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Prevention of hypothermia in newborn submitted to surgical procedures: an integrative review

Prevenção da hipotermia em recém-nascido submetido a procedimentos cirúrgicos: revisão integrativa

Prevención de la hipotermia en recién nacido procedimientos quirúrgicos: revisión integrativa

Lucas Amaral Martins[I,II]
ORCID: 0000-0003-1497-6576

Climene Laura de Camargo[I]
ORCID: 0000-0002-4880-3916

Elionara Teixeira Boa Sorte Fernandes[III]
ORCID: 0000-0001-8302-6887

Patrícia Figueiredo Marques[II]
ORCID: 0000-0002-0242-5024

Aline Cristiane de Sousa Azevedo Aguiar[III]
ORCID: 0000-0002-8210-5775

Caroline Tianeze de Castro[IV]
ORCID: 0000-0002-9445-8842

[I] *Universidade Federal da Bahia. Salvador, Bahia, Brazil.*
[II] *Universidade Federal do Recôncavo da Bahia. Santo Antônio de Jesus, Bahia, Brazil.*
[III] *Universidade do Estado da Bahia. Guanambi, Bahia, Brazil.*
[IV] *Universidade Federal da Bahia. Vitória da Conquista, Bahia, Brazil.*

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Corresponding author:
Lucas Amaral Martins
E-mail: lucas.martins@ufrb.edu.br

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ABSTRACT

Objective: to discuss in the scientific literature the strategies used to prevent hypothermia in newborns undergoing surgical procedures. **Methods**: this is an integrative literature review, with structured search in April and May 2020 in 08 databases, using the descriptors: Hypothermia; Surgical Procedures, Operative; Infant, Newborn; Protocols. Four primary studies were selected and analyzed using three instruments to assess the methodological quality of the Joanna Briggs Institute and content analysis. **Results:** Among the strategies used, the following stand out: room temperature control; establishment of humidification and quality of air conditioning cleanliness; use of a heated incubator or cradle; use of thermal mattress; use of caps and blanket; heated fluids; temperature monitoring and abdominal organ coverage. **Conclusion**: good hypothermia prevention strategies were identified, despite the small number of publications on this topic; thus, it points out the need for research with strong evidence.
Descriptors: Infant, Newborn; Hypothermia; Surgical Procedures, Operative; Disease Prevention; Neonatal Nursing.

RESUMO

Objetivo: discutir, na literatura científica, as estratégias utilizadas para prevenção de hipotermia em recém-nascido submetido a procedimentos cirúrgicos. **Métodos**: revisão integrativa de literatura, com busca estruturada em abril e maio de 2020 em 08 bases de dados, utilizando os descritores: *Hypothermia*; *Surgical Procedures, Operative*; *Infant, Newborn*; *Protocols*. Foram selecionados e analisados 04 estudos primários por meio de três instrumentos para avaliação da qualidade metodológica da *Joanna Briggs Institute* e da análise de conteúdo. **Resultados:** dentre as estratégias utilizadas destaca-se: controle da temperatura ambiente; estabelecimento de umidificação e qualidade de limpeza do ar condicionado; utilização de incubadora ou berço aquecido; uso de colchão térmico; uso de toucas e cobertor; fluidos aquecidos; monitoramento da temperatura; cobertura de órgãos abdominais. **Conclusão**: identificaram-se boas estratégias de prevenção de hipotermia, apesar de haver um número reduzido de publicações nesta temática; dessa forma, aponta-se a necessidade de pesquisas com evidências fortes.
Descritores: Recém-Nascido; Hipotermia; Procedimento Cirúrgico; Prevenção; Enfermagem Neonatal.

RESUMEN

Objetivo: discutir, en la literatura científica, las estrategias utilizadas para prevenir la hipotermia en recién nacidos sometidos a procedimientos quirúrgicos. Métodos: revisión integrativa de la literatura, con búsqueda estructurada en abril y mayo de 2020 en 08 bases de datos, utilizando los descriptores: Hypothermia; Surgical Procedures, Operative; Infant, Newborn; Protocols. Se seleccionaron y analizaron cuatro estudios primarios utilizando tres instrumentos para evaluar la calidad metodológica del Instituto Joanna Briggs y el análisis de contenido. **Resultados:** entre las estrategias empleadas destacan: control de la temperatura ambiente; establecimiento de humidificación y calidad de aire acondicionado limpio; uso de una incubadora o cuna con calefacción; uso de colchón térmico; uso de gorros y mantas; fluidos calentados; monitoreo de temperatura; cobertura de órganos abdominales. **Conclusión:** se identificaron buenas estrategias de prevención de la hipotermia, a pesar del escaso número de publicaciones sobre este tema; por lo tanto, señala la necesidad de realizar investigaciones con evidencia sólida.
Descriptores: Recién Nacido; Hipotermia; Procedimientos Quirúrgicos Operativos; Prevención de Enfermedades; Enfermería Neonatal.

INTRODUCTION

Inadvertent hypothermia in a surgical procedure is a problem for patients worldwide and is associated with harmful side effects[1]. In newborns (NBs), hypothermia is characterized by a reduction in body temperature reaching values below 36.5ºC[2]. This is the result of an internal redistribution of body heat from the nucleus to the periphery, followed by heat loss greater than metabolic production[3].

In NBs, thermal control is in the maturation and adaptation phase, therefore, to maintain normothermia it is necessary to have a balance between the production and the elimination of heat[4]. Ineffective thermoregulation is one of the main complications that affect NB, since hypothermia predisposes to metabolic disorders, respiratory distress, enterocolithenecrotizing and intracranial hemorrhage[5-6]. The thermoregulatory mechanism is, therefore, considered a critical function for the survival of NBs[5-6].

Providing an environment that favors NB normothermia is a strong predictor of reduced morbidity and mortality at all gestational ages, being considered an indicator of quality of care[7], meeting the principles that guide patient safety strategies, which are defined as the absence of avoidable damage and the reduction of unnecessary risks associated with health care to an acceptable minimum, in order to reduce the occurrence of adverse events (AEs). AEs are characterized by incidents that result in unintentional damage to patient[8-9], thus hypothermia in surgical NB is considered as an AE.

Accidental hypothermia is a frequent occurrence during neonatal surgery, which indicates the importance of developing evidence-based warming strategies for prevention[10]. NBs that present hypothermia in the intra and/or postoperative period will have a greater number of AEs when compared to normothermic ones[11]. In Canadian hospitals, it was found that there is a greater proportion of AE in surgical NBs when compared to clinical NBs[12].

A study reveals that AEs in relation to hypothermia in surgical patients constitutes a health problem and its incidence varies between 26% and 90%, with half of these events being preventable[13]. Even though surgical treatment aims to save lives, security breaches and uncontrolled risks during surgical care can cause irreparable damage to patients[14]. Thus, it is necessary to have an accurate view of health professionals and, in particular, the nursing team, for prevention of hypothermia in surgical NBs[15].

In this sense, the need for studies that aim to: identify the procedures that predispose to perioperative hypothermia is highlighted; determine the relative value of quality improvement interventions; characterize the morbidity and mortality associated with perioperative hypothermia in neonatal patients[16]; seek new methods and care strategies for surgical NB, ensuring quality care, safe and free from risks and damage[15]. There is still a high incidence of inadvertent hypothermia in the perioperative period[1].

Given the above, the need for an integrative literature review emerged as a way to synthesize the national and international scientific evidence in this context of care for surgical NBs.

OBJECTIVE

To discuss in the scientific literature the strategies used to prevent hypothermia in newborns undergoing surgical procedures.

METHOD

Ethical aspects

The study respected national and international ethical principles, maintaining the ideas of the authors of the publications used in the development of this study.

Research design

This is an integrative literature review, a method that allows the broad analysis of a given subject, with deep knowledge about the proposed theme, allowing discussions about methods, results and conclusions from selected studies as well as reflections on conducting future studies[17].

The construction of this research was structured in five stages, according to the proposal of Whittemore and Knafl[18]: elaboration of the research question and/or identification of objectives; literature search; data evaluation; analysis of studies; presentation of the integrative review results.

The Cumulative Index to Nursing & Allied Health Literature (CINAHL) and the National Library of Medicine (PubMed) databases were consulted. No systematic bibliographic research on the prevention of hypothermia in NBs submitted to surgical procedures was found, coupled with the absence of protocols and systematic review reports registered in the Joanna Briggs Institute (JBI) collections in the Prospective Register of Systematic Review (PROSPERO) and Cochrane Library.

Research question development

The question that guided the research was: what are the strategies used to prevent hypothermia in NBs submitted to surgical procedures? Its elaboration was based on the PICO strategy (Population; Intervention; Comparison; Outcomes)[19], being P- NB, submitted to surgical procedures, I - strategies used to prevent hypothermia, C - not applicable and O - prevention of hypothermia.

Literature search

Search for primary studies was carried out in April and May 2020 in the Scientific Electronic library online (SCIELO), Latin American and Caribbean Literature in Health Sciences (LILACS), Medical Literature Analysis and Retrieval System Online (MEDLINE), National Library of Medicine (PubMed), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Excerpta Medica Database (Embase) and Web of Science databases. Google Scholar was also used, using the advanced search method. The descriptors were delimited according to the Medical Subject Headings (MeSH) and Health Sciences Descriptors (DeCS), being used: Hypothermia; Surgical Procedures, Operative; Infant, Newborn; Protocols. In the search strategy implemented for the crossing, the Boolean operator "AND" was used to associate the descriptors, as shown in Table 1.

Original articles published in full and addressing the topics on strategies for prevention of hypothermia in surgical NB, methods of thermal control in surgical procedure, thermal control of the surgical environment for NB, technologies used in the prevention of hypothermia in surgical NB were included. There was no

language restriction and initial investigation time limiting the final time to 2020, since there were no changes in the basic principles of thermal control over the years; however, new technological resources were added in order to qualify the care, thus enabling a breadth in the investigative process.

Table 1 – References found at the respective crossings (n=201), 2021

DATABASE	SEARCH STRATEGY	Number of articles
CINAHL	*"Hypothermia" and "Surgical Procedures, Operative" and "Infant, Newborn"*	5
MEDLINE	*"Hypothermia" and "Surgical Procedures, Operative" and "Infant, Newborn"*	18
SciELO	*"Hypothermia" and "Surgical Procedures, Operative"* *"Hypothermia" and "Infant, Newborn"* *"Hypothermia" and "Infant, Newborn" and "protocols"*	8 17 15
LILACS	*"Hypothermia" and "Surgical Procedures, Operative" and "Infant, Newborn"*	1
PubMed	*"Hypothermia" and "Surgical Procedures, Operative" and "Infant, Newborn"*	7
Web Of Science	*"Hypothermia" and "Surgical Procedures, Operative" and "Infant, Newborn"* *"Hypothermia" and "Surgical Procedures, Operative"* *"Hypothermia" and "Infant, Newborn"* *"Hypothermia" and "Infant, Newborn" and "protocols"*	1 6 30 75
Embase	*"Hypothermia" and "Surgical Procedures, Operative" and "Infant, Newborn"*	10
Google Acadêmico	*"Hypothermia" and "Surgical Procedures, Operative" and "Infant, Newborn"*	8

Gray literature (thesis, dissertation, monographs, books, protocols, manuals, among other non-indexed documents) and documents that did not answer the research question were excluded. After selecting the articles, they were submitted to the Mendeley bibliographic management tool, in order to exclude duplicate articles (n=14).

Data assessment

The investigation and selection of articles was carried out by 02 independent researchers, with the sequence of use of descriptors and crosses in each database being standardized. Then, results obtained and consensus among researchers were compared, so that each article was examined by title, abstract and full text, according to the inclusion and exclusion criteria established.

After selecting the articles, the researchers performed a critical assessment of methodological quality using three JBI instruments: JBI Critical Appraisal Checklist for Cohort Studies, JBI Critical Appraisal Checklist for Case Control Studies and JBI Critical Appraisal Checklist for Case Series[20]. The first assesses the methodological quality of cohort studies, the second, case-control, and the third, case series.

In these instruments, each question must be answered through four options: yes (Y), no (N), unclear (U) and not applicable (NA). The calculation of percentage of risk of bias and methodological quality is performed by the amount of "Y" selected in the checklist. Questions where the answers are "NA" are not included in the final calculation. The answers "N" and "U" do not score in the calculation. Studies with scores of up to 49% are considered to be at high risk of bias and low methodological quality; between 50% and 70%, the risk and methodological quality are moderate; above 70%, the risk of bias is low and the methodological quality is high.

The articles' level of evidence was assessed according to the classification model proposed by JBI[21]. Considering that both cohort studies, as well as the case-control study have high methodological quality and low risk of bias, the evidence found is level III according to the JBI classification, being included in this review.

Data analysis

Critical analysis of the studies was based on content analysis[22], in order to present the scientific evidence about the best practices used for prevention of hypothermia in NBs submitted to surgical procedures. The articles were read in a dynamic and cyclical back and forth process that allowed for data reduction, data presentation and verification of conclusions, thus enabling the visualization of four categories of analysis for the presentation of results[22].

To present the studies included in the integrative review, the flowchart proposed by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes)[23] was used, as shown in Figure 1, as well as charts containing information on study characteristics, strategies, outcomes and recommendations.

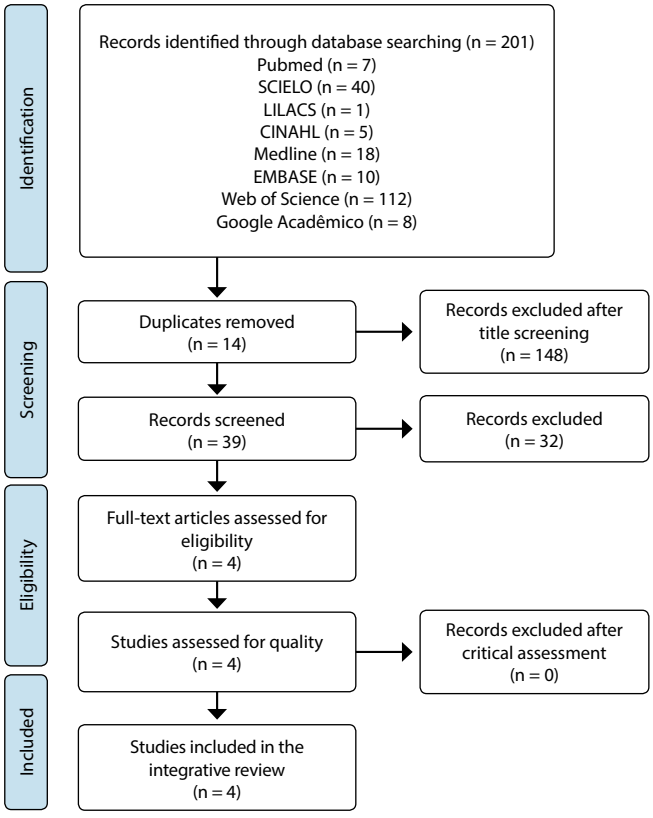

Figure 1 – Informative flowchart of integrative review phases anchored in PRISMA, 2021

RESULTS

After searching in database and according to established selection criteria, this integrative review included four articles[11,24-26], which are presented in Chart 1. These were distributed in PubMed (2; 50%), followed by Embase (1; 25%) and MEDLINE (1; 25%) databases, published in the last 50 years, totaling as a sample 268 NBs submitted to surgical procedures.

The studies used methodologies with quantitative approaches, and the language of all articles was English, and the publications in medicine[24-26] and nursing[11].

In assessing the articles' methodological quality, the scores ranged from 50% to 100% and all had the same level of evidence according to JBI.

The strategies, outcome and recommendations for hypothermia reduction presented in the selected articles are described in Chart 3. The main strategy in the prevention of hypothermia in surgical NB presented in the studies was thermal environment control in which surgery is performed[11,24-26].

Other strategies for prevention of hypothermia in surgical procedures are also identified, namely: use of thermal mattress, chemical or heated blankets[11,24-25]; caps, overalls, and blankets[11,24-25]; use of a previously heated incubator or heated cradle[11,24-26]; infusion of heated fluids[11,24-26]; monitoring of body temperature in the axillary, nasopharyngeal, esophageal or rectal regions[11,24]; perioperative temperature measurement routines[11,24]; coverage of abdominal organs with wet and heated surgical compresses[25]; establishment of relative air humidification[24,26]; air conditioning cleaning quality[26] and heat lamps[11].

The strategies used to prevent hypothermia in surgical NB are varied and can be categorized into: environment care[11,24-26]; NB care related to temperature monitoring and the use of technological equipment[11,24-26]; NB care related to preparing for surgery[11,24,26]; care related to the use of solutions, liquids, fluids and blood products[11,24-25]. It appears that hypothermia is a real and unresolved AE in the studies[11,24-26] analyzed. Thus, it points to the need for professionals involved in the care of surgical NB to rethink their practices and develop effective care protocols that stratify these data and develop actions that meet the clinical, environmental, structural and care demands in the prevention of hypothermia in surgical NB.

Chart 1 - Characteristics of articles, 2021

Reference	Year/ Country	Objective	Design/number of patients	Journal
Tsingoglo and Wilkinson[24]	1971 England	Describe the causes of heat loss in NBs undergoing surgery.	Case series n=37	Archives of Disease in Childhood
Tander et al[25]	2005 Turkey	Assess the factors that led to intraoperative hypothermia in 60 (31 neonates and 29 infants).	Cohort n=60	Pediatric Anesthesia
Morehouse et al[11]	2014 England	Describe the perioperative thermal instability of NBs and identify where (surgical center and Neonatal Intensive Care Unit) and when (pre, intra and/or postoperative) occurs; describe adverse cardiovascular, respiratory and metabolic outcomes associated with hypothermia; describe supportive interventions and diagnostic tests associated with hypothermia.	Case-control study n=108	Advances in Neonatal Care
He et al[26]	2018 China	Report experience in performing surgical procedures in a Neonatal Intensive Care Unit, including air cleaning.	Cohort n=92	Medicine (Baltimor)

Chart 2 - Assessment of methodological quality of articles through three Joanna Briggs Institute (JBI) instruments, 2021

JBI Critical Appraisal Checklist for cohort studies												JBI
STUDY	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**SCORE**	**Level of evidence**
Tander et al.[25]	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA	Y	100.0%	3
He et al.[26]	Y	Y	Y	N	N	Y	Y	Y	Y	NA	Y	80.0%	3

JBI Critical Appraisal Checklist for case-control studies											JBI
STUDY	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**SCORE**	**Level of evidence**
Morehouse et al.[11]	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	90.0%	3

JBI Critical Appraisal Checklist for case series studies											JBI
STUDY	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**SCORE**	**Level of evidence**
Tsingoglou e Wilkinson[24]	Y	Y	U	U	U	N	Y	Y	N	Y	50.0%	3

JBI - Joanna Briggs Institute.

Chart 3 - Strategies, outcome and recommendations of articles for reducing hypothermia, 2021

Reference	Strategies used to prevent hypothermia in surgical newborn	Outcome	Recommendations
Tsingoglou and Wilkinson[24]	- Transport incubator temperature of 32ºC (29.2 to 35.6ºC average); - NB covered to the shoulders with sweater; - Room temperature of the operating room (22.7 to 28ºC, with average of 25.7ºC); - Temperature of the microclimate (27.2 to 38.5ºC, with average of 32.4°C); - Relative air humidity during surgery ranged from 32% to 62%, with an average of 43%; - Fixation of thermometer in the axillary, abdominal and close to the rectum region; - NB temperature check at 15-minute intervals. - Electric heated mattress (37 to 42°C); - All cleaning solutions and intravenous fluids except blood were kept in a cabinet at a temperature between 40 and 43ºC; - Heated blood products.	- 17 NB evolved with an average normothermia of 36.9ºC; - 7 NB evolved with an average hyperthermia of 38.3 ° C; - 13 evolved with an average hypothermia of 35.9ºC; - There were small temperature changes in the surgery, but some patients went to the operating room with subnormal temperatures; - The postoperative period was quiet, except in a NB with septicemia (temperature of 39.5ºC) having to be cooled after the operation; - The microclimate temperature varied between 32.8 and 42°C. - In the rapid infusion of 10 ml of cold blood a drop of 0.1°C in the rectal temperature occurred in 7 patients, but this did not occur when the blood in the syringe was heated for the first time in the electric blanket.	- Establish the temperature of 37 to 42ºC for the electric mattress; - Before the surgery, NBs must be protected with some type of tissue, such as a blanket/blanket, since there is repeated opening of the incubator doors for NB examinations; - When it is necessary to transfuse large volumes of blood, the microclimate may have to be kept at a higher temperature to avoid cooling NBs.
Tander et al[25]	- Two temperature parameters were established for surgery on NBs: low (20.5 to 23ºC) and high (23.5 to 27ºC). Perioperative interventions: - Hot gel mattresses/compresses, with a temperature of 39ºC; - Liquids and fluids heated to 37ºC; - Blood products heated to 37ºC; - The abdominal organs were covered with moist and warm compresses at 37ºC; - Head, legs and arms covered with warm cotton pads; - NB covered with heated surgical wrap.	- The type of surgery and the operating room temperature are factors that affect NBs' temperature. - Major surgeries were 2.66 times more likely to decrease core temperature; - Operating rooms with temperature <23°C have 1.96 times more chance of lowering the core temperature, compared to rooms with temperatures> 23°C.	- In major surgeries it is necessary to use thermal resources to guarantee NB normothermia; - The operating room temperature must be adjusted according to the type and size of surgery; - The main factors that predispose to hypothermia are: type of surgery and operating room temperature.
Morehouse et al[11]	- Performing a surgical procedure in two different environments, Neonatal Intensive Care Unit and operating room; Perioperative interventions: - Heated incubators or cradles with radiant heat; - Caps, extra blanket, heated blanket; - Chemical mattress and thermal mattress; - heated intravenous fluids; - Monitoring of axillary, nasopharyngeal, esophageal or rectal temperature. Temperature record: - Before transporting NB to the operating room; - In the preoperative period, after delivery to the operating room team or the arrival of the surgical team at the Neonatal Intensive Care Unit; - In the intraoperative period, continuous verification; - In the postoperative period, check every 15 minutes, in the 1st hour; every 30 minutes, in the 2nd hour; every hour for 4 hours or until the temperature is stable.	Hypothermia developed in 40% (n=43) of children during the perioperative period. The operating room group had a higher rate of perioperative hypothermia (65.45%, n=36; p <001) and were 7 times more likely to develop perioperative hypothermia (p=008) than the Neonatal Intensive Care Unit group (13.21%, n=7). Likewise, NBs in the operating room group were 10 times more likely to develop hypothermia during intra and postoperative periods than those in the Neonatal Intensive Care Unit group. (p=001). The hypothermic group had significantly more adverse respiratory events (p=025), were 6 times more likely to require thermoregulatory interventions (p <001). Both groups experienced unacceptable rates of clinical hypothermia.	- Use of a cap before and during surgery; - Use preheated transport incubator and heated mattress when transferring to the operating room; - Use of a cap before and during surgery; - Use of a heated mattress during surgical procedures; - Intravenous fluids must be preheated; - In the postoperative period, NBs must return to a preheated bed; - In family rooms of the Neonatal Intensive Care Unit, the room temperature must be set at 23.8°C.
He et al[26]	- Performing a surgical procedure in two environments; - Neonatal Intensive Care Unit: Room temperature from 23º to 26ºC, air humidity (50% to 60%), ISO 14644-1, evaluation of air conditioning cleanliness (Class 7); - Operating room: room temperature at 18º to 22ºC, air humidity (55% to 75%), ISO 14644-1 evaluation of air conditioning cleanliness (Class 5 and 6). - Before surgery, NB were transferred to an incubator and extra heaters for NB were added, according to body temperature.	Average postoperative body temperature was significantly different between the 2 groups, although it was similar before surgery (36.4°C in the Neonatal Intensive Care Unit group and 35.9°C in the operating room group p=002). The lowest body temperature during surgery was 35.2°C in the operating room group, which was significantly lower than in the Neonatal Intensive Care Unit group (36.1°C, p <001). Four patients (9.1%) in the Neonatal Intensive Care Unit group presented hypothermia during surgery, compared with 27 patients (56.3%) in the operating room group (p <001).	- Suggests that performing surgical procedures in a Neonatal Intensive Care Unit with air cleaning class 7 is as safe as in an operating room.

DISCUSSION

There is a shortage of literature that evaluates neonatal thermal care strategies[10]. This review also reveals that there is a reduced number of publications aimed at preventing hypothermia in NB undergoing a surgical procedure. The findings are concentrated in European and Asian countries and point to the need for research on this theme with strong evidence, outlined by methods of randomized clinical trials and cohort studies, since authors point out that the prevention of hypothermia is a critical determinant of neonatal morbidity and mortality[27].

Implementing practices based on scientific evidence results in a significant reduction of hypothermia in neonates and become a standard of care[28]. This evidence is essential to support changes in care practices with NBs, allowing autonomy for multidisciplinary teams, supporting clinical practice, qualifying care safely and enabling innovation in the thermal control of NBs[29].

Establishing a neutral thermal environment is essential for prevention of hypothermia in the NBs that will undergo surgery, since it provides a reduced metabolic expenditure of heat loss, a minimum consumption of calories and oxygen, thus allowing temperature stability with the loss of heat equal to production[30].

Care with room temperature control was identified as the main concern in publications focused on the theme of neonatal thermal care[11,24-26]. Two articles[11,26] compared the performance of a surgical procedure in different environments (Operating Room (OR) and Neonatal Intensive Care Unit (NICU)) and evaluated where there was a higher incidence of hypothermia in the NBs; another[25] analyzes the OR temperature and correlates it with small and large surgeries and, finally, investigates[24] the necessary strategies to provide the ideal surgical environment for maintaining normothermia in NBs. It is stipulated as thermal parameters of a neonatal operating room: room temperature with a variation of 22.7ºC to 28ºC[11,15,24-26,31-32], air humidity control between 32% and 62%[24-26,32] and quality of air cleaning, based on the International Standardization Organization (ISO) 14644-1 with numerical classes[26].

Studies[11,26] that compared surgical procedures in NICUs and OR identified that, in OR, the number of NBs that presented episodes of hypothermia was higher. The research[25] that analyzes the temperature management of the OR in small and large sized procedures found that NBs that undergo major surgery cannot maintain thermal stability as well as NBs that undergo minor surgery size in very cold rooms. In view of this evidence, the researchers point out the need to use exogenous sources of heat as well as other actions to provide normothermia for surgical NB. Another article[24] points out strategies and parameters for prevention of hypothermia in NB undergoing surgical procedures.

Scientific evidence also points to the use of equipment and accessories to provide an adequate environment and reduce NB heat losses, such as an incubator, heated cradle, thermal, chemical mattresses and heated blanket[11,15,24-26,31].

NB care related to temperature monitoring and the use of technological equipment such as the cradle with radiant heat and the heated and humidified incubators provide a neutral thermal environment for NBs. Thus, this equipment monitors NBs' temperature via a skin sensor, which needs to be positioned in the axillary or abdominal region so that more accurate and safe monitoring occurs, since these equipment use feedback mechanisms to determine the production of heat and maintain normothermia[11,15,24,27].

Thermal mattress is another resource that has been widely used in the prevention of NB hypothermia, with an adjustment temperature between 37ºC and 42ºC[11,15,24,27]. This has shown satisfactory results and should be used during all operative procedures, regardless of the duration of the procedure[11]. In the situation where the body temperature reaches a value above 37ºC, it is recommended that temperature is reduced or the blanket is turned off to neutralize the NB temperature[24].

Thermal blanket is an effective method to correct hypothermia, since it allows the central temperature to rise by about 0.75ºC in approximately one hour, being programmed with a temperature between 38º and 40ºC; if used previously for 30 minutes to the procedure, this temperature recovery can drop to 30 minutes[33].

In Chinese hospitals, other strategies have been shown to be effective, namely: heated and humidified CO_2 insufflation (35°C temperature and 95% relative humidity) in laparoscopic surgeries[32]; rewarming of children with postoperative hypothermia with the combination of an electric blanket and a forced air heating system[34]. These resources were associated with positive postoperative results, including less tremors and hypothermia, faster recovery of bowel movements and shorter hospital stay[32].

A Brazilian study[15] points out actions used for thermal control similar to those identified in this review: i) keep NB involved in previously heated sweaters, when removing it from the incubator or heated cradle for transportation; ii) start the surgical procedure only when NBs present a normothermic state; iii) insert an esophageal thermometer before the surgical procedure for monitoring intraoperative temperature; iv) use a thermal blanket during major surgical procedures; v) monitor the temperature of NBs in the NICU after returning from the postoperative period, with a digital thermometer; vi) monitor the temperature of NBs at 15-minute intervals in situations that present a hyper or hypothermia chart; vii) administer solutions and blood products at an appropriate temperature. It should be noted that the fluids must be heated in thermoregulated greenhouses at an average temperature of 40º. Thus, when administered, infusions maintain a temperature between 37ºC and 38ºC[35].

Regarding NB care related to the preparation for surgery and fluids, European research[11] recommends that, to prevent hypothermia in surgical NB, the orientation is: wearing a cap before and during surgery; transport must take place in a transport incubator preheated with the use of a chemical heating mattress; NICU heaters must be used intraoperatively within the OR parameters; intravenous fluids must be preheated; postoperatively, NBs must return to a preheated cradle or incubator[11].

Another study[36] confirms the importance of using the thermal blanket and transport incubator in the transfer of NB between UTN and OR, since the use of these resources reduces neonatal hypothermia in the intraoperative period and presents significant improvements in obtaining postoperative normothermia in seriously ill neonates.

Among the surgical stages, the immediate preoperative period presents the highest risk of hypothermia, as NBs undergo clinical

procedures and interventions, such as anesthetic induction, orotracheal intubation, venous access and soundings, which are usually performed with the exposed neonate and without an additional heat source. These actions predispose to heat loss and to reach the stabilization of body temperature it can take around 45 minutes[10,30]. It is noteworthy that, in these situations, the intervention of health professionals, especially nurses, is necessary, adjusting the heated incubator/cradle parameters and implementing actions to reduce heat losses, such as the use of thermal bags and mattresses[30].

In NB, homeothermic control is imperfect, since it has the ability to overheat and cool quickly and has an inability to conserve heat when exposed to thermal stress[37]. To achieve improved thermal control, in surgical NB, it is necessary to apply basic thermodynamic principles - reducing heat loss and providing a combination of radiant and conductive heat. Thus, thermal control of neonates must be individualized, continuously monitored with a skin temperature probe throughout hospitalization and associated with continuous monitoring of data on quality of care improvements[38].

Nursing care is necessary and essential for the recovery of NB, which is dependent on fundamental care for the promotion of a thermal environment capable of ensuring its survival, as well as adequate growth and development. Thus, health professionals, and especially nursing, need to be aware of the thermoregulation mechanisms to help NBs achieve thermal neutrality[37].

It is noteworthy that, in order to achieve high levels of thermoregulatory performance, the service team needs to engage in quality improvement (QI) intervention in partnership with other units, given that NICUs that participate in collaborative QI achieved better results in thermoregulation of those whose efforts are exclusively local[30].

A study shows that during the surgical approach there is a significant number of AEs, which are, in most cases, caused by the lack of a safe practice by health professionals working in the sector, in which the existing safety measures are not used properly[14]. This fact is related to the non-compliance with the guidelines recommended by WHO for safe surgery, representing a risk for surgical patients[39].

This research identified actions to prevent hypothermia, which favors reduction of AE in the perioperative period. However, it became evident that there are weaknesses in the implementation of new care technologies, which justifies the need for professionals to rethink their care process, with actions that eradicate the occurrence of neonatal hypothermia[40], as well as launching strategies to improve the prevention of perioperative hypothermia so that it is evaluated in the context of feasibility, effectiveness, safety, acceptability, cost and teamwork[1], to safeguard the OR ideal conditions, taking care of a person, taking care of their individuality and vulnerability before, during and after surgery[41].

Hypothermia in surgical patients is an AE of high incidence and constitutes a public health problem[13]. This research identified actions to prevent hypothermia, which favors the reduction of AE in the perioperative period; however, it was evident that there are weaknesses in the implementation of new care technologies, which justifies the need for professionals to rethink their care process, with actions that eradicate the occurrence of neonatal hypothermia.

NB surgical safety depends on actions that aim to prevent the occurrence of preventable AE and when it is not possible to minimize its consequences. Attention to NB hypothermia, during the pre, intra and postoperative period, is of fundamental importance and becomes the focus of nursing care, as it favors the reduction of neonatal morbidity and mortality secondary to hypothermia triggered by the surgical approach.

Study limitations

This study, because it is an integrative review, has limitations for using secondary data, since the information has already been previously constructed and for having presented a small number of articles. It is also noteworthy that research was restricted to level III of evidence, according to assessment instrument; however, studies have brought good strategies for prevention of hypothermia in NB submitted to surgical procedures. Furthermore, the limited number of studies related to the theme makes it impossible to include more up-to-date references, both in the study's foundation and in the discussion of the study.

Contributions to nursing and health

This integrative review brings contributions to the health area, especially for neonatal nursing, since: i) identifies strategies for improving clinical and care practices in care for surgical NB; ii) describes actions to prevent hypothermia, which favors the reduction of AEs in the perioperative period; iii) contributes to the strengthening of international patient safety policies; iv) indicates care strategies that can favor the reduction of neonatal morbidity and mortality; v) points out the need to build an assistance protocol for prevention of hypothermia in surgical NB.

FINAL CONSIDERATIONS

The evidence in the scientific bases reveals that the main strategies used for prevention of hypothermia in surgical NBs were: room temperature control; establishment of relative air humidity and evaluation of quality of air conditioning cleanliness; use of heated and humidified incubator or heated cradle for hospitalization; operative procedure and transport; use of thermal, chemical mattress or heated blankets in surgical procedures; use of caps, underwear and blanket for heating in the perioperative period; use and infusion of fluids that must be previously heated; monitoring of body temperature in the axillary, nasopharyngeal, esophageal or rectal regions; perioperative temperature measurement routines; coverage of abdominal organs with wet and heated surgical compresses in the intraoperative period; use of environmental heating equipment.

Analyzing the findings of this study, it is recommended to develop further research on this topic, with strong evidence, outlined by methods of randomized clinical trials and cohort studies. Along with this, there is a need for professional training for the use of new technologies and new studies that can investigate the factors that predispose NB to perioperative

hypothermia, prevention of AEs in the intraoperative period related to thermoregulation and elaboration of protocols based on scientific evidence that aligns the basic principles of thermal control to the new technological resources for prevention of hypothermia to NBs submitted to surgical procedure, among other themes that favor safe practice. In the studies analyzed, episodes of hypothermia were still identified in the surgical NB with the strategies used.

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