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Review

The Effect of Cold Oral Applications in the Management of Postoperative Thirst: A Systematic Review

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A B S T R A C T

Purpose: Thirst is one of the most bothersome symptoms experienced by surgical patients. Effective thirst intervention and management in the Post Anesthesia Care Unit (PACU) and hospital wards is critical because patients are less sedated and more aware than in the past. There is a need to review the literature on the identification and management of thirst in the inpatient and PACU settings. The aim of this systematic review was to examine the available evidence on the effectiveness of oral cold applications on thirst in postoperative patients.
Design: This was a systematic review study. Articles in PUBMED, Web of Science, ScienceDirect, TÜBİTAK-ULAKBİM, and TRDizin databases between January 2008 and January 2023 that included oral cold applications to relieve the thirst of patients in the postoperative period were included.
Methods: The PICOT-SD (Patients Interventions Comparison Outcome Time-Study Design) method was used as an eligibility criterion for inclusion in the study. The eligibility criteria included that the articles were written in English-Turkish and within the target dates, the studies included nursing interventions, the primary outcome of the studies was thirst, and the study sample included postoperative patients. The risk of bias was assessed using the RoB2 tool developed by Cochrane.
Findings: A total of 254 articles were retrieved from the databases using the specified keywords. 244 articles did not meet the study criteria: 30 were excluded because they were not interventional studies, 61 were not conducted in a postoperative population, 56 were duplicates, and 79 were not on a related topic. A total of 10 studies consisting of randomized controlled trials and quasi-experimental articles met the criteria for our review. Oral cold applications effectively reduced the thirst rate of postoperative patients and improved their health-related quality of life. The intervention has also been shown to reduce other anesthesia-related complications.
Conclusions: This systematic review concluded that cold oral applications have promising effects on thirst, dry mouth, and health-related quality of life. Cold oral applications are cost-effective and suitable for large-scale health care applications.

The feeling of thirst, or being thirsty, refers to the desire to drink water or other liquids, and is an important trigger for the consumption of water or other fluids necessary for the proper continuation of bodily functions.[1] Although a subjective experience, this symptom is influenced by environmental and individual factors such as medications, dehydration, fever, excessive sweating, salty diet, and surgery.[2,3] The prevalence of thirst, defined as a multifactorial symptom, has been reported to range from 18.5% to 97.6% in postoperative patients.[4–6] Studies investigating the intensity of thirst using a numerical scale of 0 to 10 have reported that patients experience thirst at an intensity of 6.7 and 6.9.[4,7]

Patients in the perioperative period often describe thirst as intense suffering, more significant than hunger, and, in some cases, described as more distressing than physical pain.[7–9] Causes of postoperative thirst include preoperative fasting time, perioperative blood loss, dehydration, endotracheal intubation, anticholinergics, and anesthetics such as opioids that reduce salivation, as well as other medications used in the surgical procedure.[7,10]

Thirst induced by hypovolemia or surgical changes in osmolarity develops because of hypothalamic-pituitary neuroendocrine responses. Osmoreceptors located in the hypothalamus are responsible for the conscious perception of thirst in response to

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hyperosmolarity and transmit signals to the hypothalamus for the release of antidiuretic hormone.[11–15] In addition, activation of the renin-angiotensin-aldosterone system in the kidney results in the release of angiotensin II, which also leads to hypovolemic thirst.[1,16,17] Thirst quenching relies on two mechanisms that are activated after oral water intake: pre-absorption satiety and postabsorption satiety. Preabsorptive satiety occurs when cold receptors in the oropharynx, called transient receptor potential melastatin 8, are stimulated by cold water or ice.[13,14,16,19] In addition, products containing menthol or cooling agents are perceived as refreshing or stimulating due to their effect on transient receptor potential melastatin 8 cation channels. This mechanism induces satiety faster than other stimuli and allows one to feel full without consuming large amounts of fluid.[18,20,21] Postabsorption satiety occurs as a result of the absorption of water from the gastrointestinal tract and the perception of the decrease in blood osmolarity by osmoreceptors in the hypothalamus. Preabsorptive satiety occurs earlier than postabsorptive satiety and does not require osmotic equilibrium.[7,18] Therefore, thirst-quenching begins before the fluid is absorbed by the body.

Strategies that focus on using the cooling effect to provide preabsorptive satiety[21] and stimulating oral cold receptors with small volumes without using large volumes are appropriate alternatives to reduce thirst for patients who experience thirst during periods of fluid restriction.[22] Therefore, nurses can apply specific interventions that activate preabsorptive satiety.[19] These interventions include frozen drinking water, frozen saline, ice cubes with cold flavored water, cold water spray, cold saline spray, frozen mentholated saline, and mentholated ice after surgery.[7,23–31] Ice is defined as water frozen into a solid state that typically forms at temperatures below 0 °C (Celsius) or 32 °F (Fahrenheit), while cold water is defined as the cooling of water above its freezing point, approximately 5 to 10 °C or 41 to 50 °F.[32–34] The distinction between 'cold' and 'frozen' is crucial in understanding the scope and implications of the results of studies, as each type of application offers different levels of cooling intensity and therapeutic benefits for postoperative thirst management.

There are several studies on the application of cold or ice for thirst-quenching; however, there appears to be a limited number of studies evaluating the efficacy of oral cold applications for postoperative thirst-quenching, and there is no systematic review on this topic. The fact that this systematic review was conducted in a way that included postoperative patients distinguishes this study from other systematic reviews evaluating cold oral strategies. We believe that the results of the present study will guide surgical nurses in incorporating cold oral applications into their routine practice for thirst-quenching in postoperative patients.

Methods

Study Design

This study used a systematic review design.

Search Strategy

This systematic review was conducted using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist.[35] This study is registered in the PROSPERO (International Registry of Prospective Systematic Reviews) database (CRD42023408326).

Eligibility Criteria

The keywords of the study were selected according to the Medical Subject Headings and PICOS. The inclusion criteria for the studies according to the PICOT-SD (Patients Interventions Comparison Outcome Time-Study Design) are as follows.

1. Participants (P): Adult patients undergoing surgery
2. Intervention (I): Cold and oral applications for the prevention and management of postoperative thirst
3. Comparisons (C): Routine care and applications
4. Outcomes (O): Prevention or management of postoperative thirst
5. Time (T): Postoperative period
6. Setting (S): Hospital environment
7. Study Design (SD): Randomized controlled trials (RCTs), experimental studies and quasi-experimental studies

Nonexperimental studies, qualitative studies, reviews, case studies, non-English or non-Turkish language articles, and articles for which the full text was not available were excluded from the study.

Information Resources and Search Strategy

Included articles were retrieved from seven databases, namely ScienceDirect, PubMed, Scopus, Web of Science, CINAHL, TÜBİTAK-ULAKBİM, and TRDizin, between December 2012 and February 2023. Databases were searched using the keywords "postoperative", "thirst", "water", "ice", "cold". Another search was performed for key concepts in each database using the relevant subject headings. The final search was performed by combining individual search hits using appropriate conjunctions (ie, “or” and “and”). An academic librarian was consulted to adjust the search strategy. All records were imported into RAYYAN for analysis.

Study Selection and Data Extraction

The study data were analyzed using the content analysis method.[36] Inductive content analysis was used.[37] Subthemes and themes were created by coding the data (Figure 1).

Using RAYYAN, the first evaluation was started by reading the titles and abstracts, after excluding duplicate publications. All reviewers (SSC, SM, HA) independently performed this assessment procedure to identify potential studies that met the inclusion and exclusion criteria. Studies were discussed again by all investigators if there was any uncertainty about whether they met the inclusion/exclusion criteria.

After this initial phase, two investigators (SM, HA) independently read the full texts of the included articles. Finally, a table was created by obtaining data such as “author(s), year, country, study name, study design, type of surgery, type of intervention, control group, data collection tools and results” to determine the characteristics of the studies (Table 1). The table was extensively reviewed by three investigators.

Risk of Bias

Risk of Bias in Individual Studies

Two reviewers independently assessed the quality of the studies included in this review using the Cochrane bias assessment tool RoB2. The RoB2 risk assessment tool includes selection bias, performance bias, detection bias, attrition bias, and reporting bias, which are rated as "high risk", "low risk", or "uncertain risk".

Results

Search Results

The database search returned 254 articles related to this topic. Duplicates were identified and excluded from the study, resulting in a total of 198 articles. As a result of the title and abstract review, an additional 198 articles were excluded from the study, resulting in 10 articles that met the inclusion criteria. Reasons for excluding

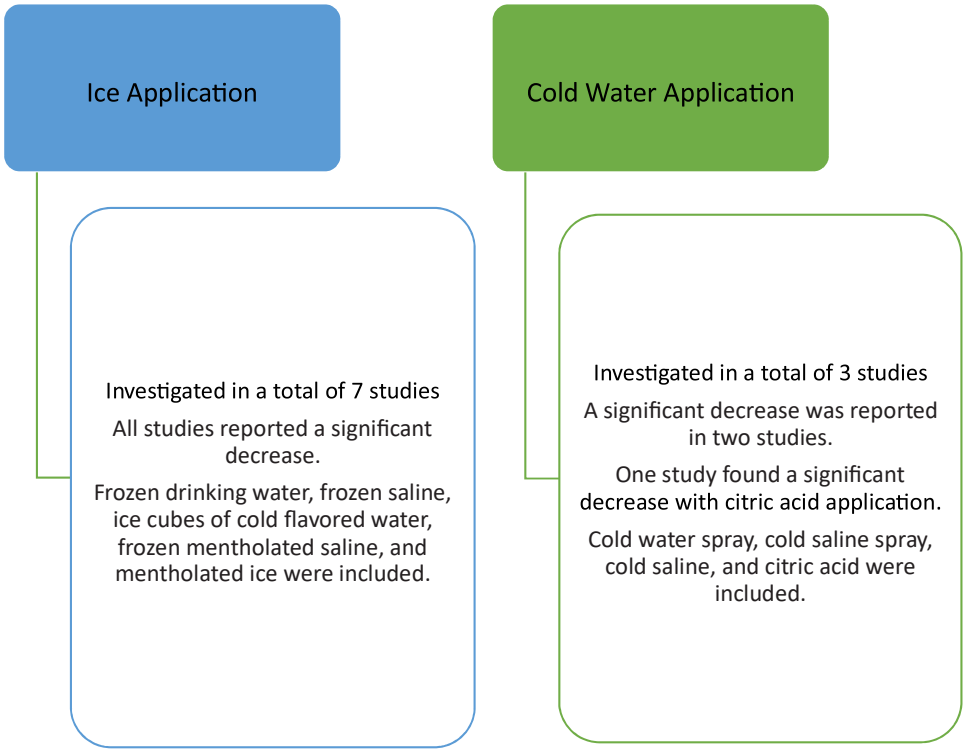

Figure 1. Themes and subthemes obtained according to the results of the content analysis of the studies. "This figure is available in color online at www.jopan.org."

publications were as follows: the study design was non-experimental and not randomized controlled trials, the interventions were not cold applications, and the sample group was not postoperative patients (Figure 2).

Characteristics of Included Studies and Participants

Table 1 shows the characteristics of the 10 studies included in this systematic review. All studies were published between 2017 and 2021, and the designs were randomized controlled trials (50%) and quasi-experimental (50%). Three of the studies were from Brazil,[7,24,25] two from Egypt,[28,29] two from China,[26,27] and three from other countries (Turkey, South Korea, and India).[23,30,31] The minimum sample size was 50 patients, and the maximum sample size was 208 patients in the included studies.

The Numerical Rating Scale was the most commonly used scale to assess postoperative thirst in these studies.[7,25–27,29,30] Other commonly used assessment tools include the Visual Analog Scale,[23,28,31] Perioperative Thirst Discomfort Scale,[27–29] and the Numerical Verbal Scale.[24]

Applications used in the studies to quench postoperative thirst included ice (n:7) and cold liquid (n:3).

Ice Application for Postoperative Thirst

Ice was used to quench postoperative thirst in seven of the included studies. These included ice pops with water (n = 1), mentholated ice pops (n = 2), frozen saline (n = 1), normal saline ice cubes mixed with menthol (n = 1), frozen flavored gargle solution (n = 1) and ice-cold normal saline (n = 1). A decrease in postoperative thirst intensity was observed in all studies using ice.[7,24,25,28–31] Among these studies, Conchon et al[7] compared 10 mL of ice pops with water to 10 mL of fluoridated mineral water at room temperature in 208 patients undergoing elective surgery and observed a significant decrease in postoperative thirst intensity in patients given 10 mL of ice pops with water. In the study by Serato et al,[24] which compared the application of mentholated pops (10 mL) and lip balm with menthol-free ice pops (10 mL) in 127 patients undergoing elective bariatric surgery, a significant decrease in postoperative thirst was observed in the experimental group that was given mentholated pops. In a quasi-experimental study, Elmashad and Gouda[29] applied frozen saline to 66 patients undergoing gynecologic surgery and reported a decrease in thirst intensity and distress in the intervention group one hour after surgery, with a dramatic difference between the two groups one hour after the second intervention.

Cold Liquid Application for Postoperative Thirst

The other three studies included in the review used cold liquid spray to quench postoperative thirst. These included low-temperature cold spray (n:1), cold normal saline and cold water spray (n:1), and cold water spray (n:1). A decrease in postoperative thirst intensity was observed in all studies using cold spray.[23,26,27] Among these studies, Lin et al[27] compared low-temperature cold spray and near-normal temperature spray in 145 patients undergoing cardiac surgery and reported a significant decrease in postoperative thirst in the low-temperature cold spray group. Wu et al[26] compared 30 mL of 75% citric acid spray and 30 mL of cool water spray in 108 patients and reported a significant decrease in postoperative thirst in the experimental group receiving citric acid.

Risk of Bias Results

The studies included in this systematic review were assessed for risk of bias using the RoB2 tool developed by Cochrane.[38] All studies were found to have a low risk of bias. Figures 3 and 4 show the risk of bias and the quality assessment of the studies.

Table 1
Summary of Key Features and Main Conclusions of the Articles Included in the Systematic Review

Author (s)-Year	Study Design	Sample	Intervention			Assessment-Evaluation	Outcome
			Type	Frequency	Control Group		
Conchon and Fonseca, 2018[7]	RCT	208 patients undergoing elective or urgent/ emergency surgery	10 mL ice pops with water	One additional dose 15 min after the previous dose	10 mL room temperature fluoridated mineral water	• Thirst intensity scale (NRS)	Significant difference in the experimental group.
Elmashad and Gouda, 2018[29]	Quasi-experimental	66 patients undergoing gynecological surgery	30 mL frozen saline	Twice (2)	Routine care	• Thirst intensity scale (NRS) • Thirst discomfort scale • Satisfaction survey	Significant difference in the experimental group.
Kaur et al, 2018[30]	Quasi-experimental	60 patients undergoing abdominal surgery	Ice-cold saline	-	Saline at room temperature	• Thirst intensity scale (NRS) • Oral condition assessment tool	Significant difference in the experimental group.
Lin et al, 2022[27]	RCT	208 patients undergoing surgery	Low temperature cold spray	Twice (2) per hour	Wet cotton swab	• Thirst intensity scale (NRS) • Perioperative thirst discomfort scale (PTDS)	Significant difference in the experimental group.
Oh et al, 2017[31]	Quasi-experimental	70 patients undergoing spinal surgery	60 cc frozen flavored gargle solution	Thrice (3)	• Gargle with cold water • Gauze dipped in cold water	• Thirst intensity scale (VAS)	Significant difference in the experimental group.
Oztas and Oztas, 2022[23]	RCT	130 patients undergoing abdominal surgery	50 mL cold normal saline 50 mL cold water spray	Twice (2) per hour	A small amount of water (1–2 mL) at room temperature using a syringe	• Thirst severity (VAS)	Significant difference in the cold water group.
Serato et al, 2019[24]	Quasi-experimental	127 patients undergoing elective bariatric surgery	10 mL mentholated pops + lip balm	Twice postoperatively with an interval of 30 min	Menthol-free ice pops (10 mL) + lip balm	• Numerical verbal scale (NVS)	Significant difference in the experimental group.
Wu et al, 2021[26]	RCT	112 patients undergoing open and endoscopic surgery	30 mL citric acid 75%	Once (1)	30 mL cool water spray	• Thirst intensity scale (NRS)	Significant difference in the experimental group.
Conchon et al, 2021[25]	RCT	50 patients undergoing elective surgery	20 mL mentholated pops	Once (1)	Routine care	• Thirst intensity scale (NRS)	Significant difference in the experimental group.
Sebaee, Elhadary, 2017[28]	Quasi-experimental	60 patients undergoing abdominal surgery	3 mL ice cubes of normal saline mixed with menthol	Twice (2) with an interval of 1 h	Routine care	• Thirst severity (VAS) • Oral condition assessment tool	Significant difference in the experimental group.

RCT, randomized controlled trials; NRS, Numerical Rating Scale; VAS, Visual Analog Scale.

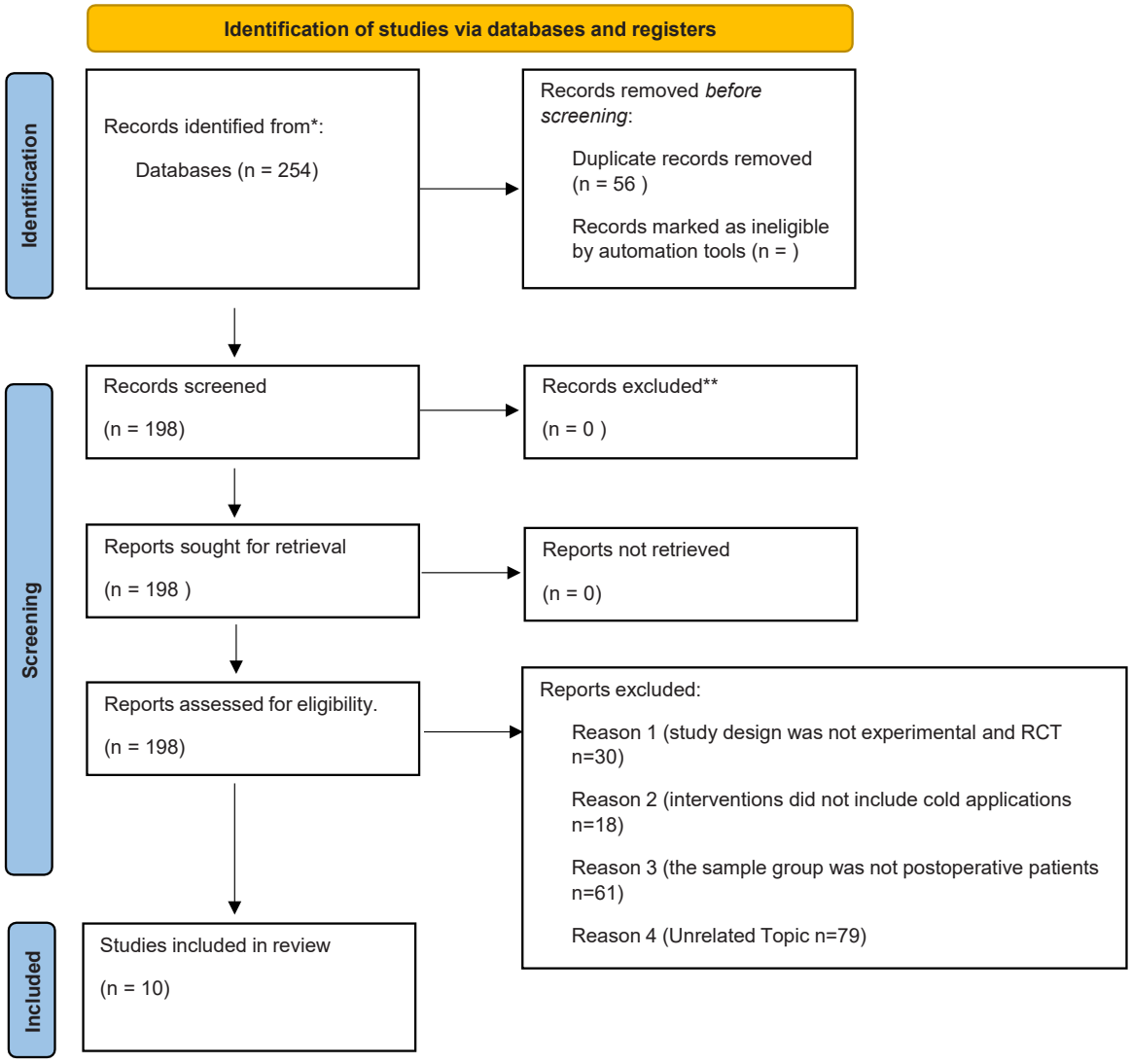

Figure 2. PRISMA flowchart of the current study. "This figure is available in color online at www.jopan.org."

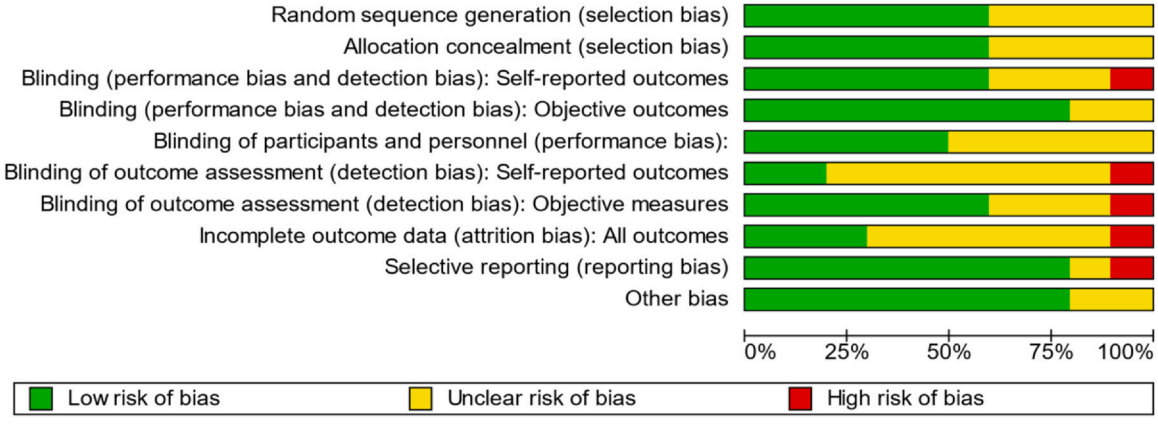

Figure 3. Risk of bias graph. "This figure is available in color online at www.jopan.org."

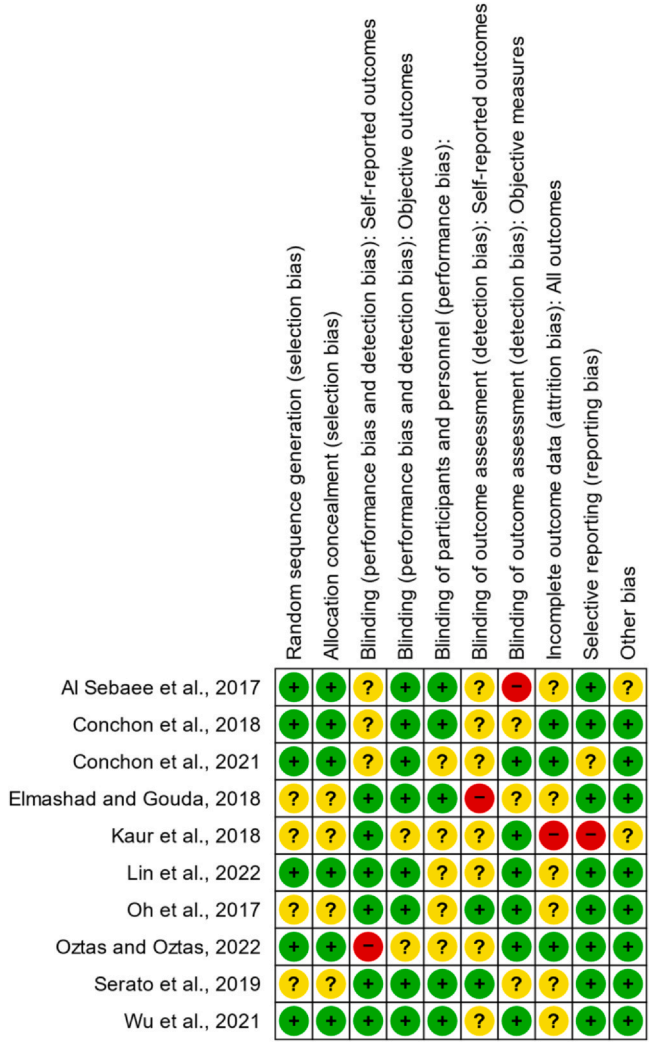

Figure 4. Risk of bias summary. "This figure is available in color online at www.jopan.org."

Discussion

Postoperative thirst is a common problem that causes patient discomfort and triggers negative behaviors such as stress, anxiety, irritability, and hopelessness.[6,39] Perioperative team members should assess patients for signs of perioperative thirst and ask them directly if they are thirsty.[3] This systematic review found that ice and cold liquid applications are used as cold oral interventions to quench or reduce postoperative thirst. These two methods were found to have a positive effect on postoperative thirst.

In our systematic review, we found that the intensity of postoperative thirst decreased in all studies that used ice.[7,24,25,28–31] Similar to the results of our study, other studies have found ice application to be effective in reducing or eliminating the feeling of thirst.[40,41] Aroni et al[42] applied room temperature water and ice to their patients in the early postoperative period and reported that the decrease in thirst intensity was higher in the ice group than in the water group, a finding that parallels the study by Conchon et al[7] included in this review. Studies by Conchon et al[25] and Serato et al[24] found that mentholated ice applied to patients in the postoperative period significantly reduced thirst intensity. These results are consistent with those reported by Karthick et al,[43] who investigated the effect of mentholated ice on thirst in patients undergoing abdominal surgery. Two studies that met the inclusion criteria of our systematic review reported that saline increased salivary secretion and thereby significantly reduced thirst in the experimental group that received frozen saline.[28,29] Seada et al[44] administered frozen saline to patients postoperatively in the surgical ICU to quench thirst and reported a decrease in postoperative thirst consistent with our findings. In the study by Oh et al,[31] which was included in the current systemic review, using ice flavored with peppermint, tea tree, and lemon oil, it was found that the degree of thirst was lower than the control group that was given cold water. The peppermint in the flavored ice mix contains menthol, which has a thirst-quenching effect because it has an oral moisturizing and cooling effect, as well as an increase in cold receptor nerve discharge, which stimulates the sensory receptors in the mouth.[20] It is believed that the lemon oil in this flavored mixture reduces thirst due to its citric acid content. It has been reported that the main effect of flavored ice in reducing thirst is due to stimulation of the preabsorptive satiety mechanism by oropharyngeal thermoreceptors activated by both cold and the menthol in peppermint,[18,21,45] which has been included in this review, citric acid was found to significantly reduce postoperative thirst. Certain topical salivary stimulants, such as citric or ascorbic acid, have been shown to have a thirst-quenching effect in ICU patients treated with an intervention package consisting of vitamin C spray, peppermint juice, gargle, and lip balm.[46] The weak acidity of citric acid spray also stimulates the patient's salivary secretion and provides an oral moisturizing effect.[47,48] In addition, citric acid has a broad-spectrum antibacterial effect and prevents the growth of harmful bacteria in the oral cavity, freshening the individual's breath and increasing oral comfort.[49]

In the present study, it was found that cold liquid spray application is another method whose effect on postoperative thirst has been studied. In 2 of the 3 studies included in this systemic review, the application of cold fluids was shown to have a positive effect on the rate and severity of postoperative thirst.[23,27] Similar to the results of our study, other studies have found that cold liquid application is effective in reducing or eliminating thirst.[7,42,50–53] Puntillo et al[45] reported decreased thirst in 252 ICU patients using ice water spray, and this finding is consistent with the results of Lin et al[27] study included in our systemic review. The study by Öztaş and Öztaş[23] included in this systemic review compared 50 ccs of cold water spray, 50 ccs of cold saline spray, and a syringe with a small amount (1-2 mL) of water at room temperature in 130 patients undergoing abdominal surgery and reported a significant decrease in postoperative thirst intensity. Similarly, Moon et al[54] compared the effects of normal cold saline and cold water on postoperative thirst and salivary pH and observed that cold water significantly reduced postoperative thirst in their cohort.

In addition to these direct effects, effective management of postoperative thirst with cold oral applications may positively influence patients' quality of life, reducing associated discomfort and enhancing overall postoperative recovery.[23–28] A study conducted by Karthick et al[43] demonstrated that patients having cold oral interventions reported notable improvements in comfort and overall well-being during recovery. Similarly, Puntillo et al[45] found that such nonpharmacological approaches contributed significantly to enhanced patient satisfaction post-surgery, further reinforcing the importance of comprehensive symptom management in postoperative care.

Limitations

There are two potential limitations to our study. First, because only studies published in English were included in the review, the exclusion of relevant studies in other languages may have led to publication bias. Second, different interventions, assessment tools, and different follow-up periods for postoperative thirst are

confounding factors leading to clinical heterogeneity. Statistical heterogeneity was observed in the studies included in this review, but the risk of bias was low. The sources of heterogeneity may be due to differences in study design, setting, sample size, type of surgery, and duration of surgery among the studies included in the review.

Conclusion

Nine of the 10 studies included in this systemic review concluded that cold application is effective in quenching thirst, and the tenth study that compared cold application with citric acid reported that citric acid was more effective than cold application. These results strengthen perioperative care and make a significant contribution to health care practice by addressing the scientific evidence for cold oral applications, a key strategy for managing postoperative thirst. However, the fact that most of the studies investigating safe and effective interventions to reduce thirst in this setting have been conducted in the last decade indicates that this is a topic of interest to researchers today. In addition, because one study included in this systemic review found that citric acid application was more effective than cold application for quenching or reducing thirst, more research is needed in this area to determine the level of evidence for citric acid. In addition, the lack of studies comparing the effectiveness of ice application and cold water application for quenching or reducing postoperative thirst indicates a research gap in this area. In conclusion, further research is needed to develop robust evidence and standardized clinical guidelines for oral cold applications that provide a safe, harmless, cost-effective, and feasible strategy.

Declaration of Competing Interest

None to report.

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References

1. Arai SR, Butzlaff A, Stotts NA, Puntillo KA. Quench the thirst: lessons from clinical thirst trials. *Biol Res Nurs.* 2014;16(4):456–466. https://doi.org/10.1177/1099800413505900.
2. Martins PR, Fonseca LF, Rossetto EG. Developing and validating the perioperative Thirst Discomfort Scale. *Revista da Escola de Enfermagem da U S P.* 2017;51:e03240. https://doi.org/10.1590/S1980-220X2016029003240
3. Nascimento LAD, Garcia AKA, Conchon MF, et al. Advances in the management of perioperative patients' Thirst. *AORN J.* 2020;111(2):165–179. https://doi.org/10.1002/aorn.12931.
4. Pierotti I, Fracarolli IFL, Fonseca LF, Aroni P. Evaluation of the intensity and discomfort of perioperative thirst. *Esc Anna Nery.* 2018;22(3):e20170375. https://doi.org/10.1590/2177-9465-ean-2017-0375
5. Serato VM, Fonseca LF, Birolim MM, Rossetto EG, Mai LD, Garcia AKA. Package of menthol measures for thirst relief: a randomized clinical study. *Rev Bras Enfermagem.* 2019;72(3):600–608. https://doi.org/10.1590/0034-7167-2018-0057.
6. Walker EMK, Bell M, Cook TM, Grocott MPW, Moonesinghe SR, Central SNAP-1 Organisation, National Study Groups. Patient reported outcome of adult perioperative anaesthesia in the United Kingdom: a cross-sectional observational study. *Br J Anaesth.* 2016;117(6):758–766. https://doi.org/10.1093/bja/aew381.
7. Conchon MF, Fonseca LF. Efficacy of an ice popsicle on thirst management in the immediate postoperative period: a randomized clinical trial. *J Perianesth Nurs.* 2018;33(2):153–161. https://doi.org/10.1016/j.jopan.2016.03.009.
8. Conchon MF, Nascimento LA, Fonseca LF, Aroni P. Sede perioperatória: uma análise sob a perspectiva da Teoria de Manejo de Sintomas [Perioperative thirst: an analysis from the perspective of the Symptom Management Theory]. *Revista da Escola de Enfermagem da U S P.* 2015;49(1):122–128. https://doi.org/10.1590/S0080-623420150000100016.
9. da Silva, L.C.J.R., Aroni, P., & Fonseca, L.F. (2016). I am thirsty! Experience of the surgical patient in the perioperative period.
10. Gallanosa A, Stevens JB, Quick J. *Glycopyrrolate.* StatPearls Publishing; 2022.
11. Begg DP. Disturbances of thirst and fluid balance associated with aging. *Physiol Behav.* 2017;178:28–34. https://doi.org/10.1016/j.physbeh.2017.03.003.
12. Leib DE, Zimmerman CA, Knight ZA. Thirst. *Curr Biol.* 2016;26(24):R1260–R1265. https://doi.org/10.1016/j.cub.2016.11.019.
13. Zimmerman CA, Leib DE, Knight ZA. Neural circuits underlying thirst and fluid homeostasis. *Nat Rev Neurosci.* 2017;18(8):459–469. https://doi.org/10.1038/nrn.2017.71.
14. Bichet DG. Vasopressin and the regulation of thirst. *Ann Nutr Metab.* 2018;72(Suppl 2):3–7. https://doi.org/10.1159/000488233.
15. Bourque CW. Central mechanisms of osmosensation and systemic osmoregulation. *Nat Rev Neurosci.* 2008;9(7):519–531. https://doi.org/10.1038/nrn2400.
16. Arai S, Stotts N, Puntillo K. Thirst in critically ill patients: from physiology to sensation. *Am J Crit Care.* 2013;22(4):328–335. https://doi.org/10.4037/ajcc2013533.
17. Thornton SN. Thirst and hydration: physiology and consequences of dysfunction. *Physiol Behav.* 2010;100(1):15–21. https://doi.org/10.1016/j.physbeh.2010.02.026.
18. Eccles R, Du-Plessis L, Dommels Y, Wilkinson JE. Cold pleasure. Why we like ice drinks, ice-lollies and ice cream. *Appetite.* 2013;71:357–360. https://doi.org/10.1016/j.appet.2013.09.011.
19. Zimmerman CA, Lin YC, Leib DE, et al. Thirst neurons anticipate the homeostatic consequences of eating and drinking. *Nature.* 2016;537(7622):680–684. https://doi.org/10.1038/nature18950.
20. Eccles R. Role of cold receptors and menthol in thirst, the drive to breathe and arousal. *Appetite.* 2000;34(1):29–35. https://doi.org/10.1006/appe.1999.0291.
21. Leiper JB. Thirst. In: Caballero B, Allen L, Prentice A, eds. *Encyclopedia of Human Nutrition.* 2nd ed. Oxford, UK: Elsevier; 2005:278–286.
22. Garcia AK, Fonseca LF, Aroni P, Galvão CM. Strategies for thirst relief: integrative literature review. Estratégias para o alívio da sede: revisão integrativa da literatura. *Revista brasileira de enfermagem.* 2016;69(6):1215–1222. https://doi.org/10.1590/0034-7167-2016-0317.
23. Oztas M, Oztas B. Effect of spray use on mouth dryness and thirst of patients undergoing major abdominal surgery: a randomized controlled study. *J Perianesth Nurs.* 2022;37(2):214–220. https://doi.org/10.1016/j.jopan.2021.04.018.
24. Serato VM, Fonseca LF, Birolim MM, Rossetto EG, Mai LD, Garcia AKA. Package of menthol measures for thirst relief: a randomized clinical study. *Revista brasileira de enfermagem.* 2019;72(3):600–608. https://doi.org/10.1590/0034-7167-2018-0057.
25. Conchon MF, Fonseca LF, Galvão CM. Use of mentholated popsicle in the management of the elderly patient's thirst in the immediate postoperative period: a randomized controlled trial. *J Perianesth Nurs.* 2021;36(3):262–267. https://doi.org/10.1016/j.jopan.2020.09.013.
26. Wu C, Liu Y, Yang L, Tang Y, Zhou L, Wang X. Thirst relief effect of 0.75% citric acid spray during the anesthesia recovery period: a randomized controlled trial. *J Perianesth Nurs.* 2021;36(6):642–646. https://doi.org/10.1016/j.jopan.2021.01.008.
27. Lin R, Chen H, Chen L, Lin X, He J, Li H. Effects of a spray-based oropharyngeal moisturising programme for patients following endotracheal extubation after cardiac surgery: a randomised, controlled three-arm trial. *Int J Nurs Stud.* 2022;130:104214. https://doi.org/10.1016/j.ijnurstu.2022.104214
28. Sebaee, H.A., & Elhadary, S.M.2017. Effectiveness of a care bundle on postoperative thirst relief and oral condition among patients undergoing abdominal surgeries.
29. Elmashad HAM, Gouda AMI. Effect of frozen saline on postoperative thirst among Women Undergoing Gynecological surgery. *Int J Novel Res Healthc Nurs.* 2018;5(3):180–189.
30. Kaur R. A quasi experimental study to see the effectiveness of oral care with ice cold saline versus room temperature saline on thirst and oral condition among post-operative patients undergone abdominal surgeries at GGS hospital, Faridkot, Punjab. *Innov J Nurs Healthc.* 2016;02(01):198–205.
31. Oh KE, Song AR, Sok SR. Effects of aroma gargling, cold water gargling, and wet gauze application on thirst, halitosis, and sore throat of patients after spine surgery. *Holist Nurs Pract.* 2017;31(4):253–259. https://doi.org/10.1097/HNP.0000000000000219.
32. Douma MJ, Aves T, Allan KS, et al. First aid cooling techniques for heat stroke and exertional hyperthermia: a systematic review and meta-analysis. *Resuscitation.* 2020;148:173–190. https://doi.org/10.1016/j.resuscitation.2020.01.007.
33. Phelan C, Hammond L, Thorpe C, Allcroft P, O'Loughlin M. A novel approach to managing thirst and dry mouth in palliative care: a prospective randomized cross-over trial. *J Pain Symptom Manage.* 2023;66(5):587–594.e2. https://doi.org/10.1016/j.jpainsymman.2023.08.005.
34. Siao SF, Ku SC, Tseng WH, et al. Effects of a swallowing and oral-care program on resuming oral feeding and reducing pneumonia in patients following endotracheal extubation: a randomized, open-label, controlled trial. *Crit Care.* 2023;27(1):283. https://doi.org/10.1186/s13054-023-04568-6
35. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *PLoS Med.* 2009;6(7):e1000097. https://doi.org/10.1371/journal.pmed.1000097
36. Strauss A, Corbin J. *Basics of Qualitative Research.* Sage publications; 1990.
37. Elo S, Kyngäs H. The qualitative content analysis process. *J Adv Nurs.* 2008;62(1):107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x.
38. Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ.* 2019;366:2–7. https://doi.org/10.1136/bmj.l4898.
39. Dessotte CAM, Rodrigues HF, Furuya RK, Rossi LA, Dantas RAS. Stressors perceived by patients in the immediate postoperative of cardiac surgery. *Rev Bras Enferm.* 2016;69(4):694–703. https://doi.org/10.1590/0034-7167.2016690418i.

40. Lee CW, Liu ST, Cheng YJ, Chiu CT, Hsu YF, Chao A. Prevalence, risk factors, and optimized management of moderate-to-severe thirst in the post-anesthesia care unit. *Sci Rep.* 2020;10(1):16183. https://doi.org/10.1038/s41598-020-73235-5
41. Nakaya TG, Conchon MF, Garcia AKA, Uchôa ET, Fonseca LF. Effects of the ice popsicle on vasopressin, osmolality, thirst intensity, and thirst discomfort. *Revista gaucha de enfermagem.* 2021;42:e20190449. https://doi.org/10.1590/1983-1447.2021.20190449
42. Aroni P, Nascimento LA, Fonseca LF. Assessment strategies for the management of thirst in the post-anesthetic recovery room. *Acta Paulista De Enfermagem.* 2012;25:530–536.
43. Karthick P, Thenmozhi P, Kalabarathi S. Effectiveness of menthol ice cube application on thirst intensity and oral condition among postoperative patients. *Int J Res Pharm Sci.* 2020;12(1).
44. Seada AIA, Younis GAE, Eid S. The effect of a frozen saline swab on thirst intensity and dry mouth among critically ill post-operative patients at Tanta university. *Int Acad J Health Med Nurs.* 2020;1(2):189–201.
45. Puntillo K, Arai SR, Cooper BA, Stotts NA, Nelson JE. A randomized clinical trial of an intervention to relieve thirst and dry mouth in intensive care unit patients. *Intensive Care Med.* 2014;40(9):1295–1302. https://doi.org/10.1007/s00134-014-3339-z.
46. Zhang W, Gu Q, Gu Y, Zhao Y, Zhu L. Symptom management to alleviate thirst and dry mouth in critically ill patients: a randomised controlled trial. *Aust Crit Care.* 2022;35(2):123–129. https://doi.org/10.1016/j.aucc.2021.04.002.
47. Bozorgi C, Holleufer C, Wendin K. Saliva secretion and swallowing-the impact of different types of food and drink on subsequent intake. *Nutrients.* 2020;12:4–8.
48. Murugesh J, Annigeri RG, Raheel SA, Azzeghaiby S, Alshehri M, Kujan O. Effect of yogurt and pH equivalent lemon juice on salivary flow rate in healthy volunteers—an experimental crossover study. *Interv Med Appl Sci.* 2015;7:147e151.
49. Wilpiszewska K, Antosik AK, Zdanowicz M. The effect of citric acid on physicochemical properties of hydrophilic carboxymethyl starch-based films. *J Polym Environ.* 2019;27:1379e1387.
50. Aroni P, Fonseca LF, Ciol MA, Margatho AS, Galvão CM. The use of mentholated popsicle to reduce thirst during preoperative fasting: a randomised controlled trial. *J Clin Nurs.* 2020;29(5–6):840–851. https://doi.org/10.1111/jocn.15138.
51. Gómez-Moreno G, Cabrera-Ayala M, Aguilar-Salvatierra A, et al. Evaluation of the efficacy of a topical sialogogue spray containing malic acid 1% in elderly people with xerostomia: a double-blind, randomized clinical trial. *Gerodontology.* 2014;31(4):274–280. https://doi.org/10.1111/ger.12034.
52. Yoon SY, Min HS. The effects of cold water gargling on thirst, oral cavity condition, and sore throat in orthopedics surgery patients. *Korean J Rehabil Nurs.* 2011;14:136–144.
53. Gulia S, Kumari V, Khatri N. Effectiveness of an intervention bundle on thirst inten- sity and dry mouth among patients admitted in ICU. *Int J Health Sci Res.* 2019;9:397–408.
54. Moon YH, Lee YH, Jeong IS. A comparison of effect between wet gauze with cold normal saline and wet gauze with cold water on postoperative thirst, oral cavity condition, and saliva pH. *J Korean Acad Fundam Nurs.* 2015;22:398–405.