

Review

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Nursing interventions for patients with Malignant Hyperthermia in the perioperative setting: a scoping review

Intervenções de enfermagem para pacientes com Hipertermia Maligna no contexto perioperatório: revisão de escopo

Intervenciones de enfermería para pacientes con Hipertermia Maligna en el contexto perioperatorio: una revisión de alcance

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ABSTRACT

Objective: To map nursing interventions described in the literature for the prevention and control of Malignant Hyperthermia in the perioperative setting.

Method: A scoping review conducted according to the JBI methodology. The search was conducted in the following databases: Virtual Health Library, Medical Literature Analysis and Retrieval System Online, Embase, Cochrane, Cumulative Index to Nursing and Allied Health

Literature, and Web of Science. Additionally, an exploratory search and gray literature search were conducted.

Results: Fifteen documents were analyzed. Nursing interventions were identified and structured in three phases: (1) Prevention: risk assessment through anesthetic and family history and genograms; (2) Crisis control: diagnostic confirmation, activation of telephone support, clinical stabilization, preparation and administration of dantrolene; (3) Post-crisis: safe transport to the Intensive Care Unit and notification of the adverse event. Coordinated multidisciplinary team action was reported in all phases.

Conclusion: A comprehensive set of nursing interventions for the prevention, control, and post-crisis management of Malignant Hyperthermia in the perioperative period was mapped, providing evidence for the implementation of care protocols.

Descriptors: Perioperative care; Patient safety; Perioperative nursing.

RESUMO

Objetivo: Mapear intervenções de enfermagem descritas na literatura para prevenção e controle da Hipertermia Maligna no contexto perioperatório.

Método: Revisão de escopo conforme metodologia do JBI. A busca foi realizada nas bases: Biblioteca Virtual em Saúde, *Medical Literature Analysis and Retrieval System Online*, Embase, Cochrane, *Cumulative Index to Nursing and Allied Health Literature* e *Web of Science*. Adicionalmente, foi realizada busca exploratória e em literatura cinzenta.

Resultados: Foram analisados 15 documentos. Identificaram-se intervenções de enfermagem estruturadas em: (1) Prevenção: avaliação de risco por histórico anestésico-familiar e genogramas; (2) Controle da crise: confirmação diagnóstica, acionamento de suporte telefônico, estabilização clínica, preparo e administração de dantrolene; (3) Pós-crise: transporte seguro para Unidade de Tratamento Intensivo e notificação de evento adverso. A atuação multidisciplinar coordenada foi relatada em todas as fases.

Conclusão: Mapeou-se um conjunto abrangente de intervenções de enfermagem para prevenção, controle e manejo pós-crise da Hipertermia Maligna no período perioperatório, fornecendo evidências para implementação de protocolos assistenciais.

Descritores: Assistência perioperatória; Segurança do paciente; Enfermagem perioperatória.

RESUMEN

Objetivo: Mapear las intervenciones de enfermería descritas en la literatura para la prevención y el control de la Hipertermia Maligna en el contexto perioperatorio.

Método: Revisión del alcance de acuerdo con la metodología del JBI. La búsqueda se realizó en las siguientes bases de datos: Biblioteca Virtual en Salud, Sistema de Análisis y Recuperación de Literatura Médica en Línea, Embase, Cochrane, Índice Acumulativo de Literatura de Enfermería y Salud Aliada y Web of Science. Adicionalmente, se realizó una búsqueda exploratoria y una búsqueda de literatura gris.

Resultados: Se analizaron 15 documentos. Se identificaron intervenciones de enfermería estructuradas en tres fases: (1) Prevención: evaluación del riesgo a través del historial anestésico-familiar y análisis de genogramas; (2) Control de la crisis: confirmación diagnóstica, activación del apoyo telefónico, estabilización clínica, preparación y administración de dantroleno; (3) Post-crisis: transporte seguro a la Unidad de Cuidados Intensivos y notificación del evento adverso. Se reportó acción coordinada del equipo multidisciplinario en todas las fases.

Conclusión: Se identificó un conjunto integral de intervenciones de enfermería para la prevención, el control y el manejo post-crisis de la Hipertermia Maligna en el período perioperatorio, proporcionando evidencia para la implementación de protocolos asistenciales.

Descriptor: Atención perioperatoria; Seguridad del paciente; Enfermería perioperatoria.

INTRODUCTION

Malignant Hyperthermia (MH) is a potentially fatal, autosomal dominant hypermetabolic syndrome that manifests when an individual is exposed to halogenated inhalational anesthetics and/or the depolarizing neuromuscular blocking agent succinylcholine⁽¹⁾. Approximately 50% to 70% of MH cases result from mutations in the ryanodine receptor gene (RYR1), which is responsible for calcium release from the sarcoplasmic reticulum into the cytoplasm of muscle fibers; other reported mutations involve genes related to calcium metabolism, such as the dihydropyridine receptor gene (CACNA1S)^(2,3). It is a quiescent condition that, upon manifestation, leads to rapid clinical deterioration, explaining the high mortality rate. Therefore, MH is associated with substantial perioperative risk⁽³⁾.

The incidence of MH ranges from 1:10,000 to 1:250,000. The highest incidence is observed among young males (mean age of 18.3 years), with a male-to-female ratio of 2:1^(4,5). MH was first reported in Brazil in 1975 through a case report during anesthesia with halothane, however, there are no data regarding its actual incidence in Brazil⁽⁶⁾.

The pathophysiology of MH involves uncontrolled calcium release from the sarcoplasmic reticulum, as well as extracellular calcium influx into the myoplasm, both triggered by causative agents. This is followed by skeletal muscle contraction, glycogenolysis, and increased cellular metabolism, resulting in heat production and excessive lactate generation. Affected individuals develop acidosis, hypercapnia, tachycardia, hyperthermia, muscle rigidity, compartment syndrome, rhabdomyolysis with subsequent elevation of serum creatine kinase (CK) levels, hyperkalemia with the risk of cardiac arrhythmias or cardiac arrest, and myoglobinuria with the risk of renal failure. In most cases, the first manifestations of MH (tachycardia and tachypnea) occur during the intraoperative period. However, MH can also manifest in the immediate postoperative period^(6,7).

An MH event does not occur every time a susceptible individual is exposed to a triggering agent. Approximately half of the patients who develop MH had one or two previous exposures without any clinical complications^(4,6).

MH crises can be classified as: classic fulminant, which is potentially fatal and characterized by multiple metabolic and muscular manifestations; moderate, presenting metabolic and muscular manifestations without the severity of the fulminant form; mild - with subtle metabolic changes without muscular manifestations, except for masseter muscle spasm;

masseter muscle rigidity associated with metabolic changes; isolated masseter muscle rigidity; and atypical, - characterized by unexplained cardiopulmonary arrest during anesthesia or sudden death^(6,8).

The diagnosis of susceptibility to MH is established through in vitro testing by assessing the contracture responses of biopsied muscle samples to halothane and graded concentrations of caffeine^(6,7). An alternative diagnostic approach is the identification of a pathogenic variant in the CACNA1S, RYR1, or STAC3 genes through genetic testing⁽⁷⁾. Most diagnosed individuals have one parent with MH. Even in the absence of a previous MH episode, because of the autosomal dominant inheritance pattern, each child of an individual with MH has a 50% probability of inheriting the pathogenic variant responsible for the condition⁽⁷⁾.

MH prevention primarily includes obtaining a risk history during the preoperative assessment, if susceptibility is confirmed, the healthcare team should be informed to review the anesthetic plan and ensure the availability of appropriate materials, equipment, and human resources⁽⁹⁾. During an MH crisis, treatment success is directly linked to how quickly the team implements effective measures. The use of triggering agents requires the exclusion of personal or family histories associated with this trait and monitoring the patient in the operating room⁽⁹⁾. These measures are consistent with the responsibilities of nurses during the perioperative period, including collecting clinical history and conducting nursing consultations, identifying risk factors, monitoring patients, managing materials, supplies, and equipment, coordinating personnel, assisting during anesthetic induction, developing and implementing care protocols, and performing nursing interventions based on critical thinking and clinical judgment guided by the Perioperative Nursing Process (PNP) ⁽¹⁰⁻¹²⁾.

The PNP must be applied by the nurse throughout the perioperative period until patient discharge⁽¹²⁾. In the context of MH, it is essential to ensure comprehensive, continuous, and individualized care that prioritizes procedural safety, maintains control over potential situations, and prevents adverse events and complications. An MH crisis is a rapidly escalating event requiring a multidisciplinary team capable of prompt recognition and decision-making⁽¹³⁾, as well as to provide immediate diagnosis and treatment to reverse the condition and minimize the risk of complications and death.

Considering the importance of the nurse's role in the perioperative setting, a preliminary search for scoping and systematic reviews on this topic was conducted in March 2024 in the following electronic databases: Virtual Health Library, Medical Literature Analysis and Retrieval System Online, Embase, Cochrane, Cumulative Index to Nursing and

Allied Health Literature, and Web of Science. Given the lack of current reviews and available evidence, the present study aimed to conduct a scoping review to map the nursing interventions described in the literature for the prevention and control of MH in patients in the perioperative setting.

METHOD

This is a scoping review conducted in compliance with the JBI methodological guidance for scoping reviews and reported following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR)⁽¹⁴⁾. The study protocol was prospectively registered on the Open Science Framework (OSF) under the identifier <https://doi.org/10.17605/OSF.IO/4RE6K>.

The study was guided by the following research question: “What are the nursing interventions for the prevention and control of Malignant Hyperthermia in patients within the perioperative setting?”

Eligibility criteria were defined based on the PCC mnemonic (Population, Concept, and Context). Studies involving adult patients (Population) who received nursing interventions for the prevention and control of MH (Concept) in the perioperative setting (Context) were included. Studies published between 2015 and 2026 were selected to ensure that the mapped interventions reflected current clinical practice, acknowledging that interventions documented more than a decade ago may not represent contemporary technological and protocol advancements in perioperative care. The search was conducted in Portuguese and English. Portuguese was included to capture evidence contextualized to the Brazilian healthcare system through regional databases and institutional gray literature, whereas English was included to encompass the international scientific literature, which is predominantly published in this language. Documents not available in full text were excluded.

The search strategy was structured in three stages, as recommended by JBI, with the support of a professional librarian. Initially, an exploratory search was conducted to identify keywords and controlled descriptors in the Health Sciences Descriptors (DeCS), Medical Subject Headings (MeSH), and Emtree (Chart 1).

Chart 1 - Selection of descriptors according to the PCC strategy (Population, Concept, and Context). Brasília, Distrito Federal, Brazil, 2025

PCC	Keywords	DeCS/ MeSH/Emtree
Population	“Malignant	("Hipertermia Maligna" OR (Malignant Hyperthermia)

	Hyperthermia” “Anesthesia Related Hyperthermia” “Malignant Hyperpyrexias” “Hyperthermia of Anesthesia” “Anesthesia Hyperthermia” “Malignant Hyperpyrexia” Adult	OR "Anesthesia Related Hyperthermia" OR "Malignant Hyperpyrexias" OR "Hyperthermia of Anesthesia" OR "Anesthesia Hyperthermia" OR "Malignant Hyperpyrexia") (Adult OR adulto)
Concept	Nursing interventions Nursing	(Nursing care) OR nursing OR nurse
Context	Surgical centers Operating rooms	Surgicenters Operating Rooms

Source: Prepared by the authors, 2025.

In the second stage, specific search equations were developed and validated by the librarian for each database (Chart 2). The systematic search was initially conducted on March 18, 2025, and updated on March 19, 2026, in the following electronic databases: Virtual Health Library (VHL/BVS), Medical Literature Analysis and Retrieval System Online (MEDLINE via PubMed), Embase, Cochrane, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Web of Science.

Chart 2 - Databases and respective search strategies. Brasília, Distrito Federal, Brazil, 2025

Databases	Search strategy	Number of articles retrieved
BVS (LILACS)	("Hipertermia Maligna" OR (Malignant Hyperthermia) OR "Anesthesia Related Hyperthermia" OR "Malignant Hyperpyrexias" OR "Hyperthermia of Anesthesia" OR "Anesthesia Hyperthermia" OR "Malignant Hyperpyrexia") AND ((Nursing care) OR nursing OR nurse OR "Intervenções de enfermagem" OR Enfermagem) AND (adult)	7
PubMed	("Hipertermia Maligna" OR (Malignant Hyperthermia) OR	12

	"Anesthesia Related Hyperthermia" OR "Malignant Hyperpyrexias" OR "Hyperthermia of Anesthesia" OR "Anesthesia Hyperthermia" OR "Malignant Hyperpyrexia") AND ((Nursing care) OR nursing OR nurse OR "Intervenções de enfermagem" OR Enfermagem) AND (adult)	
EMBASE	("Hipertermia Maligna" OR (Malignant Hyperthermia) OR "Anesthesia Related Hyperthermia" OR "Malignant Hyperpyrexias" OR "Hyperthermia of Anesthesia" OR "Anesthesia Hyperthermia" OR "Malignant Hyperpyrexia") AND ((Nursing care) OR nursing OR nurse OR "Intervenções de enfermagem" OR Enfermagem) AND (adult)	280
Cochrane	("Hipertermia Maligna" OR (Malignant Hyperthermia) OR "Anesthesia Related Hyperthermia" OR "Malignant Hyperpyrexias" OR "Hyperthermia of Anesthesia" OR "Anesthesia Hyperthermia" OR "Malignant Hyperpyrexia") AND ((Nursing care) OR nursing OR nurse OR "Intervenções de enfermagem" OR Enfermagem) AND (adult)	0
CINAHL	("Hipertermia Maligna" OR (Malignant Hyperthermia) OR "Anesthesia Related Hyperthermia" OR "Malignant Hyperpyrexias" OR "Hyperthermia of Anesthesia" OR "Anesthesia Hyperthermia" OR "Malignant Hyperpyrexia") AND ((Nursing care) OR nursing OR nurse OR "Intervenções de enfermagem" OR Enfermagem) AND (adult)	577
WEB of Science	("Hipertermia Maligna" OR (Malignant Hyperthermia) OR "Anesthesia Related Hyperthermia" OR "Malignant Hyperpyrexias" OR "Hyperthermia of Anesthesia" OR "Anesthesia Hyperthermia" OR "Malignant Hyperpyrexia") AND ((Nursing care) OR nursing OR nurse OR "Intervenções de enfermagem" OR Enfermagem) AND (adult)	1

Source: Prepared by the authors, 2025.

Gray literature was retrieved through: (1) Google Scholar, using the search terms “Malignant Hyperthermia and Nursing,” with screening of the first ten pages of results; (2) the Brazilian Open Access Portal for Scientific Publications and Data of the Brazilian Institute of Information in Science and Technology (*Instituto Brasileiro de Informação em Ciência e Tecnologia*); (3) the Brazilian Digital Library of Theses and Dissertations; and (4)

websites of Scientific Associations (*Sociedade Brasileira de Enfermeiros de Centro Cirúrgico e Recuperação Anestésica*, *Sociedade Brasileira de Anestesiologia*, and the Malignant Hyperthermia Association of the United States), Government Agencies/Regulatory Bodies (Ministry of Health, Brazilian Health Regulatory Agency, and Federal Nursing Council), and Healthcare Institutions (Center for the Study, Diagnosis, and Investigation of Malignant Hyperthermia at the *Universidade Federal de São Paulo*). Gray literature records were included in the PRISMA-ScR flow diagram in a separate column, as recommended by the PRISMA 2020 V2 guidelines⁽¹⁵⁾ for reviews that include gray literature searches. The same eligibility criteria applied to database records were also applied to gray literature records, and the numbers of identified, screened, eligible, and included records were reported in the flow diagram.

The third stage consisted of analyzing the reference lists of the selected documents to identify additional studies.

For data management and study selection, the retrieved references were exported to EndNote Web® software, where duplicate records were removed. The selection process was managed using the Rayyan® platform. Initial screening, based on titles and abstracts, was conducted independently and blinded by three reviewers (A.F.G.C., R.T.C., and T.L.F.D.). The preselected documents were subsequently assessed in full text by the same three reviewers, independently, to confirm eligibility. Disagreements at any stage of the selection process were resolved through discussion and consensus or, when necessary, by consultation with a fourth reviewer (M.I.F.).

Data extraction was performed by the same three independent reviewers using a standardized instrument specifically developed for this study and aligned with the review objectives. The instrument included the following variables: authorship, country where the study was conducted, year of publication, article title, methodological design, and main findings regarding nursing interventions. The fourth reviewer (M.I.F.) was responsible for auditing and verifying the accuracy of the data extracted from the final sample.

The results were synthesized descriptively. Extracted data were organized into a summary matrix (Chart 3), enabling the systematic mapping and analysis of the identified evidence regarding nursing interventions for the prevention and management of MH in the perioperative setting. Additionally, the findings were organized into thematic categories, which were synthesized and presented as a visual representation (Figure 2), reflecting the

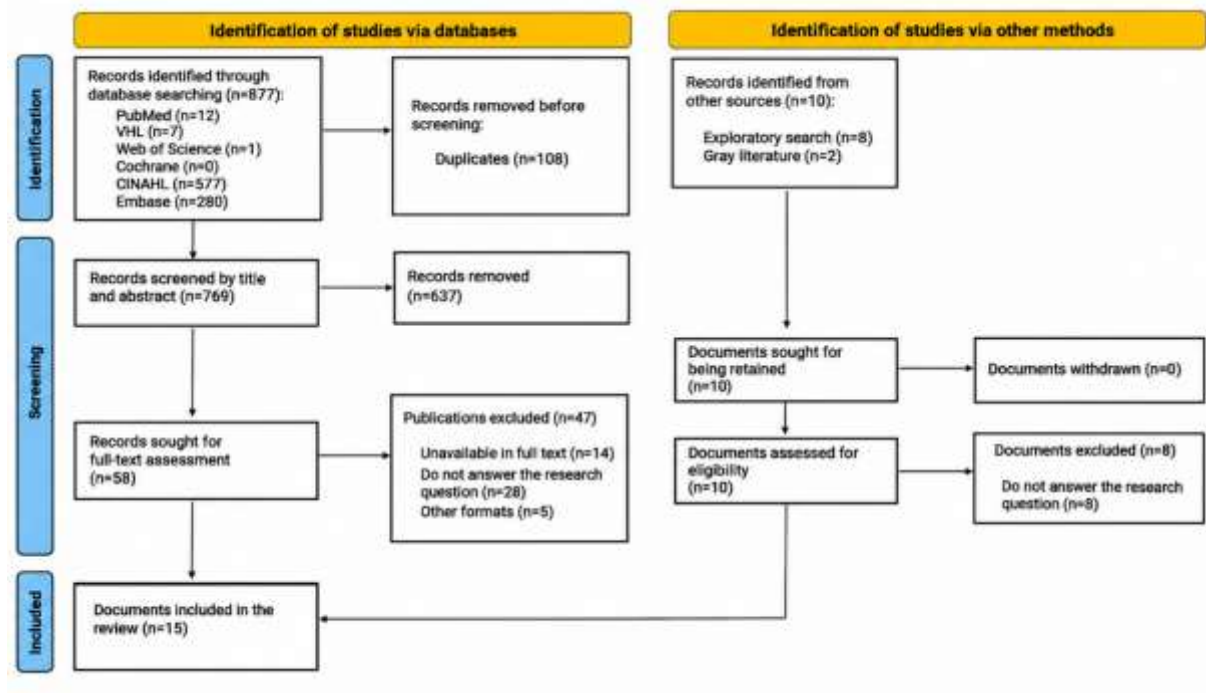
authors' interpretive synthesis of the mapped evidence and facilitating the understanding of nursing interventions in the perioperative setting.

During the preparation of this study, the authors used Artificial Intelligence (Manus) as a support tool for literature searches, identification of research gaps, improvement of language and readability, and the development of Figure 2 (NotebookLM), which summarizes the main findings of the review. Following the use of these tools, the authors critically reviewed and edited the content as necessary and assume full responsibility for the content of the published article.

RESULTS

A total of 877 records were identified (VHL: 7; PubMed: 12; Embase: 280; Cochrane: 0; CINAHL: 577; and Web of Science: 1), of which 108 duplicates were removed. Subsequently, after screening titles and abstracts and applying the eligibility criteria, 637 records were excluded. Fifty-eight articles were then selected for full-text assessment, of which 28 were excluded because they did not answer the research question, 14 were unavailable in full text, and five had ineligible publication formats. Ultimately, 11 studies were included in the sample. Through screening the reference lists of the selected studies, two additional studies were identified and included, resulting in a sample of 13 studies. The gray literature search identified one website and one mobile application. Thus, the final sample comprised 15 documents. Figure 1 presents the document selection flowchart, including the search, eligibility, and selection criteria⁽¹⁵⁾.

Figure 1 - Flowchart adapted from PRISMA-ScR⁽¹⁵⁾



Source: Prepared by the authors, 2025.

Regarding the year of publication, three articles were published in 2017 (23.1%), one in 2019 (7.7%), four in 2020 (30.8%), one in 2021 (7.7%), two in 2022 (15.4%), and two in 2024 (15.4%). Regarding the country in which the studies were conducted, the United States accounted for the largest number of publications, with five studies (38.5%), followed by China with three publications (23.1%), Portugal with one publication (7.7%), and Brazil with four publications (30.8%). The website is Brazilian, and despite the mobile application is available in English, it provides support information for Brazil. Chart 3 presents the main findings of the 13 selected articles.

Chart 3 - Characteristics of studies and nursing interventions for the prevention and control of Malignant Hyperthermia in the perioperative setting. Brasília, Distrito Federal, Brazil, 2025

Identification number, Author, country, year	Study design	Article title	Objective	Nursing interventions
1 Dagestad <i>et al.</i> , USA, 2017 ⁽¹⁶⁾	Case report	Keeping Cool When Things Heat Up During a Malignant Hyperthermia Crisis	To describe the experience of a maternity healthcare team in caring for a woman with MH in the postoperative period.	Activate the nursing team member responsible for the MH cart; request additional support; initiate body cooling; administer intravenous dantrolene; perform central temperature monitoring; monitor vital signs; make transfer to the ICU.
2 Titato <i>et al.</i> , Brazil, 2017 ⁽¹⁷⁾	Descriptive-exploratory, comparative/correlational field study with quantitative data analysis	<i>Hipertermia Maligna no centro cirúrgico: a equipe de enfermagem sabe reconhecer e intervir?</i>	To identify the operating room nursing team's knowledge regarding the diagnosis and treatment of MH.	Establish an MH management protocol; activate the MH telephone hotline for team support during an MH crisis.
3 Mullins <i>et al.</i> , USA, 2017 ⁽¹⁸⁾	Review and case report	Malignant Hyperthermia: A Review	To discuss the pathophysiology, triggering agents, antidote, and perioperative management of an MH crisis.	Call additional staff; organize the MH cart; contact the MH Association via the hotline; discontinue anesthesia and change the breathing circuit; initiate hyperventilation; switch to intravenous anesthesia; request surgical cessation; order laboratory tests; administer dantrolene; treat hyperkalemia and metabolic acidosis; monitor central temperature; implement cooling measures; arrange transfer to the ICU.
4 Parsons <i>et al.</i> , USA, 2019 ⁽¹⁹⁾	Pre-test, post-test, and repeated measures design	High-Fidelity Simulation Training for Nurse Anesthetists Managing Malignant Hyperthermia: A Quality Improvement Project	To assess nurse anesthetists' knowledge regarding the management of an MH crisis.	Use an MH action/treatment checklist.
5 Sene <i>et al.</i> , Brazil, 2020 ⁽¹⁾	Quasi-experimental before-and-after study	<i>Estratégia educativa com profissionais de enfermagem sobre</i>	To evaluate nursing knowledge regarding MH and the implementation of an MH	Develop an MH treatment kit for the operating room.

		<i>hipertermia maligna em um centro cirúrgico cardiovascular</i>	treatment kit.	
6 An <i>et al.</i> , China, 2020 (20)	Case report	Nursing Interventions of Intraoperative Malignant Hyperthermia in Patients with Scoliosis: A Report of 3 Cases	To provide information on intraoperative nursing intervention protocols for MH in patients with scoliosis.	Immediately discontinue the triggering anesthetic agent; replace the breathing circuit and initiate hyperventilation; perform body cooling; provide treatment for hyperkalemia; obtain laboratory tests; transfer the patient to the ICU; apply the MH Clinical Grading Scale.
7 Moreira <i>et al.</i> , Portugal, 2021 ⁽⁵⁾	Clinical protocol	<i>Hipertermia Maligna: Protocolo de Atuação do centro Hospitalar de Lisboa Ocidental</i>	To develop an action protocol and a dedicated MH cart.	Use an MH treatment checklist/protocol; request the MH cart; replace the ventilation equipment; monitor temperature; prepare medications; establish venous access; perform urinary and gastric catheterization; collect urine for analysis; complete all interventions.
8 Kleidon, USA, 2020 (21)	Case study	Malignant hyperthermia in a regional facility: A case study.	To present the safe and effective management of an MH crisis for perioperative nurses.	The team followed the guidelines of the Malignant Hyperthermia Group of Australia and New Zealand (MHANZ): discontinuation of the triggering agent; flushing of the breathing circuit and hyperventilation; administration of dantrolene; body cooling; insertion of a urinary catheter; transfer to the ICU.
9 Alves Oliveira <i>et al.</i> , Brazil, 2022 ⁽⁸⁾	Integrative review	<i>Enfermagem no contexto da Hipertermia Maligna: revisão integrativa</i>	To describe, based on the literature, the profile of publications regarding nursing in MH.	Follow the competencies of perioperative nurses; obtain the patient's and family's medical history; analyze genograms; educate the family about MH and test results; notify the anesthesia team regarding MH susceptibility; complete the mandatory adverse event notification form.
10 Bin <i>et al.</i> , China, 2022 (22)	Review	Malignant Hyperthermia: A Killer If Ignored	To define MH, discuss its pathogenic mechanisms, review predisposing factors and clinical manifestations, and describe MH crisis management.	Provide sedation and oxygen therapy to control seizures; perform cooling using ice packs and intravenous cold fluids; correct fluid and electrolyte imbalances; closely monitor vital signs; monitor acid-base status, blood gases, and serum electrolytes for 24 hours; transfer to the ICU.
11 Gallegos and Hennen, USA, 2022 (23)	Review and case report	Malignant Hyperthermia Preparedness Training: Using Cognitive Aids and Emergency Checklists in the	To prepare the perioperative team of a military ambulatory surgery center to effectively manage an MH crisis using the Stanford Emergency Manual cognitive aid.	Develop checklists; recognize the MH crisis; administer dantrolene; initiate cooling measures; perform urinary catheterization; treat hyperkalemia and acidosis; communicate with MHAUS; transfer the patient to the ICU.

		Perioperative Setting		
12 Tian <i>et al.</i> , China, 2024 (3)	Case report	Treatment and nursing care of a patient diagnosed with malignant hyperthermia after general anesthesia: a case report	To present interventions and nursing care for the management of a patient with MH.	Proceed with: discontinuation of inhalational anesthesia; body cooling measures; intravenous administration of dantrolene; arterial blood gas analysis; vital sign monitoring; pupillary reactivity testing; performance of laboratory tests (creatinine kinase, myoglobin, cardiac injury markers, cardiac enzyme profile, and complete blood count); application of the MH Clinical Grading Scale.
13 Neto <i>et al.</i> , Brazil, 2024 (24)	Case report	Suspected malignant hyperthermia reaction during renal transplantation: a case report	To report a case of MH during kidney transplantation and review published reports of suspected MH crises during solid organ transplantation.	Provide: discontinuation of the triggering agent; blood gas analysis; administration of dantrolene; fluid resuscitation; administration of sodium bicarbonate and insulin/glucose solution; transfer to the ICU.

Source: Prepared by the authors, 2025.

Figure 2 presents the main findings of this review, highlighting the main nursing interventions for patients with MH in the perioperative setting.

Figure 2 - Highlights of nursing interventions for patients with Malignant Hyperthermia in the perioperative setting.



Source: Prepared by the authors based on the findings of the scoping review (2015-2026). AI-generated. NotebookLM platform. March 30, 2026.

Important nursing interventions related to MH prevention were identified. Study 9⁽⁸⁾ highlights: obtaining personal and family history, analyzing genograms, educating the family about MH and test results, and communicating MH predisposition to the anesthesia team. Meanwhile, study 11⁽²³⁾ presents preoperative recommendations and measures for patients with a history of MH, organized into the following categories: equipment, planning, premedication, anesthetic technique, and postoperative care.

When an MH crisis is suspected, Studies 6 and 12^(3,20) address the use of the Malignant Hyperthermia Association of the United States (MHAUS) clinical grading scale by healthcare professionals, without specifying a particular professional category. The scale evaluates six items: muscle rigidity, muscle breakdown due to elevated creatine kinase levels, respiratory acidosis, increased body temperature, cardiac impairment, and family history. Developed in the United States, it has become a standardized tool for assessing MH susceptibility, contributing to early diagnosis and improved treatment success rates. Study 6 describes the scale and its scoring ranges: 0 - almost never; 3-9 unlikely; 10-19 somewhat less than likely; 20-34 somewhat greater than likely; 35-49 very likely; and >50 almost certain. The scale was

applied to the three MH cases in the study, in all instances, the score indicated an “almost certain” diagnosis (score >50), highlighting the importance of its use.

Once an MH crisis is confirmed, studies 2, 4, 7, and 11^(5,17,19, 23) recommend the use of a protocol or checklist. Study 2⁽¹⁷⁾ describes the institutional MH protocol used at the study site, highlighting the following recommendations: monitoring by electrocardiography, blood pressure, pulse oximetry, capnography, and core temperature; consideration of invasive monitoring, including mean arterial pressure and central venous pressure; monitoring of respiratory rate and tidal volume; use of a warming mattress on the operating table; availability of an MH treatment kit containing dantrolene; and monitoring of vital signs every 15 minutes for 1–2 hours. In Study 4⁽¹⁹⁾, the checklist was developed according to the guidelines of the MHAUS and the American Association of Nurse Anesthesiology and consisted of 20 items encompassing the recognition, diagnosis, treatment, and recovery phases of an MH crisis.

Study 7⁽⁵⁾ describes the use of visual aids consisting of individualized flashcards for each member of the healthcare team, based on the institutional protocol, allowing professionals to rapidly focus on and coordinate their assigned responsibilities. During an MH crisis, clearly predefined roles for each team member are essential to minimize duplication of interventions and inadequate preparedness, thereby ensuring effective and successful treatment.

Studies 7 and 10^(5,22) describe the roles of nurses and other operating room professionals, presenting the protocol as a multidisciplinary intervention that includes discontinuation of anesthesia, management of complications, and patient stabilization. Study 10⁽²²⁾ describes a management approach based on five clinical decisions that physicians, together with other healthcare professionals - although these professionals are not specifically identified - should make when managing an MH crisis. These decisions include seizure control, sedation and adequate oxygen administration; cooling; correction of fluid and electrolyte imbalances; caution with the administration of calcium and narcotics; and continuous monitoring. Study 11⁽²³⁾ addresses the critical steps following the immediate recognition of an MH crisis: calling for help, discontinuing the triggering agent, hyperventilation, administering dantrolene, cooling, treating complications, calling the hotline, and transferring the patient to the Intensive Care Unit (ICU).

Studies 1, 3, 5, and 7^(16,18,1,5) highlight the use of a kit and a cart for MH treatment. Study 1⁽¹⁶⁾ recommends maintaining an emergency cart organized into six drawers containing supplies for pharmacological treatment, venous access, urinary catheterization, body cooling,

and replacement of ventilation equipment. Study 3⁽¹⁸⁾ describes the importance of using the emergency cart during an MH crisis, noting that it includes the MHAUS emergency poster and the MH hotline number for telephone consultation, although its contents are not described. Study 5⁽¹⁾ presents the development and implementation of an MH treatment kit available in the operating room pharmacy and describes the required components and quantities. Study 7⁽⁵⁾ describes the organization of the emergency cart according to the responsibilities of each healthcare professional, with dedicated drawers for the nurse anesthetist, anesthesiologist, circulating nurse, scrub nurse, and operating room assistant. The cart also contains a folder with the institutional management protocol, as well as separate compartments for a pediatric kit and a supply of dantrolene. Study 7⁽⁵⁾ recommends that dantrolene dosages be pre-calculated and preparation instructions clearly outlined to ensure readiness for administration within recommended timeframes.

The body cooling measures addressed in the sample comprised cooling via chilled solutions - intravenous fluid infusion^(3,5,8,17,22), gastric, bladder, or rectal lavage^(5,17); cold compresses applied to the body surface and/or ice packs applied bilaterally to the groin and axillae^(8,18,20); and the use of cooling blanket^(8,20) and ambient air conditioning^(8,20). Continuous monitoring of body temperature is recommended to prevent excessive cooling⁽¹⁷⁾.

Study 2⁽¹⁷⁾ addresses the Brazilian MH telephone consultation service, known as the Hotline (+55-11-5575-9873), which operates 24 hours a day and is located at Hospital São Paulo, Paulista School of Medicine, *Universidade Federal de São Paulo* (UNIFESP). The service is staffed by two supervising researchers who are MH specialists, along with eight physicians. The literature does not specify which healthcare professional should be responsible for contacting the service. However, one of the analyzed studies reports that the circulating nurse used the hotline as a communication strategy during the critical event⁽¹⁸⁾. Studies 3 and 11^(18,23) describe the use of the 24-hour MHAUS hotline available in the United States. As an additional resource to support the diagnosis and management of MH, the MHApp – Malignant Hyperthermia mobile application is available through the App Store for iOS devices and in English only. The application has a questionnaire regarding the anesthetic agent used and the patient's clinical manifestations and, based on the responses, provides guidance for MH management. The application also provides hotline telephone numbers for several countries, including Brazil⁽²⁵⁾. There is no description of a specific professional designated as being responsible for using the hotline or the mobile application. Information regarding both the hotline and the application is available on the website of the Center for the Study, Diagnosis, and Investigation of Malignant Hyperthermia (*Centro de Estudo,*

Diagnóstico e Investigação de Hipertermia Maligna - CEDHIMA) at the *Universidade Federal de São Paulo*⁽²⁵⁾.

Following the successful control of the MH crisis, study 9⁽⁸⁾ emphasizes the importance of mandatory reporting by the nurse.

DISCUSSION

The present study aimed to conduct a scoping review to map the nursing interventions described in the literature for the prevention and control of MH in patients in the perioperative setting. The findings demonstrated that nursing interventions encompass nursing care standards, interprofessional care standards, and healthcare program standards, with a predominance of interventions established through clinical care protocols⁽²⁶⁾. It is important to consider that there are significant interventions preceding the intraoperative period, such as obtaining personal and family histories, analyzing genograms, providing education on MH, and communicating risk to the team⁽⁸⁾. Interventions related to the recognition and management of an MH crisis include application of the MH Scale and protocol^(3,5,17,19,20); provision of an MH emergency cart or treatment kit, when available in the unit^(1,5,16,18); activation of the MH hotline, when available^(15,16,21); requesting additional staff⁽¹⁶⁾; assisting with replacement of the breathing circuit and management of complications^(18,20,23); performing arterial blood gas analysis, urinary catheterization, and laboratory testing^(3,5,18,20,21,23); monitoring vital signs^(3,5,14,16,20); and implementing body cooling measures^(3,16,18,20-23). Following crisis control, studies describe transferring the patient to the ICU^(16,18,20-24) and completing the mandatory notification form⁽⁸⁾.

The literature review revealed that nurses perform a wide range of roles during a MH crisis, varying according to the country of practice and applicable legislation. Nurse Anesthesia, the first clinical nursing specialty, originated in the United States in 1870 and is currently practiced in more than one hundred countries worldwide, although it has not yet been formally recognized in Brazil. In the Brazilian context, despite the absence of formal recognition of this specialty, the Federal Nursing Council (*Conselho Federal de Enfermagem* - COFEN), through Opinion No. 26/2025, acknowledges that the perioperative nurse plays an essential and leading role in monitoring the patient's clinical stability, early identification of anesthetic complications, and provision of immediate intensive care⁽²⁷⁾. This institutional recognition legitimizes the role of Brazilian nurses in the management of MH crises, granting them the technical and legal authority to perform functions that, in other countries, are exclusively assigned to nurse anesthetists. In this regard, the variability in nursing roles

identified in this review reflects not only legislative differences among countries but also the nursing profession's ability to adapt to local clinical demands while respecting the regulatory frameworks and professional competencies established within each healthcare system. Therefore, based on current COFEN regulations and the Brazilian Professional Practice Law (Law No. 7,498/1986)⁽²⁶⁻²⁸⁾, Brazilian perioperative nurses possess the legal and technical competence to actively participate in the prevention, recognition, and management of MH crises, even in the absence of a formally recognized Nurse Anesthesia specialty. This professional is responsible for anesthesia-related care during the preoperative, intraoperative, and postoperative periods, including post-anesthesia recovery and patient transfer to hospital units⁽²⁹⁾. It was identified that many of the MH prevention and control interventions performed by nurse anesthetists in international settings can also be performed by perioperative nurses in Brazil. For example, in Portugal, the nurse anesthetist is responsible for the MH treatment kit/emergency cart and the preparation of dantrolene⁽⁵⁾, responsibilities that may likewise be assigned to nurses in Brazil^(1,17,24). Furthermore, it was observed that the nurse's role in this context is primarily guided by institutional protocols and coordinated action with the multidisciplinary team, following the same dynamics already well-established for operating room practice⁽³⁰⁾. This characteristic is explained by the critical nature of MH, a condition that requires a rapid and coordinated team response for effective management. Therefore, the implementation of well-established institutional protocols and collaborative teamwork are essential measures to ensure patient safety in the perioperative setting. Indeed, MH is recognized as one of the best models for team-based perioperative crisis management, as a rapid and coordinated team response can significantly improve patient survival rates⁽¹³⁾.

Moving forward with the analysis of the Brazilian context, the nursing team in the operating room comprises registered nurses, who may perform direct patient care or service coordination roles, nursing technicians, surgical technologists, and perfusion nurses⁽³⁰⁾. These professionals play a fundamental role throughout the perioperative period, ensuring the reduction of risks and complications associated with anesthesia, surgery, and hospitalization⁽³¹⁾. Perioperative nursing care is based on the Nursing Process (NP), a scientific method that guides critical thinking and clinical judgment, as established by COFEN Resolution No. 736/2024⁽²⁶⁾. It is validated and recommended by the Brazilian Society of Operating Room, Post-Anesthesia Care, and Sterile Processing Nurses (*Associação Brasileira de Enfermeiros de Centro Cirúrgico, Recuperação Anestésica e Centro de Material e Esterilização* - SOBECC), which recognizes it as essential for the quality and safety of perioperative care⁽³⁰⁾. In the perioperative setting, the NP is operationalized through

the PNP, a structured framework that integrates the preoperative, intraoperative, and postoperative phases in a continuous, participatory, and individualized manner⁽¹²⁾. The PNP comprises five interconnected stages: nursing assessment, nursing diagnosis, nursing planning, nursing implementation, and nursing evaluation, enabling the comprehensive organization of patient needs as well as human and material resources^(12,26). Thus, the PNP supports nursing practice by promoting appropriate, planned, and evidence-based interventions tailored to each patient's individual needs, while facilitating the recognition, interpretation, and anticipation of human responses to health alterations through systematic evaluation of outcomes⁽¹²⁾. This model is aligned with international nursing standards, particularly the guidelines of the American Nurses Association and the Association of periOperative Registered Nurses, both of which recognize the Nursing Process as the essential foundation of perioperative practice, as well as with the International Classification for Nursing Practice, which standardizes nursing terminology worldwide⁽³²⁻³⁴⁾.

Nursing interventions during an MH crisis in the perioperative period begin during the preoperative assessment, through a nursing consultation or visit, with the purpose of collecting the patient's medical history, providing perioperative education, reviewing and interpreting laboratory results, and preparing the patient for the proposed surgical procedure⁽³⁵⁾. The primary objective is to reduce intraoperative and postoperative complications⁽³⁵⁾. During nursing assessment, family history should be obtained and genograms analyzed to identify previous cases of MH within the family⁽⁸⁾. If a positive history is found, the team must be notified, the information documented in the medical record, and education regarding the condition provided to patients and their families⁽⁸⁾.

In Brazil, institutional support is available through CEDHIMA, which provides patient and family support services for diagnostic investigation through muscle biopsy with the *in vitro* contracture test, muscle histopathological analysis, and genetic testing^(9,17,25).

During the perioperative period, the nurse is responsible for anticipating and providing all necessary resources, as well as managing nursing care⁽³⁶⁾. It is essential that information regarding the patient's risk of MH has been communicated to the operating room team, allowing for the provision of appropriate equipment, supplies, and human resources to effectively manage a potential crisis. Among the nursing responsibilities during an MH crisis identified in the present study are the application of the clinical scale and institutional protocol, provision of the MH emergency cart or treatment kit, and activation of the MH hotline^(3,5,8,16-24).

In Brazil, the diagnostic likelihood scale for MH is adopted, which is the same scale developed in the United States and presented in Studies 6 and 12^(3,20), covering the same indicators and scoring criteria. In the Brazilian Portuguese version, scores range from 0 to 50 or higher, with probability classified as follows: 0 - almost never; 3 to 9 - unlikely; 10 to 19 - somewhat unlikely; 20 to 34 - somewhat likely; 35 to 49 - very likely; and 50 or more - almost certain⁽³⁷⁾. Given the wide range of clinical manifestations of MH and the diversity of differential diagnoses, the application of this scale has relative value and should not supersede clinical judgment⁽³⁷⁾. The studies included in the sample do not specify which professional should apply the scale.

The absence of a designated professional responsible for applying the MH diagnostic likelihood scale in the analyzed studies reflects the inherently multidisciplinary nature of managing this critical condition. In the perioperative setting, effective crisis management requires a rapid, simultaneous, and coordinated response from the entire healthcare team. Within this context, the perioperative nurse, as a central and permanent member of the surgical team, has the technical and scientific basis to incorporate the application of the scale into nursing practice. The scale serves as a tool to support clinical reasoning, facilitate communication among team members, and guide individualized decision-making, in accordance with the legal competencies of professional nursing practice. Similarly, neither the MH Hotline nor the MHApp – Malignant Hyperthermia mobile application, resources made available by CEDHIMA in the Brazilian context, designate a specific healthcare professional responsible for their use. This finding reinforces the understanding that these resources constitute accessible interventions for perioperative nurses, strengthening their ability to recognize an MH crisis, obtain specialized support, and coordinate patient management with technical-scientific support.

The findings of the present review demonstrate that, once an acute MH crisis has been confirmed, several interventions should be implemented according to an institutional protocol, checklist, or set of guiding principles for crisis management^(5,17,19,22,23). Furthermore, surgery should be halted, if possible, and postponed until the patient has fully recovered^(5,8,18-20,22).

The recommended management should include the following steps, although their sequence may vary among publications: (1) Discontinuation of triggering agents (halogenated anesthetics and/or succinylcholine); (2) Calling for help and obtaining the MH emergency cart or treatment kit; (3) Hyperventilation with 100% oxygen; (4) Administration of intravenous dantrolene; (5) Body cooling using cold compresses, ice packs, and lavage of body cavities with cooled solutions; (6) Management of complications, including metabolic acidosis,

respiratory acidosis, hyperkalemia, cardiac arrhythmias, shock, and renal dysfunction; (7) Calling the MH hotline; and (8) Transfer to the ICU^(5,17,19,23).

The analysis of the studies included in this review reveals that, although the interventions for managing an MH crisis are consistent in content, including discontinuation of triggering agents, administration of dantrolene, body cooling, management of complications, and transfer to the ICU, the sequence in which these interventions are performed varies across publications, highlighting a scientific gap regarding the most appropriate and/or effective order of implementation. Paradoxically, the lack of a rigid sequence may represent an advantage for perioperative practice, as MH does not present uniformly among patients, varying in severity, rate of progression, and predominance of signs and symptoms. Consequently, the flexibility of protocols may be particularly advantageous, providing nurses and the multidisciplinary team with the autonomy required to exercise clinical judgment and adapt the sequence of interventions to each patient's clinical condition while preserving the fundamental principles of institutional protocols and promoting care that is systematic, safe, and individualized.

As evidenced by the findings of this research, the availability of an MH emergency cart or treatment kit is essential to support immediate and accurate patient management by standardizing the necessary supplies and ensuring that updated management protocols are readily available to the entire operating room multidisciplinary team^(1,5,16,18). The availability of dantrolene for MH treatment in healthcare facilities performing surgical procedures requiring anesthesia is often insufficient to initiate immediate crisis management, and in some locations, it is completely unavailable^(1,36,39). The role of the nursing team in providing and maintaining drug stock is emphasized to ensure the service can respond effectively to an MH crisis. Corroborating the findings of the present study, MHAUS recommends that, following the recognition of an MH crisis, medications and supplies should be available for use within 10 minutes⁽⁴⁰⁾. This makes the availability of a centralized cart for MH treatment essential. The cart should be organized into two main categories: 1) Medications and 2) Supplies required for an MH crisis⁽⁴⁰⁾.

There is no consensus in the literature regarding the dantrolene dosage. The Brazilian Society of Anesthesiology recommends a dose of 2.5 to 10 mg/kg IV for the acute phase of an MH crisis, repeated until clinical signs are fully controlled⁽³⁷⁾. Once the crisis has been controlled, the patient should remain under observation in the ICU for at least 24 hours. During the late phase, treatment consists of intravenous dantrolene at 1 mg/kg every 6 hours for 48 hours, in addition to monitoring body temperature, arterial blood gases, CPK,

potassium, calcium, coagulation parameters, and serum and urinary myoglobin⁽³⁷⁾. The objective is the complete resolution of all clinical manifestations of MH (hyperthermia, hypercapnia, and muscle rigidity), as well as complete control of its complications. Increased myoglobinemia, myoglobinuria, and creatine phosphokinase levels are expected during the first 12 to 24 hours after treatment initiation, followed by a subsequent decline⁽⁹⁾.

The PACU is a critical care setting in which attention should also be directed toward the possibility of an MH crisis, as episodes may develop while patients are staying in this unit.

Monitoring patients during the immediate postoperative period in the PACU is essential both for post-crisis follow-up and for the early recognition of clinical signs suggestive of a developing MH event. The entire healthcare team should be prepared to recognize, manage, and support recovery following an MH event. Patient follow-up in the PACU should include continuous monitoring, collection of information regarding the anesthetic and surgical procedure, including medical history, intraoperative complications, administered replacements assessment of the level of consciousness, vital signs, and evaluation of clinical status using the Aldrete and Kroulik Index⁽³⁶⁾. The nurse must evaluate the effectiveness of the implemented actions throughout the postoperative period⁽³⁵⁾. Attention should also be paid to systemic complications, such as dysrhythmias, coma, renal failure, cardiac dysfunction, and disseminated intravascular coagulation⁽²⁰⁾.

The PACU is a highly complex clinical setting in which nurses exercise considerable autonomy and play a leading clinical role, requiring the systematic application of the PNP. Federal Nursing Council Opinion No. 26/2025 reaffirms that, during the post-anesthesia period, the nurse plays a leading role in monitoring the patient's clinical stability, identifying complications early, and providing immediate intensive care⁽²⁷⁾. Consequently, given the possibility of the occurrence^(16,21) or recurrence of an MH crisis in the PACU, the systematic application of the PNP equips nurses to make autonomous clinical decisions, ensuring the rapid recognition of warning signs and the prompt implementation of the interventions required to promote patient safety and stabilization.

A Brazilian study highlights the nurse's role in completing the Mandatory Adverse Event Reporting Form and forwarding it to the State Pharmacovigilance department⁽⁸⁾. In Brazil, any undesirable medical occurrence resulting from the use of medications or vaccines is classified as an adverse event and must be reported to the Brazilian Health Regulatory Agency (ANVISA - *Agência Nacional de Vigilância Sanitária*)⁽⁴¹⁾.

Scientific updating deserves particular attention because it enables nurses, as team leaders, to expand their knowledge and enhance their competence in recognizing clinical

manifestations and intervening during an MH crisis⁽¹⁾. Simulation and continuing education serve as valuable tools for training the perioperative team to recognize and respond to an MH crisis^(1,5,17-19,23). These educational strategies complement the organization of care through institutional protocols and the availability of an MH treatment kit or emergency cart. Early recognition and prompt treatment are essential for improving survival rates; therefore, the ability to recognize and appropriately manage an MH crisis can reduce the morbidity and mortality associated with this condition⁽⁴⁰⁾.

It is essential that operating room professionals remain aware of the importance of MH, as well as its prevention and early treatment, with a focus on patient safety⁽⁹⁾. Besides theory, it is essential to provide healthcare professionals with practical training on the key aspects required for successful management, including early recognition, requesting specialized support through the MH Hotline, implementing appropriate clinical measures, and preparing dantrolene for administration ⁽⁹⁾.

This study makes important contributions to multiple areas of nursing knowledge and practice by identifying and updating nursing interventions for the prevention, management, and post-crisis care of MH throughout the different phases of the perioperative period. It also emphasizes the importance of nursing care beyond the operating room by: (1) Addressing preoperative interventions focused on prevention; and (2) Presenting data identifying the PACU as a critical setting for the occurrence of delayed MH crises.

Regarding clinical practice, the findings offer opportunities for innovation through the implementation of care protocols based on scientific evidence and aligned with the legal scope of nursing practice, aiming to ensure the safety and quality of care for surgical patients.

Regarding education, it is recommended that these interventions be integrated into perioperative nursing curricula, with an emphasis on continuing education and training multidisciplinary teams to recognize and manage Malignant Hyperthermia crises.

Regarding research, important knowledge gaps remain, highlighting the need for primary studies to validate the effectiveness and applicability of these interventions within the specific context of Brazilian perioperative nursing and across different international settings. In particular, studies investigating the implementation of these protocols in Brazilian healthcare institutions and evaluating their impact on patient safety are recommended.

Regarding management, it is recommended to strengthen institutional policies that ensure the availability of material and human resources, as well as the systematic implementation of patient safety protocols. This includes allocating resources for maintaining

Malignant Hyperthermia kits, providing continuous team training, and monitoring adherence to the protocols.

This study has limitations regarding the number of articles included in the sample, given the scarcity of studies addressing the topic. Furthermore, the absence of the Nurse Anesthesia specialty in Brazil limits the interpretation of international recommendations and the determination of which interventions may or may not fall within the scope of Brazilian nursing practice. When interpreting the results, one must consider the existing protocols in each institution, and which interventions are regulated for nursing in each country.

CONCLUSION

The results of this scoping review make it possible to contextualize and identify nursing interventions during a MH crisis in the perioperative period. Interventions were identified for the prevention, control, and post-crisis care of MH.

Among the principal nursing interventions identified are: risk assessment through the collection of personal anesthetic and family history during the preoperative visit; identification of patients susceptible to MH and communication of this information to the healthcare team; provision of the human and material resources required in the operating room; recognition of the signs and symptoms of MH in the surgical setting; participation in MH management within the legal scope of nursing practice in the respective country; ensuring the safe transfer of patients to the ICU; assessment and monitoring of patient recovery or the occurrence of an MH crisis in the PACU; reporting adverse events; participation in the development of identification and treatment protocols, including the organization of MH treatment kits or emergency carts; and contributing to staff training.

This study provides contributions and innovations for clinical practice, nursing education, research, and healthcare management by identifying and updating nursing interventions for Malignant Hyperthermia crises throughout the different phases of the perioperative period. It provides opportunities for innovation through the implementation of clinical protocols aimed at improving patient safety, based on up-to-date scientific evidence and aligned with the legal responsibilities of nurses in different countries. These findings are expected to strengthen the role of nursing within the multidisciplinary healthcare team.

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Data and material availability

Access to the dataset is available upon request from the corresponding author.

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