, sevoflurane, isoflurane, desflurane, enflurane) and the depolarizing muscle relaxant **succinylcholine**. Onset is usually intra-op or within the first hour post-op (rarely later).

WHO IS AT RISK

Family history of MH, prior anesthesia complications, certain muscular dystrophies (Duchenne, Becker), central core disease, King-Denborough syndrome. Heat/exercise can rarely trigger in susceptible patients.

WHY IT MATTERS

Untreated mortality once approached 70%. With early dantrolene and MHAUS protocol, mortality is now under 5%. NCLEX expects you to recognize the earliest cue ($\uparrow\text{ETCO}_2$) and act *before* temperature rises.

Core concept

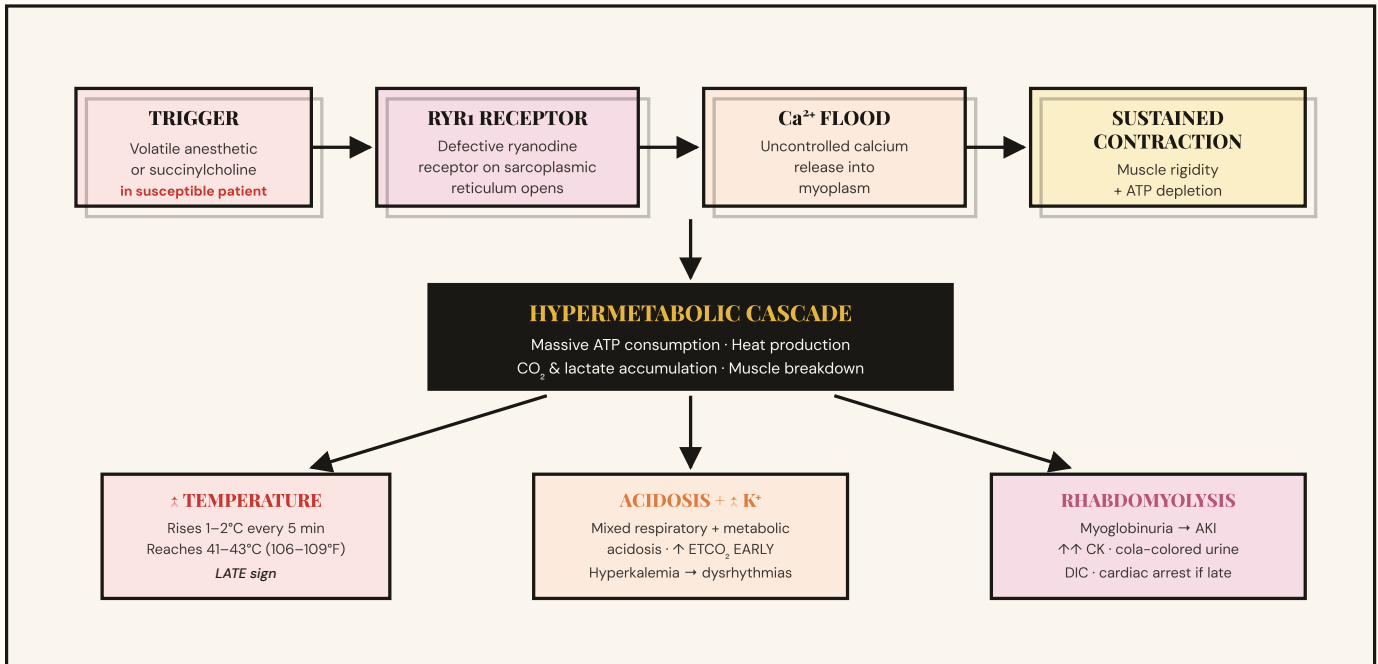


Hyperthermia is a LATE sign. The first cue is almost always **unexplained rising end-tidal CO_2** despite increased minute ventilation — followed by tachycardia and masseter rigidity.

2

Pathophysiology

A calcium runaway inside muscle



Key insight: Without dantrolene, calcium keeps pouring out of the sarcoplasmic reticulum. Dantrolene blocks the RYR1 receptor, halting calcium release and breaking the cycle. Cooling, bicarb, insulin/dextrose, and IV fluids treat the *downstream* effects — but dantrolene is the only drug that stops the underlying problem.



Signs & Symptoms

Early cues save lives · Late signs mean delay

EARLY (Recognize NOW)

FIRST 15 MIN

- ☒ **↑ End-tidal CO₂** — earliest, most sensitive sign; rises despite ↑ minute ventilation
- ☒ **Unexplained tachycardia** — often the first vital sign change noticed
- ☒ **Masseter (jaw) muscle rigidity** — especially after succinylcholine; classic clue
- ☐ **Tachypnea** & increased oxygen consumption
- ☐ **Mottled, flushed skin**; profuse diaphoresis begins
- ☐ Cardiac dysrhythmias (PVCs, V-tach)

LATE (Crisis · Poor outcome)

AFTER 15–30 MIN

- ☒ **Hyperthermia 41–43°C (106–109°F)** — temp can rise 1–2°C every 5 min
- ☒ **Generalized muscle rigidity** (whole body, board-like)
- ☒ **Cola-colored / dark urine** — myoglobinuria
- ☐ Hyperkalemia, hypercalcemia, then ↓ Ca²⁺
- ☐ Mixed metabolic + respiratory acidosis
- ☐ DIC, AKI, cardiac arrest, multi-organ failure

 **RED FLAG TRIAD** ↑ ETCO₂ + Tachycardia + Masseter rigidity in a patient receiving volatile anesthetic or succinylcholine = MH until proven otherwise. *Do not wait for the temperature to rise.*

4

Priority Nursing Interventions

MHAUS Crisis Protocol · ABCs · Stop. Drop. Cool.

PRIORITY

1

STOP triggering agents

Discontinue all volatile anesthetics and succinylcholine immediately. Switch to TIVA (propofol). Do NOT remove the breathing circuit — keep it.

PRIORITY

2

Call for help

Activate MH cart, anesthesia team, code team. Call MHAUS hotline **1-800-644-9737**. Abort surgery if possible.

PRIORITY

3

Administer DANTROLENE

2.5 mg/kg IV bolus; repeat q5–10 min up to 10 mg/kg until reversal. Reconstitute with **sterile water** (NOT NS or D5W).

4

Hyperventilate with 100% O₂

High flow ≥10 L/min at 2–3× normal minute ventilation to flush CO₂. Use new circuit/CO₂ absorber if available.

5

Active cooling

Cold IV NS (NOT LR — contains calcium), ice packs to axilla/groin/neck, cooling blanket, cold gastric/bladder lavage. **Stop at 38°C** to prevent rebound hypothermia.

6

Treat hyperkalemia

Insulin 10 units + D50 IV, calcium chloride/gluconate for cardiac protection, sodium bicarb for acidosis, albuterol nebulizer.

7

Protect the kidneys

Maintain urine output >2 mL/kg/hr. Mannitol or furosemide if needed. Foley to monitor color (cola = myoglobin) & output.

8

Continuous monitoring

Core temp, ETCO₂, ABGs, K⁺/Ca²⁺/CK/myoglobin, coag panel (DIC), continuous ECG, arterial line, central line.

9

Treat dysrhythmias

Standard ACLS — but **AVOID calcium channel blockers** with dantrolene (causes profound hyperkalemia & cardiac arrest).

10

ICU 24–72 hours

Recurrence happens in ~25% of cases within 24 hr. Continue dantrolene 1 mg/kg IV q4–6h × 24–48 hr. Monitor for DIC, AKI, compartment syndrome.

5

Pharmacology

The antidote, the triggers, and the safe alternatives

Drug / Class	Mechanism	Key Points	Nursing Considerations
Dantrolene (<i>Dantrium, Ryanodex, Revonto</i>)	Direct skeletal muscle relaxant; blocks Ca^{2+} release from sarcoplasmic reticulum (RYR1)	2.5 mg/kg IV bolus, repeat q5–10 min to 10 mg/kg total. Mix with sterile water . Ryanodex dissolves in 5 sec; older Dantrium takes 60+ sec per vial.	Stock on every MH cart. Hepatotoxicity, muscle weakness, phlebitis (give via large vein/central line). Continue 24–48 hr post-event.
Volatile Anesthetics (<i>TRIGGERS</i>)	Activate defective RYR1 → calcium release	Halothane, sevoflurane, isoflurane, desflurane, enflurane. All volatile inhaled agents are triggers.	STOP immediately at first cue. Use TIVA instead (propofol).
Succinylcholine (<i>TRIGGER</i>)	Depolarizing NMB — sustained depolarization triggers RYR1 in susceptible patients	Causes classic masseter rigidity after induction. Only depolarizing NMB still in use.	Avoid in known/suspected MH. Use rocuronium or vecuronium (non-depolarizing) instead.
Calcium Channel Blockers (<i>AVOID</i>)	Block calcium channels — interact dangerously with dantrolene	Verapamil, diltiazem with dantrolene → severe hyperkalemia & cardiac arrest.	Use other ACLS drugs for dysrhythmias (amiodarone, lidocaine). NEVER co-administer with dantrolene.
Sodium Bicarbonate	Buffers metabolic acidosis	1–2 mEq/kg IV titrated to ABG / base deficit	Monitor ABG q15–30 min, Na^+ , fluid balance.
Insulin (regular) + D50	Drives K^+ into cells	10 units regular insulin + 50 mL D50 IV for hyperkalemia	Monitor blood glucose q15 min × 1 hr, then q1h.
SAFE Alternatives (<i>non-trigger</i>)	—	Propofol, etomidate, ketamine, opioids, benzodiazepines, nitrous oxide, local/regional anesthesia, non-depolarizing NMBs (rocuronium, vecuronium, cisatracurium)	These are the agents used for MH-susceptible patients in future surgeries.

NCLEX cue: If the question asks what to mix dantrolene with — it's **sterile water**, not saline. If it asks what NOT to give with dantrolene — **calcium channel blockers**. If it asks what fluid to cool with — **cold 0.9% NS**, never LR (contains calcium).

6

NCLEX Test Traps

Wrong-vs-right · Where students lose points

 THE TRAP	 THE RIGHT ANSWER
Wait for fever before suspecting MH	Hyperthermia is a LATE sign . Act on $\uparrow$ ETCO_2 , tachycardia, masseter rigidity FIRST .
Cool the patient with ice packs BEFORE giving dantrolene	Dantrolene comes FIRST . Cooling alone won't stop the calcium release driving the crisis.
Mix dantrolene with 0.9% normal saline	Reconstitute with sterile water only . NS and D5W are incompatible.
Give verapamil for the tachycardia/dysrhythmia	NEVER give a calcium channel blocker with dantrolene — causes hyperkalemia & arrest. Use amiodarone/lidocaine.
Cool with Lactated Ringer's	Use cold 0.9% NS . LR contains calcium, which fuels the crisis.
Continue cooling until temp is normal (37°C)	Stop active cooling at 38°C (100.4°F) to avoid rebound hypothermia.
Stop dantrolene once the patient looks better	Continue dantrolene 1 mg/kg IV q4–6h $\times$ 24–48 hr — recurrence occurs in ~25% within 24 hr.
"Patient feels fine" — discharge home from PACU	Admit to ICU for 24–72 hours . Monitor for DIC, AKI, compartment syndrome, recurrence.
MH only happens during surgery	Can present intra-op OR up to 1 hour into PACU (rarely later). Stay vigilant in recovery.
Family members don't need testing	Autosomal dominant — first-degree relatives need genetic testing or CHCT before any future anesthesia.

7

Patient & Family Education

After the crisis · Lifetime considerations



It's Genetic

- ▶ Autosomal dominant — 50% chance children inherit it
- ▶ Inform ALL first-degree relatives (parents, siblings, children)
- ▶ Relatives need testing before any future anesthesia



Medical Alert

- ▶ Wear MedicAlert bracelet stating "MH susceptible"
- ▶ Carry wallet card with diagnosis & MHAUS hotline
- ▶ Inform every healthcare provider, including dentists



Diagnostic Testing

- ▶ **CHCT** (caffeine-halothane contracture test) — gold standard, requires muscle biopsy
- ▶ Genetic testing for RYR1 & CACNA1S mutations
- ▶ Only done at specialized MH centers



Future Anesthesia

- ▶ Use TIVA, regional, or local anesthesia
- ▶ Non-depolarizing NMBs only (rocuronium, vecuronium)
- ▶ Dantrolene must be available on-site
- ▶ Anesthesia machine "flushed" of volatile agents



Trigger Avoidance

- ▶ Avoid extreme heat & strenuous exercise in heat
- ▶ Treat fevers early and aggressively
- ▶ Stay well-hydrated during exertion
- ▶ Report any unexplained muscle pain or cola urine



MHAUS Resources

- ▶ Register with the North American MH Registry
- ▶ 24/7 Hotline: **1-800-644-9737**
- ▶ Free wallet cards & family information at mhaus.org
- ▶ Genetic counseling for family planning



Memory Boosters

Mnemonics · Pattern recognition

"MH HOT" — Recognition

M H H O T

- M** **Muscle** rigidity (masseter first, then generalized)
- H** **Hypercarbia** — $\uparrow$ ETCO_2 is the earliest cue
- H** **Hyperkalemia** & hyperthermia (late)
- O** **Oxygen** consumption skyrockets, tachycardia
- T** **Temperature** rises 1–2°C every 5 min (LATE)

"STOP · DROP · COOL" — Treatment

S D C

- S** **STOP** the triggering agent & call for help
- D** **DROP** the dantrolene — 2.5 mg/kg IV, mixed with sterile water
- C** **COOL** with cold NS, ice packs, lavage — stop at 38°C

"SAD" — The Triggers

S A D

- S** **Succinylcholine** (the only depolarizing NMB)
- A** **Anesthetics** — volatile inhaled (halo-, sevo-, iso-, des-, enflurane)
- D** **"-flurane" Drugs** — if it ends in "-flurane," it's a trigger

Pattern Recognition Pearls

- **Earliest cue:** $\uparrow$ ETCO_2 on capnography (NOT fever)
- **Classic clue:** Jaw clenches after succinylcholine
- **Only drug that works:** Dantrolene — block the RYR1
- **Never with dantrolene:** Calcium channel blockers
- **Never mix dantrolene in:** NS or D5W → sterile water only
- **Never cool with:** Lactated Ringer's (has Ca^{2+})
- **Stop cooling at:** 38°C (100.4°F)



NCJMM Clinical Judgment

Six-step Next-Gen NCLEX framework · Worked scenario

SCENARIO

"A 22-year-old male is 35 minutes into a knee arthroscopy under general anesthesia with sevoflurane and succinylcholine. The anesthesia provider notes the patient's $ETCO_2$ has risen from 38 mmHg to 58 mmHg over the past 10 minutes despite increasing minute ventilation. HR is 138 bpm (was 82), BP 154/96, temp 37.9°C (was 36.6°C), SpO_2 96%. The patient's jaw remains tightly clenched. The surgeon asks the circulating nurse, 'What's going on?'"

1

RECOGNIZE
CUES

What's relevant?

Pull out the abnormal findings that don't fit "stable patient under anesthesia":

- $\uparrow\uparrow ETCO_2$ (38 → 58 mmHg) DESPITE $\uparrow$ ventilation — earliest red flag
- Unexplained tachycardia (82 → 138)
- Masseter (jaw) rigidity after succinylcholine
- Hypertension, low-grade temp rise (37.9°C)
- Trigger exposure: sevoflurane + succinylcholine

2

ANALYZE
CUES

What do these mean together?

The combination of $\uparrow ETCO_2$ + tachycardia + masseter rigidity in a patient receiving a volatile anesthetic AND succinylcholine is the classic early triad of **malignant hyperthermia**. The temperature is only beginning to rise — this is exactly when intervention saves lives. Other considerations (sepsis, thyroid storm, light anesthesia) don't fit the trigger exposure and rigidity pattern.

3

PRIORITIZE
HYPOTHESES

Which is most urgent?

- **#1 (Highest priority): Malignant hyperthermia crisis** — life-threatening, time-sensitive, has a specific antidote
- #2: Inadequate ventilation / hypercarbia from other cause (much less likely given the full picture)
- #3: Light anesthesia (would explain HR/BP but not $ETCO_2$ rise or masseter rigidity)

Treat as MH until proven otherwise — the cost of delay is death; the cost of being wrong is minimal.

4

GENERATE
SOLUTIONS

What should be done?

- STOP sevoflurane and succinylcholine; switch to TIVA (propofol)
- Activate MH cart, call anesthesiologist & code team, call MHAUS hotline
- Reconstitute dantrolene with **sterile water**; give 2.5 mg/kg IV bolus, repeat up to 10 mg/kg
- Hyperventilate with 100% O_2 ≥ 10 L/min
- Start cold 0.9% NS, ice packs to groin/axilla/neck
- Insert Foley, arterial line, second large-bore IV; draw ABG, K^+ , CK, lactate, coags
- Prepare to abort/expedite surgery

First actions, in order:

5 TAKE ACTION

- **1st:** Tell anesthesia provider — "I'm concerned about MH; let's stop the volatile and sux now." Activate MH cart.
- **2nd:** Hyperventilate with 100% O₂ while dantrolene is reconstituted.
- **3rd:** Administer dantrolene 2.5 mg/kg IV bolus through a large-bore IV.
- **4th:** Initiate active cooling — cold NS, ice packs.
- **5th:** Insert Foley, draw labs, prep for ICU transfer.

6 EVALUATE OUTCOMES

Is it working?

Expected improvements (within 10–30 min of dantrolene):

- ETCO₂ trending down toward normal
- HR decreasing, BP stabilizing
- Muscle rigidity resolving
- Temperature stops rising; stop active cooling at 38°C
- Urine output ≥2 mL/kg/hr; urine clearing from cola color
- K⁺, lactate, ABG normalizing

If no improvement: repeat dantrolene up to 10 mg/kg total. Transfer to ICU; continue dantrolene 1 mg/kg IV q4–6h × 24–48 hr because **recurrence happens in ~25%**. Initiate genetic counseling & family education before discharge.