SYSTEMATIC REVIEW

Effectiveness of Cold Application in Relieving Pain of Chest Drain Removal among Patients with Open Cardiac Surgeries: A Systematic Review and Meta-Analysis

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Abstract

Background: The process of chest drain removal exposes patients to immense pain, widely recognised as "the worst" experience for patients. Contradictions prevail among researchers regarding pain management during chest drain removal (CDR). Numerous alternative therapies, such as cold application, music relaxation, and aromatherapy, have been attempted to alleviate pain, as pharmacological agents frequently incur significant adverse effects.

Objective: The objective of this systematic review and meta-analysis was to investigate the effectiveness of cold application to relieve the pain of chest drain removal among open cardiac surgical patients.

Methods: The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) was utilised to carry out this study. A sensitive search strategy was conducted in PubMed, CINAHL, PsycINFO, Ovid, Medline and Google Scholar for relevant literature. All studies were Randomised Clinical Trials (RCTs), published between 2002 and 2023 in the English language. The pooled estimate of mean differences, reported with a 95% confidence interval of pain assessment, immediately after CDR (Time 2) and 10 to 20 minutes after CDR (Time 3), were used to analyse pain intensity. Time 1 was not included in the analysis as it was baseline data before intervention.

Results: 10 RCTs satisfied the eligibility criteria, involving 620 participants. The majority of the participants were men. The pooled effect demonstrated that the intervention group experienced statistically significant lower pain (Time 2) immediately after CDR (1.93, 95%CI: 0.68,2.11, p<0.01) and 10 to 20 minutes after (Time 3) CDR (0.95,95%CI:0.36,1.54) than the Control group.

Conclusion: The review concluded that the cold application is an effective therapy to decrease pain due to chest drain removal among patients who underwent open cardiac surgery.

Keywords: *Cardiac surgeries, chest drain removal, cold application, pain, meta-analysis, systematic review.*

INTRODUCTION

Chest drains are placed in the thoracic cavity following cardiac surgeries with the aim to detect hemorrhage, evacuate blood and air from the plural cavity and pericardial cavity, and to prevent effusion, cardiac tamponade, pneumothorax and hemodynamic instability [1]. The safe removal of chest drain is accomplished when the appearance of blood in the tube change to serosanguinous fluid which manifest cessation of active bleeding [2]. Despite contemporary advancement in pain management, the process of chest drain removal (CDR) is accompanied by immense pain, which is reported as the "worse pain" experience for the patients [3-5].

Currently, there is no modality or guideline for this purpose [6]. According to the literature, contradictions prevail regarding pain management of CDR, however recently music therapy, aromatherapy, and cold application have been attempted to alleviate the pain [7, 8]. Furthermore, evidence suggests that pharmacological agents often incur substantial adverse effects such as nausea, hypotension, and gastrointestinal (GI) bleeding [9]. Consequently, the researchers emphasize the need to utilize complementary therapies in patients for cardiac surgeries [10, 11]. Similarly, the researchers showed that cold application has been employed for years to manage pain as a nonpharmacological therapy due to low cost and easy administration [12]. In the first place, cold application stimulates touch receptors with gate control mechanism and releases endogenous opioids. Secondly, it decreases pressure on nerve endings by reducing inflammation, spasm and oedema [13].

There are undesirable consequences if the pain of CDR is poorly managed. Evidence has demonstrated that poorly controlled pain leads to decreased satisfaction and increases stress and anxiety among patients [7, 14]. To prevent this, nurses are required to establish the efficacy of the alternative therapies for pain management.

The current study utilised a systematic review approach to investigate the effect of cold application to the areas around the chest tube to relieve pain of CDR in

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patients with open cardiac surgery and compare it to routine nursing management. The implementation of cold application could offer a simple yet impactful strategy to enhance the postoperative care of patients recovering from open cardiac procedures. Although systematic reviews have documented the effectiveness of cold application in managing the pain of CDR, the populations in these reviews had different diagnoses [9, 15, 16]. No systematic review was found exclusively among patients with open cardiac surgeries.

To clarify the contribution of cold application among patients with cardiac surgery to relieve pain during CDR, an exclusive review of the cardiac surgical patients is important to adequately manage pain. The objective of this review is to estimate the effect of cold application in relieving pain during CDR among open cardiac surgical patients.

METHODS

The current systematic review was carried out using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [17]. The study was registered with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42023479396) on November 14, 2023.

Selection Criteria

Inclusion criteria for the studies were developed from the PICO question. We considered Randomised Clinical Trials (RCTs) focused on cardiac surgical patients aged ≥18 years, published between 2002 and September 2023, in the English language. We excluded studies where pharmacological agents were used, as well as studies that used music therapy, acupuncture and all dissertations.

Data Search Information Sources

A search was conducted in PubMed, CINAHL, PsycINFO, Ovid, Medline and Google Scholar by using the terms "chest drain removal", OR "chest tube removal", AND "cold application", OR "cold sponging", OR "cryotherapy" along with some filters (age range 18 and more, publication from 2002 to 2023, human, peer reviewed articles and full text).

Selection Process

To identify the eligible studies, the reviewer (AK) independently searched, selected the articles and evaluated the studies for inclusion criteria. A second reviewer (SZ) also independently searched using the same MeSH terms and inclusion and exclusion criteria. The search for the studies was performed during October and November 2023. Initially, 495 studies were accessed for abstracts and titles. Of these records, 424 studies were not relevant, and 22 were duplicates.

Further, 49 studies were screened, and 25 were removed, which were not aligned with the inclusion criteria. Of the 24 studies, three studies were removed because they were not related to cardiac surgeries. Twenty-one studies were retrieved in full text. The 21 studies were evaluated for eligibility; six studies were removed because they included participants other than cardiac surgical patients, three used a quasi-experimental design, one study was written in Farsi (Persian), and one was written in the Chinese language. Therefore, the data extraction was performed on 10 studies. The reasons for exclusion and inclusion are presented in the PRISMA flow diagram [17].

Data Extraction

Data from the 10 studies were extracted. An Excel spreadsheet was utilised for the organisation of data. The information extracted from the studies included the first author, year and country of publication, sample size, proportion of men, pain assessment tool, and time and duration of cold application on the chest. Mean differences and standard deviations (SD) of outcomes were extracted from the studies before the CDR procedure, and 10-20 minutes after the CDR procedure. In cases when the studies had documented data multiple times (more than two times) after removal, then, for maintaining uniformity of outcome measures, the assessment immediately after removal of the drains and 10-20 minutes after removal was extracted [18].

The data were verified three times to check for omission and ensure precision and completeness. In the instances of discrepancies, the data were deliberated with subject experts for consensus. The history of data extraction is shown in **Fig. (1)**.

Assessment of the Methodological Quality

Quality assessment of each study was evaluated for five domains with Cochrane Collaboration risk of bias assessment tool [19]. The five domains included randomization process, deviation from intended intervention, missing outcome data, measurement of outcome, and selection of reported result. The methodological quality was assessed with Rob 2 (Risk-of-bias version 2). A single study reported that it was a double blinded study [18]. Three studies reported that the assessors of pain were "blinded" to group assignments [7, 20, 21]. The overall scores of all studies are indicative of low risk of bias. The summaries of the quality assessment are shown in **Figs. (2 and 3)**.

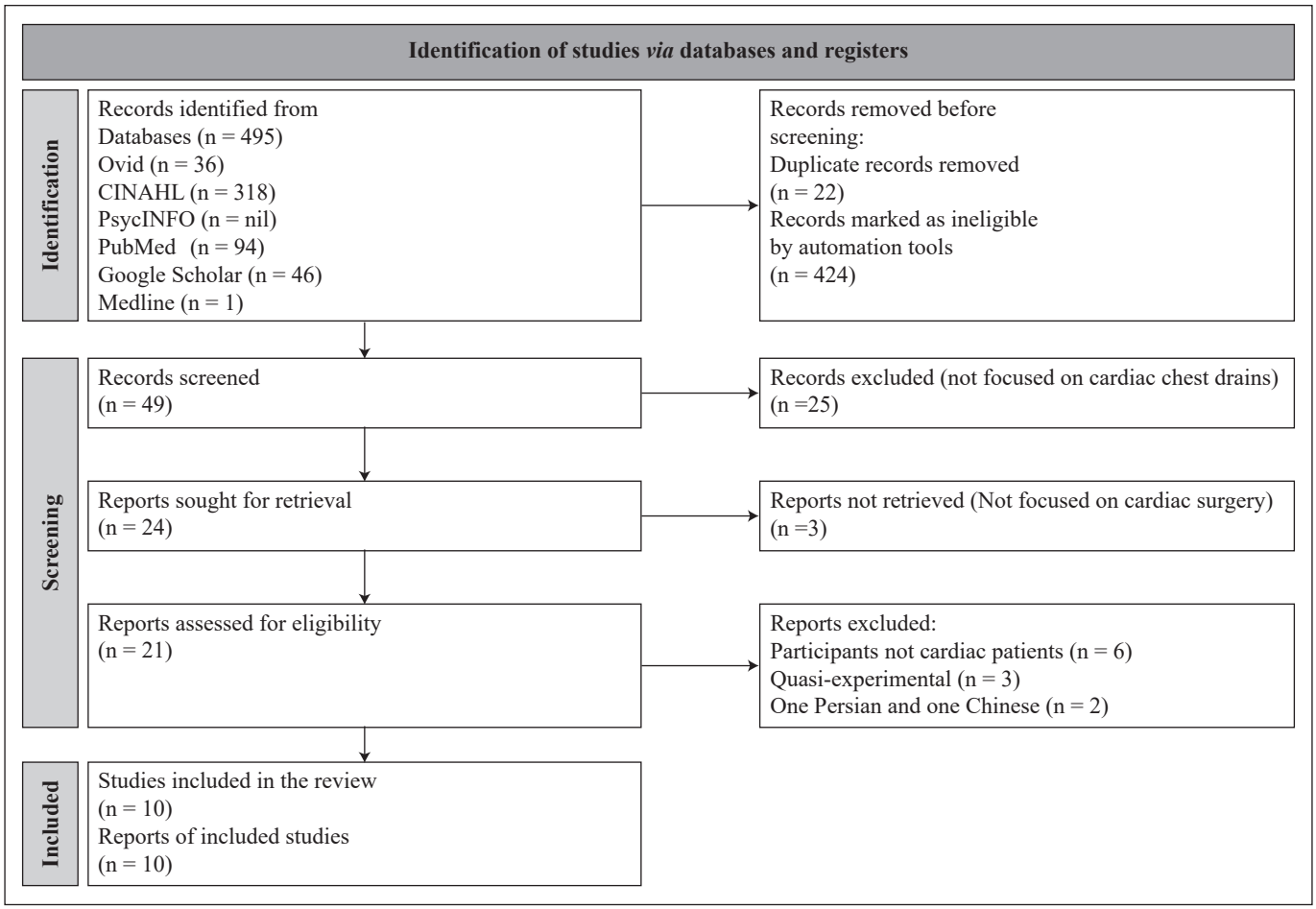

Fig. (1): PRISMA flow chart of the included studies for the meta-analysis.

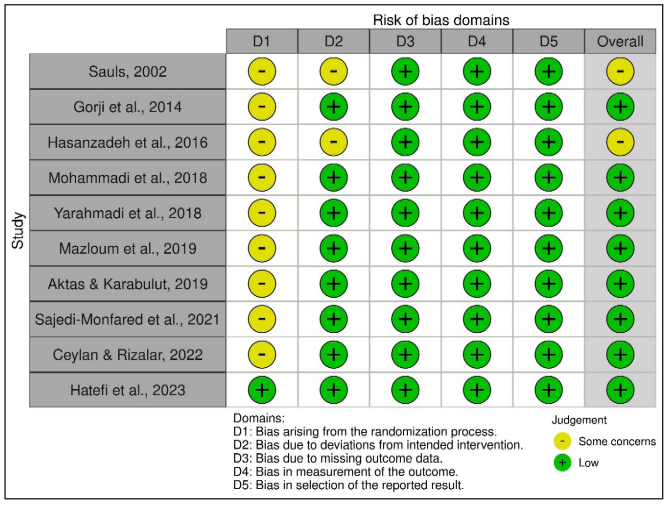

Fig. (2): Graph of risk of bias of included studies.

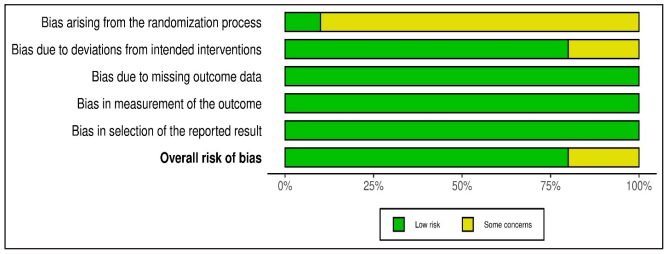

Fig. (3): Graph of the summary of the risk of bias of included studies.

Data Synthesis and Analysis

A meta-analysis was carried out using the Review Manager 5.4 to obtain the pooled effects of cold application on the intensity of pain, choosing the random effect model. Time 1 was not included in the analysis because it was baseline data before the intervention. The pooled estimate of mean differences and 95% Confidence Interval (CI) of pain assessment immediately after CDR (Time 2) and 10 to 20 minutes after CDR (Time 3) were used to estimate the difference in pain intensity between the control and intervention group. A p-value of < 0.05 was considered significant for analysis.

RESULTS

Study Characteristics

For this systematic review, 10 RCT studies met the eligibility criteria. Of these, seven studies [18, 20-25] were published in Iran and two were published in Tukey [7, 26] while one study was published in the US [27], involving 620 participants. Across all studies, 310 were in control groups while 310 in intervention groups. None of the studies had documented adverse effects of the cold application therapy **(Table 1)**.

Table 1: Characteristics of studies and interventions.

Author/ publication year country	No of participants C/I	Mean age n/C/I	M % C/I	No of chest tube	Duration of cold therapy	Assessment tool	Analgesia used	Cold therapy modality	Before intervention Mean ± SD		Immediately After CDR Mean ± SD		Mean difference	After (10-20) CDR Mean ± SD		Mean difference
									C	I	C	I		C	I	
Sauls, 2002. US [27]	25/25	n= 59.70	—	1-3	10	NRS	Yes	Ice bag	1.04 ± 1.60	1.18 ±2.19	6.34 ± 2.52	5.86 ± 2.82	**0.48**	1.94 ± 2.39	1.68 ± 2.30	**0.26**
Gorji *et al*., 2014. Iran [22]	40/40	n =58.11 C= 58.48 I= 57.75	C=57.5 I=57.5	2	10	VAS	Yes	Gel ice pack	0.89 ± 0.56	0.85 ± 0.57	4.6 ± 0.66	2.4 ± 0.52	**2.2***	0.64 ± 0.47	0.42 ± 0.31	**0.22**
Hasanzadeh *et al*., 2016. Iran [18]	20/20	n= 54.3	—	2	—	VAS	Yes	Ice bag	3.6 ± 1.5	2.8 ± 2.0	6.5 ± 1.4	4.4 ± 1.8	**2.1**	3.4 ± 1.6	1.2 ± 1.7	**2.2**
Mohammadi *et al*., 2018. Iran [24]	44/43	C= 58.9 I= 56.8	C=65.9 I=65.1	1	20	VAS	No	Ice bag	1.91 ± 1.21	2.23 ± 1.02	4.73 ± 1.08	3.58 ± 1.09	**1.15**	0.89 ± 0.97	0.72 ± 0.79	**0.17**
Yarahmadi *et al*., 2018. Iran [25]	45/45	n= 58.8 C= 56.8 I=58.9	C=65.9 I=65.1	1	20	VAS	No	Ice bag	1.91 ± 1.21	2.23 ± 1.02	4.73 ± 1.08	3.58 ± 1.09	**1.15**	0.89 ± 0.97	0.72 ± 0.79	**0.17**
Mazloum *et al*., 2019. Iran [20]	17/17	n= 55.4	—	2	20	SFMPQ	No	Ice bag	3.8 ± 3.2	2.8 ±2.7	5.0 ± 3.2	3.5 ± 3.2	**1.5**	—	—	**—**
Aktas & Karabulut, 2019. Turkey [7]	30/30	C= 65.80 I= 62.69	C=76.7 I=73.3	2-3	20	VAS	No	Gel ice pack	2.76 ± 1.27	3.76 ± 0.97	8.20 ± 1.15	8.06 ± 1.63	**0.14**	1.76 ± 1.10	1.60 ± 0.67	**0.16**
Sajedi-Monfared *et al*., 2021. Iran [21]	30/30	R= 18-78 C= 57.70 I=59.43	C=56.7 I=56.7	2	20	NRS	No	Ice bag	1.80 ± 2.21	1.46 ± 2.34	6.33 ± 2.35	5.83 ± 2.42	**0.5**	1.76 ± 2.29	1 ± 1.61	**0.76**
Ceylan & Rizalar, 2022. Turkey [26]	30/30	R= 60-69	C=63.3 I=80	1	15	VAS	No	Gel ice pack	5.57 ± 1.37	4.82 ± 1.79	7.97 ± 1.11	3.92 ± 0.68	**4.05**	5.48 ± 0.90	1.85 ± 0.66	**3.63**
Hatefi *et al*., 2023. Iran [23]	29/30	n= 57.88 C= 55.90 I= 57.03	C=51.7 I =73.3	—	15	VAS	No	Ice bag	0.03 ± 0.18	0.03 ± 0.18	3.83 ± 1.07	2.03 ± 1.0	**1.8**	1.62 ± 0.77	0.53 ± 0.73	**1.04**

*Where **C** = Control Group, **NRS** = Numerical Rating Scale, **I** = Intervention Group, **R**= Range, **n** = Total Participants, **M** = Male, **SD** = Standard Deviation, **CDR** = Chest Drain Removal, **SFMPQ** = Short Form of McGill Pain Questionnaire.*

Demographic Characteristics

All the studies included participants older than 18 years of age while one study [27], included participants of ages 60 to 69 years. Most of the participants were men; while three studies [18, 20, 27], did not indicate the gender of their participants. The number of chest-drains in these studies ranged from one to three **(Table 1)**.

Measurement Tools

The primary outcome of all the studies was reduction in pain experienced from the CDR in patients who has undergone cardiac surgeries. Seven of the studies used a Visual Analogue Scale (VAS) for the assessment of pain. One [20] had used Short-form McGill Pain Questionnaire (SEMPQ) and the other two [21, 27] had used Numeric Rating Scale (NRS). The time duration for the cold application to be kept on the chest around the tube was 10 to 20 minutes. One of the studies [18] did not mention the time but only the temperature of the skin at the end of intervention. Six studies [18, 21, 22, 23, 25, 26] provided cold application together with other nonpharmacological interventions. In that case, only the results for cold therapy were extracted **(Table 1)**.

Measurements

Baseline measures of pain intensity were taken just before CDR (Time 1), then immediately after the CDR (Time 2) and then 10 to 20 minutes later (Time 3). Of the 10 studies, three studies did not show statistically significant difference between the control groups and intervention groups [7, 21, 27].

Data Synthesis and Analysis

The meta-analysis included 10 studies. At time 3 analysis, one study was not included because it had not assessed the pain after 10 to 20 minutes of CDR. The pooled effect demonstrated that the patients in the intervention group who received cold application experienced statistically significant lower pain scores at Time 2 immediately after CDR (1.93, 95% CI: 0.68, 2.11, p< 0.05, **Fig. 4)** and 10 to 20 minutes at Time 3 after CDR (0.95, 95% CI: 0.36,1.54, p<0.05, **Fig. 5**) than those patients who did not receive cold therapy. A high level of heterogeneity was detected for both Time 2 & Time 3 assessments (I2 = 97% and 96% respectively).

Subgroup Analysis

A subgroup analysis was carried out to investigate whether administration of usual pain medication, duration of cold therapy, and modality of cold therapy modify the overall effect of cold application. The result of these analyses is shown in Table **2** (Time 2) and Table **3** (Time 3). The results (Time 2 & Time 3) demonstrated that there were no significant changes when pain medications were administered (p>0.05), duration of therapy (p>0.05), and the modality of cold therapy (p>0.05).

DISCUSSION

This review was carried out to examine the effects of cold application on pain during CDR of patients with open cardiac surgeries. The salient findings of this study show that the there was less pain reported in the intervention group than the control group immediately after CDR and 10 to 20 minutes after CDR. This

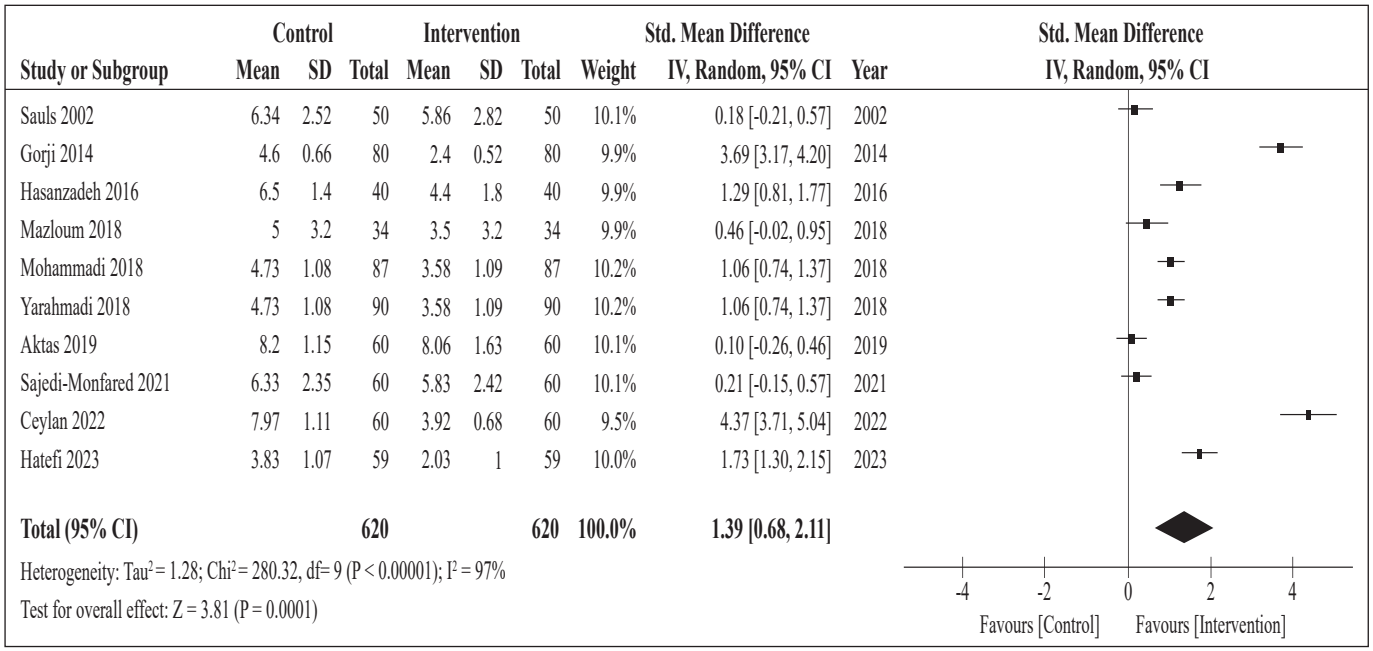

Fig. (4): Time 2 immediately after CDR.

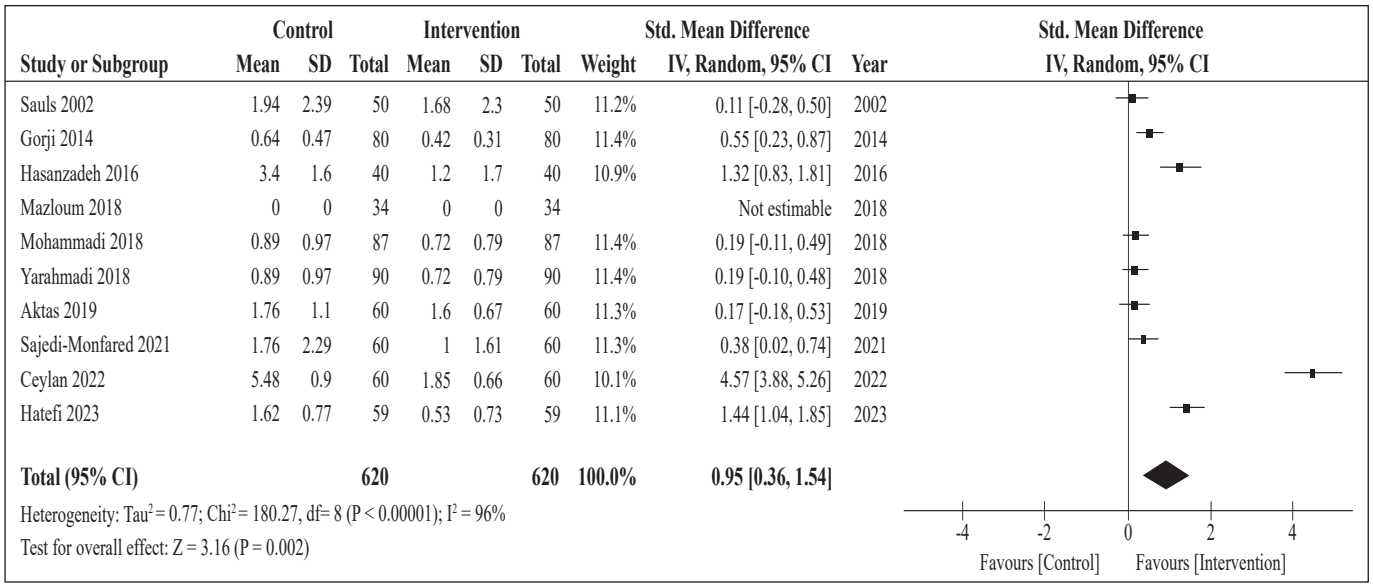

Fig. (5): Time 3, 10 to 20 minutes after CDR.

provides conclusive evidence that cold application was effective intervention to alleviate pain among open cardiac surgical patients. However, the confidence intervals (CI's) were wide indicating low precision in the estimates. The most likely reasons are the variations in populations, sample sizes, methods of interventions, and measurements.

The findings of the current systematic review are consistent with those reported in prior systematic reviews that determined the effects of cold application for CDR [9, 15, 16]. The participants of these reviews had chest tubes due to different diagnoses such as pulmonary effusion, thoracic surgeries and VATs (Video-assisted thoracotomies). The results demonstrated that cold application resulted in a reduction of pain and anxiety from the chest drain removal. Additionally, these researchers advocate the utilisation of cold therapy as it is easy to use, cost-effective, practical, and has no side effects [9, 15, 16].

A similar pattern of empirical evidence was also presented in the systematic review to clarify the effect of cold application in the context of incisional pain of abdominal surgeries [28], the pain from episiotomy [29], bruises and pain of subcutaneous injection of Heparin [30], and migraine pain [31]. These researchers have also demonstrated that cold application is an effective therapy in surgical or medical contexts. The same results were also obtained in the reduction of incisional pain during spirometry [13], coughing and deep breathing exercises among patients undergoing cardiac surgery

Table 2: Subgroup analysis of the effect of cold therapy on pain immediately after CDR (Time 2).

Variable	Effect size	Weight (%)	I^2 (%)	95% CI	p-value
Pain medication before CDR					
Yes	2.08	19.8	98	2.49 (0.14 to 4.83)	0.27
No	3.22	80.2	96	1.11 (0.44 to 1.79)	
Duration of cold therapy					
20 minutes	3.39	60.5	85	0.69 (0.29 to 1.09)	0.06
15 ≤ minutes	2.65	39.5	98	2.48 (0.65 to 4.31)	
Cold therapy modality					
Ice bag	4.02	70.5	88	0.85 (0.44 to 1.27)	0.21
Gel ice pack	1.86	29.5	99	2.71 (.14 to 5.56)	

Table 3: Subgroup analysis of the effect of cold therapy on pain 10 to 20 minutes after CDR (Time 3).

Variable	Effect size	Weight (%)	I^2 (%)	95% CI	p-value
Pain medication before CDR					
Yes	2.37	22.2	85	0.91 (0.16 to 1.67)	0.92
No	2.53	77.8	86	0.96 (0.22 to 1.71)	
Duration of cold therapy					
20 minutes	2.43	56.2	78	0.42 (0.08 to 0.75)	0.10
15 ≤ minutes	2.28	43.8	98	1.64 (0.23 to 3.04)	
Cold therapy modality					
Ice bag	2.63	67.3	89	0.59 (0.15 to 1.03)	0.26
Gel ice pack	1.76	32.7	98	1.74 (0.20 to 3.67)	

[32-35]. These results offer credible evidence of the effective applicability of cold application across diverse patient populations and surgical procedures.

Moreover, in the current review, no statistically significant differences were observed between the cold application of ice bags and the cold application of gel packs. Similar results were also demonstrated by another systematic review [15]. In contrast to this finding, one RCT identified that cold application with ice bags was more effective than cold application with gel packs [36]. The current review also illustrated that there was no significant difference between the duration of 20 minutes, and less than or equal to 15 minutes. This finding is in contradiction with the result shown by the previous study which demonstrated that the duration of cold application of 20 minutes can effectively reduce the intensity of pain due to CDR [9].

Previously, the researchers have studied the comparison of numerous complementary therapies to identify the most appropriate interventions. They have concluded that cold application possessed the same effects as other non-pharmacological therapies. Researchers in one of the studies found no statistically significant difference among cold application, inhalation of lavender oil, and a combination of these [18]. Similarly, equal effects were observed, and no statistical significance was shown between cold therapy and relaxation therapy [22]. Hence, the researchers have provided evidence that cold application may be used for patients as other complementary therapies for the management of pain due to CDR.

LIMITATIONS AND STRENGTHS

There are variations in the baseline data of pain assessment between the control and interventional groups, which may have affected the outcome data. While the findings showed statistically significant improvements in pain, the wide CI suggests that caution needs to be used in the interpretation of the results. The current review has several strengths; it is the first of its kind to be conducted specifically on the patients who had cardiac surgeries. A transparent screening system was used with two independent screeners to obtain unbiased manuscripts. The two reviewers carried out eligibility screening independently from title and abstract reading to full text review. The discrepancies were sorted out with an expert through discussion. The PRISMA guidelines were used to eliminate articles that did not fit the eligibility criteria.

CONCLUSION

The findings of this review demonstrated that cold application is an effective therapy to reduce pain at the time of chest drain removal among patients who underwent open cardiac surgeries. Furthermore, the simplicity, cost-effectiveness, and low-risk profile of cold application are the driving factors to incorporate it into standard postoperative protocols. Hence, the utilisation of cold application before chest drain removal can be recommended to reduce pain in patients during CDR after open cardiac surgery.

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None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Declared none.

AUTHORS' CONTRIBUTION

Asghar Khan: Writing-original draft, conceptualisation, investigation, methodology, data curation, data extraction, formal analysis and validation.

Erika Sivarajan Froelicher: Writing - review & editing, conceptualisation, investigation, methodology, formal analysis, supervision.

Shazia Zaheer: Data curation, software, formal analysis.

Sajid Iqbal: Methodology, Writing, review & editing, validation, supervision.

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