Peer-reviewed article

Authors

Daiane Gabiatti
MsC, PhD candidate, CNOR
Ribeirao Preto College of Nursing, University of Sao Paulo

Samia Hussein Barakat
MsC, PhD candidate, CNOR
Ribeirao Preto College of Nursing, University of Sao Paulo

Adjunct Professor Elaine Barros Ferreira
RN
Nursing Department, Health Sciences School, University of Brasilia

Professor Karina Dal Sasso Mendes
PhD, RN
Ribeirao Preto College of Nursing, University of Sao Paulo

Professor Cristina Maria Galvão
PhD, RN
Ribeirao Preto College of Nursing, University of Sao Paulo

Bruna Nogueira Santos
PhD, RN
Ribeirao Preto College of Nursing, University of Sao Paulo

Associate Professor Renata Cristina de Campos Pereira Silveira
PhD, RN
Ribeirao Preto College of Nursing, University of Sao Paulo

Corresponding author

Associate Professor Renata Cristina de Campos Pereira Silveira
PhD, RN
Ribeirão Preto College of Nursing, University of São Paulo
recris@eerp.usp.br

DOI: 10.26550/2209-1092.1386

Hypothermia and blood coagulation biomarkers and their implications for perioperative nursing: A systematic review

Abstract

Aim: The objective of this review was to synthesise research findings about perioperative hypothermia and its effects on blood coagulation biomarkers in patients undergoing elective surgery.

Method: A systematic review design was employed, across eight databases, with an updated search performed after nine months. The databases searched included PubMed, Scopus and Cochrane. The review included primary quantitative studies that focussed on adult and older patients, and examined temperature parameters, laboratory tests and coagulation biomarkers. There were no restrictions on language or publication period.

Results: Five studies were analysed, highlighting a lack of consensus on the definition and timing of tests. Common tests included prothrombin time, activated partial thromboplastin time, fibrinogen, platelet count and thromboelastography. However, the review excluded paediatric and emergency surgery studies, thereby limiting its generalisability.

Conclusion: The findings revealed that hypothermia can impact the coagulation cascade, although there is no standardised approach for testing protocols or timing. These insights emphasise the need for improvements in clinical practice to ensure more accurate and consistent results, thereby ensuring better patient outcomes.

Keywords: hypothermia, biomarkers, blood coagulation, haemorrhage, intra-operative period

Introduction

Body temperatures between 36 °C and 38 °C are considered to be within the range of normothermia[1] while perioperative hypothermia is characterised by a core body temperature below 36 °C. This event is known to frequently occur during the perioperative period and warrants the attention of health professionals, given its capacity to lead to complications in surgical patients. Complications associated with perioperative hypothermia include increased intra-operative bleeding, changes in coagulation and delayed enzyme activity[2]. Furthermore, perioperative hypothermia can prolong the effect of anaesthetics, increase the incidence of surgical site infection and impair the healing of surgical wounds[2], as well as resulting in post-operative shivering, increased oxygen consumption and cardiac abnormalities[3]. Thus, maintaining normothermia is crucial to prevent these complications[2].

The use of anaesthetics during a procedure can directly inhibit thermoregulation, reduce internal heat production and induce perioperative hypothermia. This effect is exacerbated by the exposure of the operating field to a cold environment, which increases heat loss[4].

Following the induction of anaesthesia and during surgery, the body is accessed to approach relevant organs and cavities to perform the surgical procedure. This triggers a general adaptation syndrome, resulting in a series of neuroendocrine and metabolic responses that affect hypothermia and haemostasis[5].

Perioperative hypothermia can affect coagulation and platelet function, leading to increased blood loss and, consequently, the need for blood transfusion in surgical patients. Vasoconstriction, and a reduction in tissue perfusion, typically occurs to compensate for and restore the body temperature. This leads to a reduction in oxygen pressure in the tissues which, in turn, results in neutrophil-mediated oxidative death and vasoconstriction-induced tissue hypoxia[6].

The presence of hypothermia can suppress enzymatic reactions in the coagulation cascade, even when the levels of coagulation factors are within the normal range. Specifically, hypothermia can trigger disturbances in haemostatic mechanisms, including protein C activation, platelet dysfunction, fibrinogen depletion and disruption of the endothelial glycocalyx[3,7].

Notably, mild to moderate hypothermia has been shown to prolong the mean prothrombin and partial thromboplastin times by 40 to 60 per cent. In addition, hypothermia has been reported to promote coagulation disorders after surgical trauma and metabolic acidosis, a phenomenon known as the lethal triad. Currently, there is no consensus on whether coagulopathy occurs due to metabolic acidosis, hypothermia or a combination of these factors following trauma[3,7].

Considering the complications associated with perioperative hypothermia and its implications for blood coagulation, identifying biomarkers that can be monitored pre-operatively represents an advancement in planning care for surgical patients. This practice of pre-operative monitoring and evaluating coagulation biomarkers by the surgical team not only supports the team but also allows direct interventions in modifiable factors, improving the quality of care and preventing complications[8].

The causal factors that underly vascular complications in operative wounds and coagulation disorders associated with perioperative hypothermia during elective surgeries remain multifactorial and inconclusive; nevertheless, it is crucial to examine biomarkers altered by perioperative hypothermia. The objective of this systematic review was twofold: to synthesise knowledge regarding coagulation biomarkers and perioperative hypothermia by identifying biomarkers that occur perioperatively in patients undergoing elective surgical procedures, and to determine the impacts on perioperative nursing. The guiding question was 'What evidence is available on biomarkers of blood coagulation and perioperative hypothermia associated with perioperative nursing management?'

Methods

Review methods

A systematic review was conducted following the stages of theme identification and research question selection, establishment of eligibility criteria and search strategy, data extraction/categorisation of studies, evaluation of included studies, interpretation of results and synthesis of data[9]. The PICO (patient/population, intervention, comparison, outcomes) framework was used where the population was adults (≥ 18 years) and older patients (> 60 years) undergoing elective surgery, the intervention was biomarkers of blood coagulation and the outcome was body temperature parameters (perioperative hypothermia). The comparison element was not applicable to this study. Primary quantitative studies were included in the review. This systematic review protocol was registered in the Open Science Framework (OSF) platform (DOI: 10.17605/OSF.IO/WXPRD).

To identify primary studies, the following databases were comprehensively searched: Academic Search Premier – EBSCO, Cumulative Index to Nursing and Allied Health Literature (CINAHL) – EBSCO, Cochrane Central Register of Controlled Trials (Cochrane CENTRAL) – Wiley/Cochrane, Embase – Elsevier Science, Latin American and Caribbean Health Sciences Literature (LILACS) – Bireme, PubMed – US National Institutes of Health, and Web of Science Core Collection – Clarivate Analytics. Additionally, we searched grey literature using OpenGrey. The search strategies were formulated by combining descriptors and/or keywords 'hypothermia', 'hemostasis, AND/OR perioperative', along with their synonyms, using the Boolean operators AND and OR. These strategies were adapted to the specifications of each database (see Supplement 1). The databases were searched on 11 August 2023 and again on 16 June 2024.

After searching the selected databases, the results were exported to EndNote Basic®, an online version of the reference manager, to remove duplicates. The results were then exported to the Rayyan web platform[10], where two reviewers independently read the titles and abstracts to determine which records met the guiding question and eligibility criteria of the review. Primary studies deemed eligible were independently read in full by two reviewers. In the event of a disagreement between the reviewers, a third reviewer with relevant subject matter expertise was consulted. Figure 1 summarises the study selection process.

Primary quantitative studies conducted on adult and older patients undergoing elective surgical procedures, in which the researchers assessed temperature parameters and collected laboratory tests and blood coagulation biomarkers, were included. The choice of studies with a quantitative approach to answer the research question regarding blood coagulation biomarkers and perioperative hypothermia in elective surgeries is justified by the precision and objectivity of measuring the variables, the ability to generalise the results, the identification of patterns and correlations between variables, and the reliability of the data obtained using standardised methods. These characteristics are essential for developing a robust evidence base and supporting informed and effective clinical practice.

There were no restrictions on language or period of publication. Studies that did not meet the scope of the review were excluded – studies involving paediatric patients and patients undergoing elective surgical procedures with induced hypothermia, emergency procedures, case reports, reviews, letters, expert opinions, book chapters, study protocols, dissertations, theses, institutional manuals, reports, case series and conference abstracts.

Data from the primary studies were collected using a script developed by the main author with the following information: reference and year

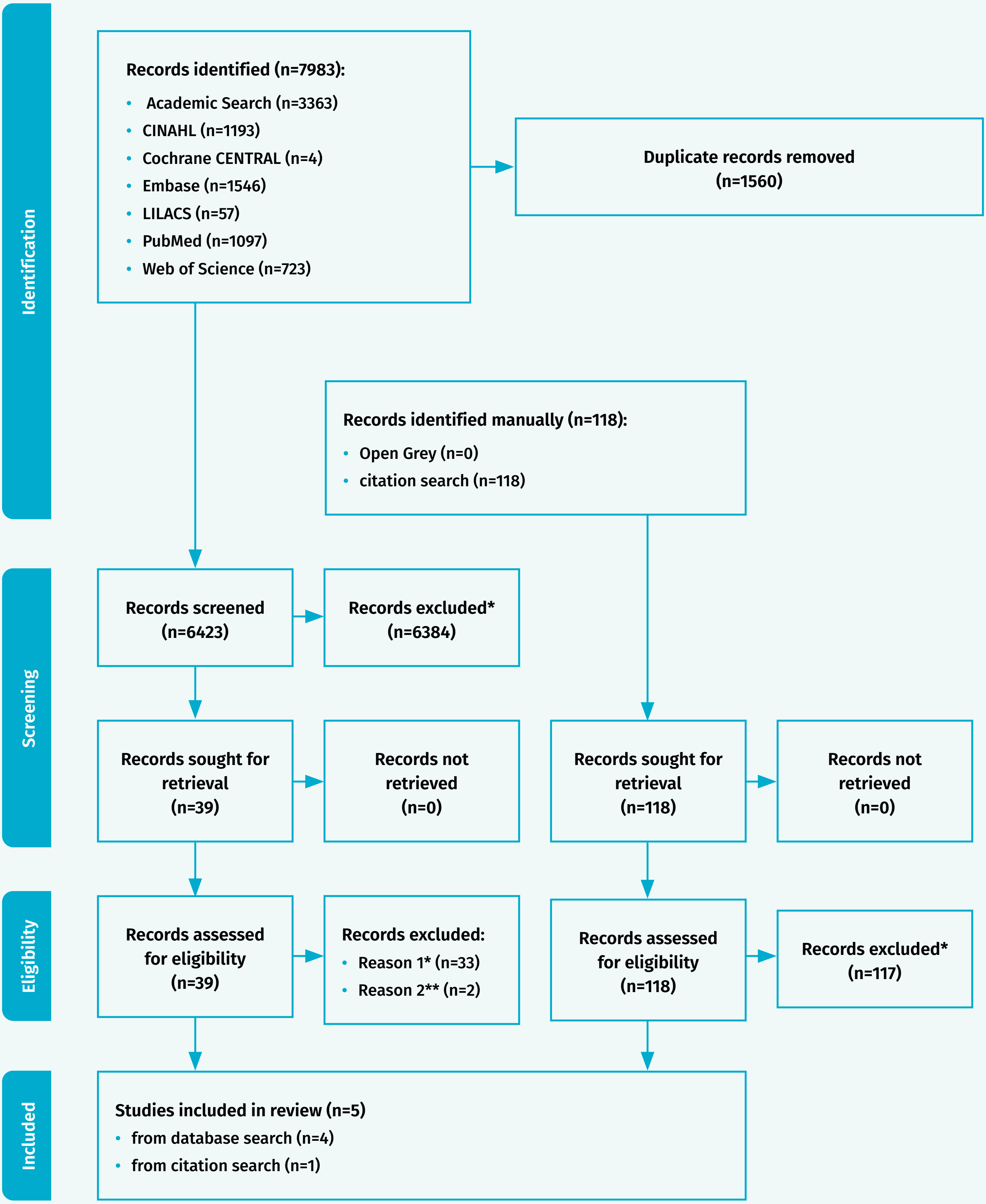

Figure 1: PRISMA flow diagram[11] of study selection process

* Studies that did not meet the scope of this review were excluded: case reports, letters, expert opinions, book chapters, study protocols, dissertations, theses, institutional manuals, reports, case series and conference proceedings and abstracts.

** Studies involving paediatric patients, patients undergoing elective surgical procedures with induced hypothermia and emergency procedures were excluded.

of publication, methodological characteristics (study design, according to the nomenclature used by the authors, and sample), objectives and main results of the study. Data was synthesised descriptively. A meta-analysis was not conducted owing to the heterogeneity of the outcomes reported in the included primary studies.

To critically evaluate primary studies, we assessed the risk of bias using tools provided by the JBI Collaboration. This international collaboration provides free critical appraisal tools for each type of study, including randomised clinical trials and case control studies. Thus, the JBI checklist for randomised controlled trials was used to assess randomised clinical trials, while the JBI checklist for case control studies was used for case control studies. Each tool contains specific questions with four answer options: yes, no, unclear or not applicable. Two reviewers performed the evaluations independently.

Results

Overall, 7983 publications were initially identified in the databases searched. Of these, 1560 were excluded owing to duplication in at least two databases, resulting in 6423 articles. After reading the titles and abstracts, 6384 publications were excluded because they failed to meet the review question or eligibility criteria. Of the remaining 39, four were considered eligible after reading the full text. (Supplement 2 lists the ineligible studies and reasons for their exclusion.) An additional study was identified during a manual search of the references listed in the primary studies included. Thus, the systematic review sample consisted of five primary studies: four randomised clinical trials and one case control study. A descriptive summary of the studies included in the review – according to the authors, title, study design, sample, control and experimental groups, type of anaesthesia, objective, temperature parameter, measurement site, blood assessments, time of collection and main results – is included in Supplement 3.

Coagulation tests and biomarkers

The main coagulation tests and biomarkers identified in these studies are related to secondary coagulation. Prothrombin time (PT) was the most investigated, assessed in all the included studies[12–16], followed by activated partial thromboplastin time (APTT)[12–14], plasma fibrinogen concentration[12,13,15,16], TT[13–15] and activated clotting time (ACT)[12]. Other tests performed in the included studies were coagulation activity[12], haemoglobin (mg/dl)[14,15], pH[13], bleeding time(s)[12], platelet count (PLT)[13,15], thrombin time (TT)[13], white blood cells[13], total bilirubin[13], glucose[13] and lactose[13].

Regarding the time of sample collection, three studies reported the collection time as follows: one hour before induction of anaesthesia and at the end of surgery[12]; at the beginning of anaesthesia induction, at the beginning of the operation, 30 to 60 minutes after the beginning of surgery, at the end of surgery and on post-operative day 1[14]; and pre-operatively, immediately after surgery and on post-operative day 1[15]. The other two studies did not mention the time of sample collection[13,16].

There were no significant differences in PT or plasma fibrinogen concentrations between the heated and unheated groups. Patients who received passive warming methods (control group) with a reduction in body temperature had significantly higher APTT and bleeding times than normothermic patients[12].

In one study, TT was the only altered factor and was lower in the group that received fluid warming. The authors observed that this measure improved post-operative coagulation function, as evidenced by the improved PLT and TT in the heated group, indicating better control of normothermia and reduced hospitalisation time compared with the control group[13].

No significant differences were detected in the results of the relevant tests conducted to support the hypothesis that hypothermia induces intra-operative coagulation. However, the evaluation of intra-operative bleeding revealed reduced bleeding in the intervention group, in which hypothermia was prevented, compared with that in the control group[14].

In another study, PT, APTT and fibrinogen were measured after leaving the operating room to determine the coagulation function of the two patient groups that received different preventive hypothermia approaches. In the group that received additional targeted preventive measures to prevent hypothermia, PT and APTT were elevated while fibrinogen was reduced[16].

Body temperature

Two studies measured temperature in the tympanic region[12,15] and two via the nasopharynx[14,16]. The other study did not describe the location of temperature measurement[13]. Temperature was measured at a range of times: one hour before anaesthesia induction and at the end of surgery, when blood samples were collected[12]; during the pre-, intra- and post-operative periods[13]; before anaesthesia, immediately after anaesthesia, immediately after the start of the operation and every ten minutes until the end of anaesthesia[14]; every 20 minutes during surgery and every 30 minutes during the post-operative period for two hours[15]; every 15 minutes during the operation[16].

Two studies reported that the control group had lower body temperatures than the experimental group: respectively, 34.9 °C and 36.1 °C six hours after the start of surgery[13] and 34.0±1.0 °C and 36.0±0.6 °C post-operatively[12]. Three studies reported the ambient temperature of the operating room was maintained at 21 °C,[15] between 22°C and 24°C[14] and between 24°C and 26°C[16].

Type of anaesthesia

Patients underwent general anaesthesia during elective procedures in four studies[12–15]. The other study did not specify the type of anaesthesia[16].

Quality appraisal

The relevant JBI critical appraisal tools were used to evaluate the studies (see Supplement 4). Three of the four randomised controlled trials received an overall score of 100 per cent, the fourth received an overall score of 85 per cent. The case control study had an overall score of 90 per cent. All primary studies included in this review reported having received prior ethical approval from their respective research ethics committees, ensuring compliance with ethical standards.

Discussion

In the current review, the analysed studies performed coagulation tests and measured coagulation factors. PT was most often investigated (assessed in all five included studies[12–16]), followed by APTT (assessed in four studies[12–15]), fibrinogen (assessed in four studies[12,13,15,16]), TT (assessed in three studies[13–15]) and ACT (assessed in one study[12]).

PT is sensitive to deficiencies in coagulation factors V, VII, X, II and fibrinogen, and determines extrinsic and common coagulation pathways, with reference values varying according to the reagents used in the laboratory. This test monitors the extrinsic pathway, which operates on the surface of cells that express tissue factors, initiating the coagulation process. The measurement of PT can guide the assessment of the levels of procoagulants involved in the coagulation initiation phase[17,18]. All studies included in this review collected PT samples. However, only Schmied et al.[15] found that the PT decreased from 94 per cent pre-operatively to 65 per cent (n = 10) immediately after surgery, remaining at 67 per cent the following morning, with no significant difference between the hypothermic and non-hypothermic groups.

APTT, the second most frequently performed test, analyses the coagulation factors of the intrinsic and common pathways, and detects deficiencies in factors VIII, IX, XI and XII; prekallikrein and kininogen; factors II, V and X, and fibrinogen. Alteration in this parameter indicates a tendency towards bleeding. Monitoring the intrinsic pathway using this test makes it possible to verify the activation of platelets that produce thrombin, resulting in the formation and stabilisation of fibrin clots. Moreover, APTT enables the assessment of levels of procoagulants involved in the propagation phase, where complexes are formed on the platelet surface[17,18].

Fibrinogen was the third most frequently measured coagulation factor. Fibrinogen deficiency (factor I) compromises the final coagulation phase. The TT assesses the time taken for fibrinogen to turn into fibrin in the presence of a standardised amount of thrombin. This test is used to detect abnormalities in fibrinogen and assess both the final fibrinogen pathway and factor I and fibrinogen levels, which are essential for surgical wound healing. During the coagulation cascade, fibrin is formed from fibrinogen by the action of thrombin and becomes stable through fibrin polymerisation. This process occurs in the presence of activated factor XIII, which promotes the formation of strong or covalent bonds. Notably, fibrin polymerisation fails to occur in the absence of factor XIII[17].

ACT was verified in one study[12], although the method used to obtain the ACT was not clarified. The reference value for this test varies depending on the laboratory and the size of the collection tube. Samples are typically collected and obtained from screening tests, such as APTT and PT clotting time. ACT results are expressed in seconds and as the ratio of the APTT of the patient's plasma to the APTT of normal plasma[17].

The studies included in this review differed in the timing of the collection and performance of laboratory tests (biomarkers). The ideal time for collection was not standardised, with collection performed at different times: pre-operatively, before and after the induction of anaesthesia, and on post-operative day 1. In future research, the tests should be conducted pre-operatively, before any medication is administered, after the induction of anaesthesia, before the surgical incision begins, 30 minutes after the incision, at the end of the procedure and 24 hours post-procedure.

It is also recommended that collection tubes, needle gauge (25×7 is suggested) and tourniquet time on the limb (avoiding applying the tourniquet for more than a minute) are standardised; the correct volume of blood is collected in the tubes, the cap of the tube is never punctured with a needle to pass the blood and the needle is removed before adding it to the open tube; blood collection in peripheral venous access is avoided, and sample transport is standardised[17].

The association between perioperative hypothermia and activation of coagulopathies or alterations in the coagulation cascade has been discussed extensively[3]. The results of the current review showed changes in laboratory test results and temperature parameters; however, the evidence generated did not clarify whether hypothermia triggers coagulopathy. Although the results of these studies indicate parameters related to reduced platelet aggregation (thromboplastin time and bleeding time) are increased in patients with hypothermia, there is a lack of consistent statistical analysis to prove the relationship between hypothermia and changes in laboratory test results[12,15].

Perioperative hypothermia directly affects the coagulation cascade and triggers increased bleeding, haemorrhage and coagulopathy. Patients with hypothermia are more prone to bleeding, with consequent alterations in haemostatic mechanisms[19]. In a revised study by Schmied et al.[15], maintaining normothermia during the intra-operative period reduced blood loss. Blood loss was substantially greater in the hypothermic group, with haemoglobin concentrations similar to those in the normothermic group but slightly lower on post-operative day 1[15]. Despite hypotheses about and research into the association between hypothermia and coagulopathy, there are gaps in the literature owing to the lack of consensus on which laboratory tests are indicated and can be reliably performed in normothermic patients, along with the ideal time for collection.

Unintentional alterations in coagulation factors can influence the entire coagulation cascade, particularly in patients with hypothermia owing to vasoconstriction. Alterations in primary coagulation begin when the coagulation cascade is activated, with repercussions during surgery owing to increased bleeding and, consequently, tissue hypoxia[19].

Considering the relationship between hypothermia and coagulation, it is crucial to adopt measures to prevent complications. The screening tests recommended for normothermic patients should focus on both primary and secondary coagulation, with emphasis on primary coagulation and factors that activate primary coagulation by initiating the coagulation cascade. Based on this review, we suggest that PT, APTT, thromboplastin (factor III), TT, fibrinogen, platelet count (activated in primary and secondary coagulation) and factor XIII are determined in future studies on hypothermia and coagulopathy. According to the discussion of physiology in the literature, pH measurement and thromboelastography must be performed; the latter was mentioned but not performed in the included studies[3,19,20].

Implications for practice

In relation to patient safety, assessing coagulation biomarkers and identifying potential alterations represent key initial steps for perioperative nurses to initiate early measures to maintain normothermia, starting in the pre-operative period. This proactive approach helps prevent inadvertent hypothermia and, consequently, disturbances in coagulation biomarkers and the coagulation cascade.

Perioperative nurses play a crucial role during pre-operative assessment and surgical scheduling in identifying patients who are at increased risk of bleeding, undergoing major procedures or more likely to experience perioperative hypothermia. Perioperative nurses are also essential in designing and implementing care protocols that include the pre-operative assessment of coagulation biomarkers, particularly for patients at high risk of hypothermia and those undergoing major surgeries, while also determining the appropriate clinical response to specific biomarker alterations. They also contribute to the establishment of and adherence to structured protocols for maintaining normothermia.

By aligning biomarker monitoring with evidence-based nursing interventions, perioperative nurses gain greater autonomy and support for clinical decision-making, ultimately promoting patient safety and standardised care practices.

Strengths and limitations

This review contributes to the available literature by identifying the most frequently assessed coagulation biomarkers worldwide, offering a valuable reference to guide perioperative nursing practices in an area that remains underexplored in the literature.

This study had some limitations. The included studies only involved adults undergoing elective surgery; therefore, the results cannot be generalised to the paediatric population. Second, studies involving patients undergoing emergency surgery were excluded; emergency surgeries may be associated with a greater need for transfusion of blood components and blood derivatives, both in terms of frequency and quantity.

Conclusions

In the current review, the evidence synthesised from the analysed studies on perioperative hypothermia and blood coagulation biomarkers indicates that hypothermia alters the coagulation cascade, as indicated by altered haemostasis biomarkers. However, there is a gap in the standardisation of the tests to be performed and the optimal time for sample collection during the intra-operative period. The most frequently investigated coagulation tests and biomarkers in the included studies were PT, APTT and fibrinogen. These should be considered in future investigations, along with thromboplastin (factor III), TT, platelets, factor XIII, screening, pH collection and thromboelastography.

For perioperative nursing care, the coagulation tests and biomarkers identified in this review are of substantial scientific relevance, ensuring evidence-based health care. This review highlights the biomarkers assessed, considering the numerous available options without consensus. The objective of this review was to assist in the prevention of possible complications related to alterations in the coagulation cascade because of hypothermia and coagulation disorders, which are often unknown.

This review highlights the most commonly assessed coagulation biomarkers, providing essential guidance to support perioperative nursing practice. Early identification of alterations in these biomarkers is pivotal for initiating relevant measures to maintain normothermia, beginning in the pre-operative period. Regarding recommendations for nurses, we emphasise that perioperative nurses play a vital role, not only in recognising patients at high risk for bleeding and hypothermia but also in developing and implementing care protocols based on biomarker monitoring and ensuring strict adherence to normothermia maintenance strategies.

It is essential to emphasise the importance of care during blood sample collection, including the appropriate time and form of limb compression, needle gauge and sample transport, to avoid activation of clotting factors, with consequent alteration of the sample results. By integrating biomarker assessment with evidence-based nursing interventions, nurses can enhance clinical decision-making, promote patient safety and contribute to standardised, high-quality perioperative care.

To advance our understanding of the complex interactions between hypothermia and coagulation, future studies should adopt standardised and detailed sample collection and processing methods. Such practices are essential for validating hypotheses related to the physiology of coagulation and hypothermia, providing a more solid basis for clinical interventions and improving perioperative practices.

Conflict of interest and funding statement

The authors have declared no competing interests with respect to the research, authorship and publication of this article.

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

1. Hooper VD, Chard R, Clifford T, Fetzer S, Fossum S, Godden B et al. ASPAN's evidence-based clinical practice guideline for the promotion of perioperative normothermia [Internet]. J Perianesth Nurs. 2009[cited 2025 May 13];24(5):271–87. DOI: 10.1016/j.jopan.2009.09.001.
2. Kander T, Schött U. Effect of hypothermia on haemostasis and bleeding risk: A narrative review [Internet]. J Int Med Res. 2019[cited 2025 May 13];47(8):3559–68. DOI: 10.1177/0300060519861469.
3. Bjertnæs LJ, Næsheim TO, Reierth E, Suborov EV, Kirov MY, Lebedinskii KM et al. Physiological changes in subjects exposed to accidental hypothermia: An update [Internet]. Front Med. 2022[cited 2025 May 13];9:824395. DOI: 10.3389/fmed.2022.824395.

4. Biazzotto CB, Brudniewski M, Schmidt AP, Auler Júnior JOC. Hipotermia no período peri-operatório [Perioperative hypothermia] [Internet]. Rev Bras Anestesiol [Braz J Anesthesiol]. 2006[cited 2025 May 13];56(1):89–106. DOI: 10.1590/S0034-70942006000100012

5. Medeiros AC, Dantas Filho AMD. Resposta metabólica ao trauma [Metabolic response to trauma] [Internet]. J Surg Cl Res. 2017[cited 2025 May 13];8(1):56–76. DOI: 10.20398/jscr.v8i1.13036

6. Ruetzler K, Kurz A. Consequences of perioperative hypothermia. Handb Clin Neurol. 2018[cited 2025 May 13];157:687–97. DOI: 10.1016/B978-0-444-64074-1.00041-0

7. Thiruvenkatarajan V, Pruett A, Adhikary SD. Coagulation testing in the perioperative period. Indian J Anaesth. 2017[cited 2025 May 13];58(5):565–72. DOI: 10.4103/0019-5049.144657

8. North WD, Kubajak CS, St. Martin BMPH, Rinker B. Dermal autograft using donor breast as alternative to acellular dermal matrices in tissue expander breast reconstruction: A comparative review. Ann Plast Surg. 2017[cited 2025 May 13];78(6S Suppl 5):S282–5. DOI: 10.1097/SAP.0000000000001041.

9. Mendes KDS, Silveira RCCP, Galvão CM. Revisão integrativa: método de pesquisa para a incorporação de evidências na saúde e na enfermagem [A research method to incorporate evidence in health care and nursing: Integrative literature review] [Internet]. Texto Contexto Enferm. 2008[cited 2025 May 13];17(4):758–64. DOI: 10.1590/S0104-07072008000400018

10. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. Syst Rev. 2016[cited 2025 May 13];5(1):210. DOI: 10.1186/s13643-016-0384-4

11. Page M, McKenzie, JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow, CD et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews [Internet]. BMJ. 2021[cited 2025 May 13];Mar 29:372:n71. DOI: 10.1136/bmj.n71

12. Cavallini M, Preis FWB, Casati A. Effects of mild hypothermia on blood coagulation in patients undergoing elective plastic surgery [Internet]. Plast Reconstr Surg. 2005[cited 2025 May 13];116(1):316–21. DOI: 10.1097/01.prs.0000170798.45679.7a

13. Luo J, Zhou L, Lin S, Yan W, Huang L, Liang S. Beneficial effect of fluid warming in elderly patients with bladder cancer undergoing Da Vinci robotic-assisted laparoscopic radical cystectomy [Internet]. Clinics (Sao Paulo). 2020[cited 2025 May 13];75:e1639. DOI: 10.6061/clinics/2020/e1639

14. Pu Y, Cen G, Sun J, Gong J, Zhang Y, Zhang M et al. Warming with an underbody warming system reduces intraoperative hypothermia in patients undergoing laparoscopic gastrointestinal surgery: A randomized controlled study [Internet]. Int J Nurs Stud. 2014[cited 2025 May 13];51(2):181–9. DOI: 10.1016/j.ijnurstu.2013.05.013

15. Schmied H, Kurz A, Sessler DI, Kozek S, Reiter A. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty [Internet]. Lancet. 1996[cited 2025 May 13];347(8997):289–92. DOI: 10.1016/s0140-6736(96)90466-3

16. Zheng P, Ye D, Yin X, Yin L, Zhong Y, Gong R. Preventive intervention for hypothermia in patients undergoing thoracic surgery reduces complications [Internet]. Int J Clin Exp Med. 2020[cited 2025 May 13];13(12):9664–72. Available from: https://e-century.us/files/ijcem/13/12/ijcem0118203.pdf

17. Ministério da Saúde [Ministry of Health]. Manual de diagnóstico laboratorial das coagulopatias hereditárias e plaquetopatias [Manual of laboratory diagnosis of hereditary coagulopathies and plateletopathies]. Brasília: Ministério da Saúde; 2016 [cited 2025 May 13]. Available from: https://bvsms.saude.gov.br/bvs/publicacoes/manual_diagnostico_coagulopatias_hereditarias_plaqueopatias.pdf

18. Ferreira CN, Sousa MO, Dusse LMS, Carvalho MG. O novo modelo da cascata de coagulação baseado nas superfícies celulares e suas implicações [A cell-based model of coagulation and its implications]. Rev Bras Hematol Hemoter [Braz J Hematol Hemother]. 2010[cited 2025 May 13];32(5):416–21. DOI: 10.1590/S1516-84842010000500016

19. Dhanapal J, Curry N. Clinical aspects of coagulation and haemorrhage [Internet]. Anaesth Intensive Care. 2019[cited 2025 May 13];20(3):164–9. DOI: 10.1016/j.mpaic.2019.01.004

20. Bontekoe IJ, Van Der Meer PF, De Korte D. Thromboelastography as a tool to evaluate blood of healthy volunteers and blood component quality: A review [Internet]. Vox Sang. 2019[cited 2025 May 13];114(7):643–57. DOI: 10.1111/vox.12823