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The effect of cold application on pain during the chest tube removal: A meta-analysis

Göğüs tüpü çıkarma sırasındaki soğuk uygulamanın ağrıya etkisi: Bir meta-analiz

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ABSTRACT

Background: In this meta-analysis, we aimed to investigate the effect of cold application on chest tube removal-related pain compared to conventional analgesic care.

Methods: A systematic review and meta-analysis were conducted (PROSPERO, 2021: CRD42020179867). We searched studies in PubMed, Ovid-LWW, Scopus, Taylor & Francis, Science Direct, EBSCO, Google Scholar, Medline Complete, Cochrane Library and ULAKBIM databases and grey literature for this study. We included the articles published from January 2009 to December 2019. We limited the language to Turkish and English and the design to randomized-controlled trials. All studies were reviewed by two independent researchers. Meta-analysis was performed using the Comprehensive Meta-Analysis version 3.3 software. Heterogeneity was investigated by meta-regression.

Results: A total of 2,462 records were identified, of which 16 studies were included in a random model meta-analysis. The cold application was used in combination with a pharmacological agent in six studies and alone in 13 studies. All patients were older than 16 years and they had at least one chest tube. Cold application was found to be effective in relieving pain during chest tube removal (d=-1.265).

Conclusion: The use of a non-pharmacological method such as cold application is helpful to reduce pain or reduce painkiller doses during chest tube removal. Its use is recommended, as it is effective, easy to use, and cost-effective without any side effects.

Keywords: Chest tube removal, cold application, non-pharmacological approaches, pain.

ÖZ

Amaç: Bu meta-analizde, standart analjezik tedaviye kıyasla soğuk uygulamanın göğüs tüpünün çıkarılması ile ilişkili ağrı üzerindeki etkisi araştırıldı.

Çalışma planı: Sistematik derleme ve meta-analiz yapıldı (PROSPERO, 2021: CRD42020179867). PubMed, Ovid-LWW, Scopus, Taylor & Francis, Science Direct, EBSCO, Google Scholar, Medline Complete, Cochrane Library ve ULAKBIM veri tabanlarındaki çalışmalar ve gri literatür tarandı. Ocak 2009 - Aralık 2019 tarihleri arasında yayımlanan makaleler çalışmaya alındı. Dil, Türkçe ve İngilizce ve çalışma türü randomize kontrollü çalışmalar ile sınırlandı. Tüm çalışmalar iki bağımsız araştırmacı tarafından gözden geçirildi. Meta-analiz, Kapsamlı Meta-Analiz versiyon 3.3 yazılımı kullanılarak gerçekleştirildi. Heterojenite meta-regresyon ile araştırıldı.

Bulgular: Toplam 2.462 kayıt tespit edildi ve bunların 16'sı rastgele modelli meta-analize dahil edildi. Soğuk uygulaması altı çalışmada farmakolojik bir ilaç ile birlikte yapılırken, 13 çalışmada tek başına yapıldı. Hastaların tümü 16 yaşından büyüktü ve en az bir göğüs tüpü yerleştirilmişti. Soğuk uygulamanın göğüs tüpü çıkarılması sırasında ağrının giderilmesinde etkili olduğu belirlendi (d=-1.265).

Sonuç: Soğuk uygulama gibi farmakolojik olmayan bir yöntemin kullanılması, göğüs tüpü çıkarılması sırasında ağrının azaltılması veya ağrı kesici dozlarının düşürülmesine yardımcı olur. Düşük maliyeti ve yan etkilerinin olmayışı ile birlikte etkinliği ve kullanım kolaylığı nedeniyle, kullanımı önerilmektedir.

Anahtar sözcükler: Göğüs tüpü çıkarma, soğuk uygulama, farmakolojik olmayan yaklaşımlar, ağrı.

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Chest tube placement (tube thoracostomy) is a common intervention in daily clinical practice and defined as draining the pleural and mediastinal air (pneumothorax), blood (hemothorax), fluid (pleural effusion or hydrothorax), chyle (chylothorax), or purulence (empyema) from the intrathoracic space by inserting a tube into the pleural space.[1] The system is airtight to prevent the inflow of atmospheric pressure. As the pleural cavity normally has negative pressure, which allows for lung expansion, any tube connected to it must be sealed so that air or liquid cannot enter the space where the tube is inserted. Removal of the drains leads to adhesion rupture and stimulation of the parietal pleura and pectoral muscles followed by the release of neurotransmitters and stimulation of pain receptors, eventually resulting in acute pain.[2,3] Chest tube removal (CTR) is a painful, distressful procedure and frightening experience described by patients to be among the most unpleasant feelings. Therefore, it should be managed with as little pain and distress as possible.[4,5]

Pain is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage".[6] Chest tube removal-related pain is one of the most important complications after cardiac and thoracic surgery. In addition to medical treatments such as paracetamol[2] and remifentanil,[7,8] the effects of complementary therapies, alone or in combination with medical treatments, have been studied for relieving pain during CTR.[4] Some of these methods are ice pack,[9-11] acupressure,[12] relaxation,[13] gel pack,[14] intravenous paracetamol combination with cold gel packet,[2] cold compress and local anesthesia,[15] cold application and aromatherapy with lavender oil, and cold application in combination with lavender oil inhalation,[16] and cold application combined with a breathing exercises technique.[17]

Cold desensitizes sensory nerve terminals and reduces the transmission of pain. Local application of cold causes vasoconstriction, reduces blood flow to tissues and muscle spasms, reduces the secretion of bradykinin, serotonin and histamine, and also decreases the severity of inflammation and edema.[4] There are no standard procedures or guidelines to manage CTR-related pain and cold application methods most appropriately. In previous studies, different cold application techniques such as cold gel packs, cooling packs, gel peds, ice pack gels, and ice bags/ice cubes are applied to the area surrounding the chest tubes by covering them with sterile gauze.[1,2,4,11-13,15-17] Nevertheless, the results of the studied on cold application during CTR vary, and no consistently satisfactory approach has become established in clinical practice. In this meta-analysis, we, therefore, aimed to investigate the effect of cold application on CTR-related pain compared to conventional analgesic care.

MATERIALS AND METHODS

Literature search

After the study was planned, an application was made in the International Prospective Register of Systematic Review System (PROSPERO). The registration number is CRD42020179867 (available from: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=179867). After the PROSPERO application, we searched in the databases of PubMed, Ovid-LWW, Scopus, Taylor & Francis, Science Direct, EBSCO, Google Scholar, Medline Complete, Cochrane Library and ULAKBIM using the keywords "cold application" and "chest tube" over the internet access network of Kocaeli University and, to find grey literature, we searched in the Turkish National Thesis Center, System for Information Grey Literature in Europe (SIGLE), ProQuest Dissertations & Theses Global (PQDT Global), Ethos, Sydney Digital Thesis, Open thesis and Theses Canada Portal databases. We included the articles which were written in English or Turkish and published from January 2009 to December 2019.

The search strategy used in PubMed was: {("chest tube" [MeSH Terms] OR ("chest tubes"[All Fields] OR "chest drain*"[All Fields] OR "thoracic catheter"[All Fields] OR "pleural drainage"[All Fields] OR "tube thoracostomy"[All Fields] OR "intercostal drain*"[All Fields] OR "thorax tube"[All Fields]) AND ("cold"[MeSH Terms] OR "ice pack application"[All Fields] OR "ice application"[All Fields] OR "cold application"[All Fields] OR "cold gel pack"[All Fields] OR "ice bag application"[All Fields]) AND (non-pharmacological"[All Fields]) AND ("pain"[MeSH Terms] OR "pain"[All Fields])}. Search strategies were adapted in each database using the same terms as above. For the keywords in English, MeSH terms were used, while for the creation of the Turkish equivalents of English keywords, Science Words of Turkey (SWT) was used. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement criteria were used to carry out this research.[18]

Eligibility criteria

Inclusion criteria for this review were as follows: *(i)* participants were adult patients with a chest tube

(>16 years), *(ii)* the intervention was a cold application during CTR, *(iii)* the interventions were delivered by physicians or nurses, *(iv)* the study design was a randomized-controlled trial, *(v)* the outcomes were measured using valid and reliable instruments, and *(vi)* full text articles. We excluded case reports, letters, meeting abstracts, review articles, published articles written in other languages than Turkish or English and duplicated articles.

Selection process and data extraction

Two reviewers searched information sources independently and assessed the identified studies for inclusion independently. Records were managed through the Microsoft Excel Program. The full text of a study was reviewed, when it could not be excluded based on its title and abstract, following discussion between the reviewers. A study was included when both reviewers independently assessed it as satisfying the inclusion criteria from the full text. In case of disagreement, third reviewers examined the documents until a consensus was reached. Data were extracted by the researchers independently. Data extracted included the following summary data: method, country, participants, surgery, tools, using analgesia, number of chest tubes, duration of intervention (min), outcomes measures and results. Data were presented in tabulated form to allow for qualitative comparison.

Quality assessment

Following the recommendations of Meader et al.[19] based on the Grading of Recommendations Assessment, Development and Evaluation (GRADE) system[20] risk of bias, inconsistency (heterogeneity), imprecision (number of included studies <10 and sample size <300), and publication bias of the results of each meta-analysis were assessed. The level of meta-analysis quality was reduced by one degree for each factor that was present. Thus, a meta-analysis without any factors present would provide high-quality evidence, whereas if it presents three or more factors, the quality of the evidence would be very low.

Statistical analysis

Following the recommendations of Cooper et al.,[21] a random effects model was used for the meta-analysis to improve the generalization of the findings to any cold application to reduce pain during CTR. For differences between the experimental and the control groups, we calculated Cohen effect size (d) with 95% confidence interval (CI). We defined the effect size following Cohen´s rule-of-thumb, the small effect is between 0.2 and 0.5, the moderate effect is above 0.5, and the larger effect is above 0.8.[22]

The Q test was used for the analysis of heterogeneity, together with the degree of inconsistency *(I^2)* of Higgins et al.[23] Meta-regression was used to investigate factors potentially contributing to the between-study heterogeneity. Univariable analysis was done for each selected variable included. To assess the publication bias, we evaluated the asymmetry of the funnel plot with the Egger's test[24] and we carried out the Trim and Fill method.[25] In the Begg´s and Egger´s tests, a p value of <0.10 suggests publication bias.[19] The Trim and Fill method computes the combined effect considering a possible publication bias.[26]

Sensitivity analyses were carried out to investigate the robustness of the findings. We used the leave-one-out method: given K studies, performing k-1 meta-analyses, removing one study and analyzing the remaining k-1 studies each time.

Analyses were performed using the Comprehensive Meta-Analysis version 3.3 software (Biostat Inc., NJ, USA).

RESULTS

A total of 2,459 records were identified in databases and three records were also found by hand and inverse searches. Thus, 2,462 records were found, and after removing duplicates, 989 records were extracted. Of these records, 838 were excluded after reading the title, since they were not relevant, and a further 151 records were screened by reading the title and abstract. Finally, 24 full texts were assessed for eligibility and 16 studies were included in the meta-analysis (Figure 1).[18]

Study characteristics

The characteristics of included studies are shown in Table 1. The cold application was used in combination with a pharmacological agent in six studies, while cold application alone was used in 13 studies. All patients were older than 16 years and they had at least one chest tube. They had an operation for thoracic surgery, cardiac surgery or cardiothoracic surgery. Two scales were used to measure the outcomes; Visual Analog Scale (VAS) was highly preferred, while the Numeric Pain Rating Scale (NPRS) was less preferred.

In the studies examined, the patients in the experimental group received cold application with different techniques such as cold gel packs, cooling packs, gel peds, ice pack gels, or ice bags/ice cubes,

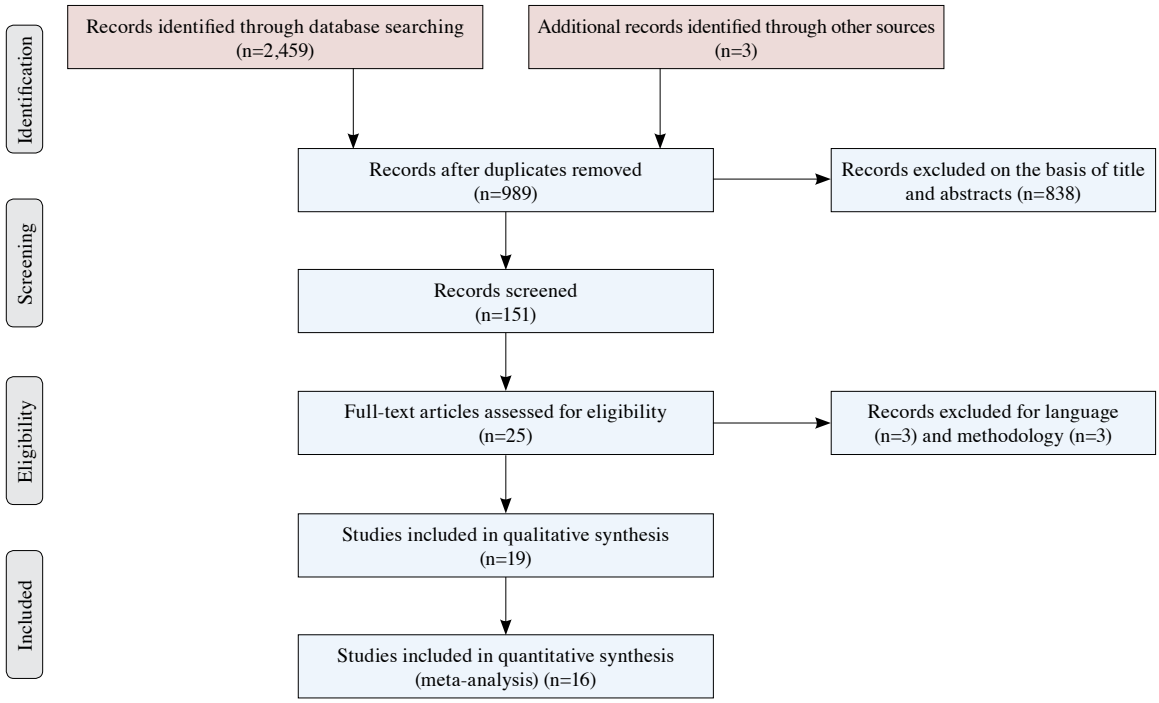

Figure 1. Flow diagram of the study selection process.

while the patients in the control group received standard clinical care. The cold application was applied to the area surrounding the chest tubes by covering them with sterile gauze in the experimental groups. When the cold/ice is applied to the skin, coldness occurs in 1 to 3 min, burning and pain occur in 2 to 7 min, and there is a decrease in numbness and pain in 5 to 10 min. The application time ranged from 9 to 20 min (9/10/15/20 min) in the included studies.[1,4,12,13,15,17,27-33] It is also recommended that the cold application cannot be continued for more than 20 to 30 min.[15] In many studies, the experimental group was exposed to the cold application for a concrete time, while in a few studies, the skin temperature of the patients was expected to decrease to 13 to 13.6°C.[2,11,16] No intervention was made on the control group patients, and only the routine procedure was conducted. The pain severity was recorded before and immediately after CTR in all studies.

Risk of bias

The risk of bias of the included RCTs was assessed according to the Cochrane Handbook version 5.0.2 by two reviewers independently and was evaluated using the following criteria: sequence generation; allocation sequence concealment; blinding of participants, incomplete outcome data; free of selective reporting; and free of other bias. Each entry was definitively judged by an answer (Yes/No/Unclear): "Yes" indicates low risk of bias, "No" indicates high risk of bias, and "Unclear" indicates unclear or unknown risk of bias.[34] The patients may express different responses to pain concerning the subjective nature of pain and their emotional, physical, and cultural status. This limitation can create some bias in the results, although such potential biases are minimized through randomization. When we examined the included studies, we determined mostly low risk of bias for random sequence generation, as the patients were randomly assigned using computer programs, random number tables, random number generators block randomization, or eight-member block randomization. Since the cold application is a non-pharmacological intervention, it is difficult to blind both participants and researchers. Of note, there are unclear risks of blinding participants or researchers. As pain is a subjective finding, researchers must accept the pain scores reported by patients. This reduces the risk of reporting bias. Regarding the absence of incomplete outcome data, as the studies are included and concluded with an equal number of patients in the experimental/control groups reduces the risk of attribution bias. We can conclude that all studies were rated as low-risk for incomplete outcome data, selective reporting, and other biases.

Table 1. Characteristics of the included studies

												Experimental group‡			Control group‡	
												Preoperative	Postoperative		Preoperative	Postoperative
Studies	Year	Allocation	Country	Age	Surgery	Scale	Analgesia	Tubes	Ice min	N	n	Mean±SD	Mean±SD	n	Mean±SD	Mean±SD
Akdoğan and Çalışkan[27]	2019	Convenience	Türkiye	16-65	Thoracic surgery	NPRS	-	1 or 2	20	60	30	3.8±2.5	2.5±2.3	30	3.0±2.8	3.2±2.3
Aktaş and Karabulut[1]	2019	Random	Türkiye	>18	Cardio-thoracic surgery	VAS	-	2	20	60	30	3.8±1.0	8.1±1.6	30	2.8±1.3	8.2±1.2
Bastani et al.[12]	2016	Random	Iran	Elderly	Cardiac surgery	VAS	-	2	20	100	50	3.0±2.1	5.9±2.2	50	3.0±2.2	9.0±1.6
Demir and Khorshid[2]	2010	Convenience	Türkiye	18-74	Cardiac surgery	VAS	Paracetamol 10 mg	1 or 2	20	60	30	3.3±2.5	6.8±2.3	30	3.3±2.4	7.1±2.2
Ertuğ and Ülker[28]	2012	Convenience	Türkiye	>18	Thoracic surgery	VAS	-	1	Until 13°	140	70	1.8±1.0	3.9±1.8	70	2.2±1.4	5.6±1.9
Gorji et al.[13]	2014	Random	Iran	>18	Cardiac surgery	VAS	Acetaminophen 1 g	2	10	80	40	0.9±0.6	2.4±0.5	40	0.9±0.6	4.6±0.7
Hasanzadeh et al.[16]	2016	Random	Iran	>18	Cardiac surgery	VAS	-	1	Until 13°	40	20	2.8±2	4.4±1.8	20	3.6±1.5	6.5±1.4
Jeevaneson and Sambasivan[30]	2017	Convenience	India	>18	Cardiac surgery	VAS	-	1-2	15	60	30	2.2±1.4	1.2±1.1	30	2.5±1.5	2.2±1.6
Mohammadi et al.,[31]	2018	Random	India	18-65	Cardiac surgery	VAS	-	1	20	90	45	2.2±1.0	3.6±1.1	45	1.9±1.2	4.7±1.1
EL Mokadem and EL-Sayed Ibraheem[17]	2017	Random	Egypt	19-65	Cardio-thoracic surgery	VAS	Acetaminophen 1 g	1 or 2	15	60	30	4.4±2.0	2±0.7	30	4.4±1.1	4±0.9
Özcan and Karagözoğlu[15]	2018	Convenience	Türkiye	18-74	Thoracic surgery	VAS	-	1 or 2	20	80	40	4.6±1.6	3.6±1.9	40	4.3±1.8	7.8±2.2
Payami et al.[2]	2014	Random	Iran	>18	Cardiac surgery	VAS	Indomethacin 100 mg	1 or 2	20	66	32	0.8±0.5	0.8±2.6	34	0.6±0.7	0.8±3.9
Shahood[29]	2019	Convenience	Hungary	>18	Cardio-thoracic surgery	VAS	-	1 or 2	9	100	50	2.4±2.8	2.3±2.2	50	2.6±2.1	7.4±2
Soydan and Ugraş[11]	2018	Random	Türkiye	>18	Thoracic surgery	NPRS	Analgesia (unspecified)	1	Until 13°	120	60	6.3±2.2	5±2.6	60	6.1±2.2	7.1±2.4
Yarahmadi et al.[32]	2018	Random	Iran	18-65	Cardiac surgery	VAS	-	1	20	90	45	2.2±1.0	3.6±1.1	45	1.9±1.2	4.7±1.1
Yılmaz and Karabacak[33]	2017	Convenience	Türkiye	>18	Cardiac surgery	NPRS	Perfalgan 1 g (optional)	2	20	40	20	1.7±2.0	1.9±1.7	20	2.2±2.9	4.4±2.4

‡ These values refer to the means of the scale used in each case; VAS or NPRS; N: Total sample in every study; n: Sample in every subgroup; SD: Standard deviation; NPRS: Numeric Pain Rating Scale; VAS: Visual Analog Scale (pain); Convenience: Non-probability sampling. On both scales the score ranges from 0 indicating no pain to 10 indicating maximum pain.

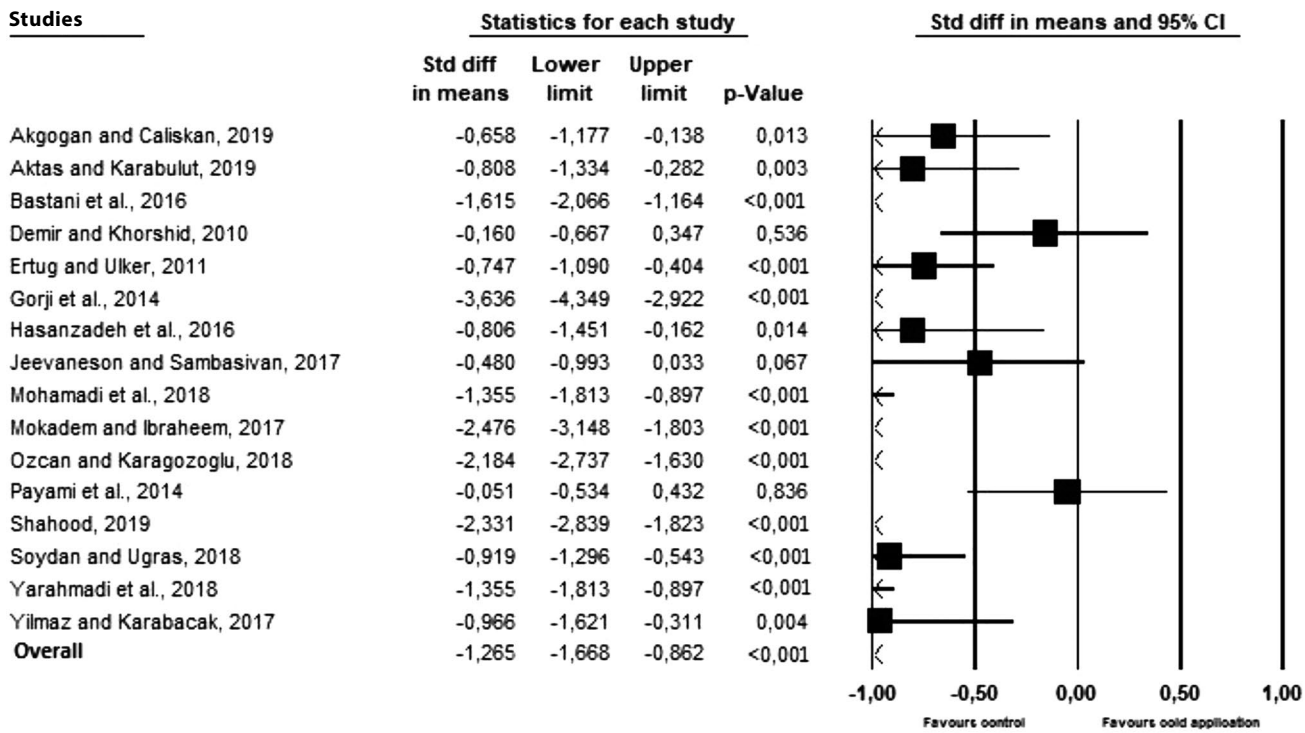

Figure 2. Meta-analysis and forest plot for the effect of cold application to reduce pain during chest tube removal.
CI: Confidence interval.

Effectiveness of the cold application during the chest tube removal

A meta-analysis was performed with 16 studies[1,2,4,11-13,15-17,27-33] and the combined effect showed a larger effect (n=1,246; d=–1.265; 95% CI: –1.67, –0.86) (Figure 2). The cold application was, therefore, effective in reducing pain during CTR (p<0.001). A substantial heterogeneity was found among the results of these individual studies (Q(15)=155.58; p<0.001; I^2=90.36%).

The funnel plot analysis (Figure 3) and the Egger´s test (p=0.11) suggested that there was no publication bias. There was no significant difference between the estimation of the pooled effect considering the possible publication bias by the Trim and Fill method. The leave-one-out method yielded variations in the combined estimate under 13.15% (range, –1.346 to –1.118).

We considered the result of the meta-analysis as highly to moderately precise due to the high number of included studies and the low risk of bias, but there was a high heterogeneity. To explore the sources of heterogeneity, a meta-regression was performed (Table 2). However, it showed that the allocation (p=0.415), the number of tubes (p=0.452), and the use of analgesia in addition to cold application (p=0.842) were not associated with heterogeneity.

DISCUSSION

Although CTR is a painful intervention, there are no standard procedures or guidelines to manage the pain associated with CTR. We attempted to determine the effects of cold application on pain during CTR.

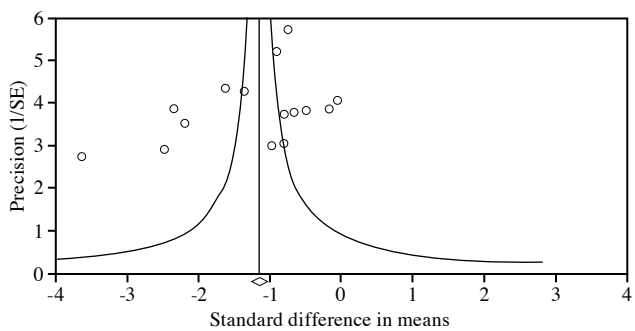

Figure 3. Funnel plot for publication bias in cold application to reduce pain during chest tube removal.

Table 2. Meta-regression analyses of potential source of heterogeneity for the effect of cold application to reduce pain during chest tube removal

					95% CI	
Heterogeneity factors	Regression coefficient	SE	Z	*p*	Lower limit	Upper limit
Allocation	-0.348	0.427	-0.82	0.415	-1.184	0.488
Tubes	-0.692	0.574	0.229	0.452	-1.817	0.434
Analgesia	-0.088	0.441	-0.20	0.842	-0.952	0.776

CI: Confidence interval; SE: Standard error.

Cold application as a non-pharmacological method is recommended prior to CTR to reduce the pain due to removal of chest tube and our study shows that cold application is effective in reducing pain due to CTR. There are significant differences and decreases in pain with the cold application during the CTR.[27,28,31] On the contrary, some studies regarding pain and CTR concluded that cold application on decreasing pain associated with CTR was no more effective than other therapies.[1,9] Hasanzadeh et al.[16] found no significant difference among the interventions (cold application, inhalation of lavender essential oil, and combination of cold and lavender essential oil inhalation). Similar to this study, the authors of other researches emphasized that there was no significant difference between the analgesic effects of cold application and relaxation.[13] A study showed that the intensity of pain during removal of chest drain tube in the elderly patients undergoing open heart surgery decreased in both intervention groups (acupressure and cryotherapy).[12] However, in the acupressure group, a significant reduction in pain was reported. Hsieh et al.[35] indicated that cold application was not more effective than sham treatment in decreasing pain during CTR. Contrary to the previous studies, there are a large number of studies emphasizing that cold application is highly effective during CTR.[10,14,28,29,36] On the other hand, cold application in combination with other therapies (cold application and music therapy) can be simultaneously effective in pain management caused by CTR; however, music therapy does not effectively reduce the pain.[32]

The methods that can be used for cold application include cold packs, ice-water baths, iced towels, ice bags, ice massage, vapor coolant sprays, and combined cooling-compression systems. Cold application is usually applied in the forms of ice pack, gel pack, or cold compress. The surface temperature of the skin is normally 34°C, but hot and cold receptors often reach temperatures between 15°C and 45 °C rapidly.[33] When these values are exceeded in cold application, some side effects such as numbness, pain, and nerve injury may occur. Therefore, cold application should be done carefully and not exceed 20 min. The ideal attitude in the cold application is to recognize that the analgesic effect begins when the skin temperature drops below 13°C.[30,37] We can see that different degrees cold application are preferred such as cooling gel packs with 4°C,[11] 0°C temperature,[12,13] 0 to 2°C,[36] keeping in the freezer for at least 2 h,[16,17,27] –5°C,[32] (–12.2°C) - (–9.40°C)[1] in included studies. Soydan and Uğraş[11] compared the effect of cold application techniques and it was found that the cold application performed using ice packs was helpful to reduce the skin temperature to a degree that is effective for pain control. Compared to the ice pack application, the analgesics were most commonly administered after the removal of chest tubes to the patients in the control group and, then, the patients who received cold application using gel pads.

The Enhanced Recovery After Surgery (ERAS) is an interdisciplinary program that accelerates patient recovery and reduces hospital length of stay, prevent complications, and reduces health expenditures. Components of the ERAS protocol include the postoperative period, early feeding and mobilization, and use of a standard multimodal analgesia. A standard multimodal analgesic strategy is required to keep the patient comfortable, allow early mobilization, and reduce the risk of pulmonary complications. In multimodal analgesia, in addition to drugs such as non-steroidal anti-inflammatory drugs (NSAIDs), paracetamol, and opioids, adjuvant analgesics such as antidepressant, anticonvulsant, anxiolytic and neuroleptic agents may also be included.[38] Multimodal approaches, such as the administration of pharmacological agents in conjunction with non-pharmacological interventions including cold therapy, have been suggested. During the postoperative period, a multimodal analgesic regimen should be employed to avoid or minimize the

use of opioids. Opioids are associated with multiple side effects that may impact a patient's ability to achieve ERAS targets such as postoperative nausea and vomiting (PONV) control, early mobilization, and quick return to oral diet. A standardized multimodal approach to pain relief, including good regional anesthesia, is recommended to reduce postoperative opioid use. Acetaminophen and NSAIDs should be administered regularly to all patients, unless contraindicated. Dexamethasone may be administered to prevent PONV and reduce pain. Ketamine should be considered for patients with preexisting chronic pain on long-term opiates. Gabapentin cannot currently be recommended as an adjunct to conventional analgesia.[39]

In some studies, the level of pain was evaluated with anesthetic, analgesic or non-pharmacological combinations. Payami et al.[4] showed that the application of cold in combination with indomethacin suppositories was more efficient than indomethacin alone in relieving pain in patients after open heart surgery ($p<0.001$). In Demir and Khorshid's[2] study, the effect of the combination of cold and intravenous paracetamol on pain of the CTR was investigated and similar results were obtained. Özcan and Karagözoğlu[15] reported that, with the cold compress and local anesthesia, pain levels decreased significantly. In other study, icepack application with hospital routine (fentanyl injection, 50 μg) was administered 10 min prior to CTR and it was found to be effective for pain.[10]

Pain is known to be a subjective experience with a dynamic interplay of the sensory, perceptual and cognitive systems. Thus, pain is a multidimensional sensation which each person experiences differently. It includes a blend of neurophysiologic, biochemical, cultural, cognitive and environmental dimensions, and there is no doubt that in the control of pain, an individual's perception of pain is affected by a variety of personal and environmental factors including age, sex, educational status, culture, personality, and previous pain experience.[2] The VAS is often used, and NPRS is rarely used to measure various subjective clinical phenomena, including pain. The primary outcome of the most of the included studies was to measure pain using a 10-cm vertical VAS with higher scores indicating greater pain intensity in all studies. The VAS score was measured before and immediately after the CTR in the groups in our meta-analysis. The VAS score was additionally measured 5 min,[28,33] 5 to 10 min,[10] 10 min,[12,35] 15 min,[2,11,13-15,31,32] and 20 min[1] after CTR.[16]

The cold application can lower the skin temperature, tie up the sensory nerve response, and speed of neural transmission producing an analgesic effect. Patients with normal weight or a body mass index of <30 kg/m^2 were selected in all studies. We believe that, in patients with obesity, this mechanism would not function properly due to excess fat in these individuals. Thus, patients with obesity were excluded from many studies.[1,2,4,13,16,31,32,35]

In some studies, cold application was compared with other techniques such as relaxation. Concerning the relaxation and cold application methods showed relatively equal effects on reducing pain due to CTR.[13] In another study applying acupressure on ST36, LI4, and P6 points are effective in reducing the intensity of pain caused by removal of drain tube from the chest of the elderly patients. Thus, it is recommended as a safe and inexpensive drug-free approach to control pain caused by the removal of the drain tube. Based on the study results, the majority of the patients (56%) in the acupressure group felt moderate pain, while nearly half of the patients (46%) in the cryotherapy group felt intense pain, and most patients (64%) in the control group felt the most intense pain imaginable. However, the level of intense pain in the acupressure group was significantly lower than that in the cold application group and the control group (18% *vs*. 46% and 32%, respectively).[12]

The application of acupressure, relaxation, cold application or aromatherapy appears to reduce the consumption of sedatives and painkillers and consequently side effects of these drugs.[12,16] Thus, the use of these methods is recommended to the practitioners owing to its ease of use, effectiveness, and cost efficacy with no side effects.

Despite the strengths of our study, it has some limitations. First, the included studies were limited to two languages; i.e., Turkish and English. Second, pain is a subjective finding and varies from an individual to another. It is not possible to fully assess the pain with self-reported scales. Patients' perceptions of pain intensity, pain quality, and anxiety can also be affected by environmental factors such as noise, light, procedures, and treatments administered to other patients hospitalized in the same intensive care unit and not controlled by the researchers. It would be necessary to take vital signs to contrast the measurement of pain with physiological parameters. Third, a large heterogeneity was found in our meta-analysis, which limits its quality, and further studies of the factors affecting pain reduction during CTR are necessary.

In conclusion, our study shows that ice cubes, ice packs, ice bags, ice pack gel application are mostly used as a cold application technique in previous studies and they are all effective. The use of a non-pharmacological methods such cold application helps to reduce the pain or reduce painkiller doses during chest tube removal. The findings of this study indicate that cold application effectively reduces the need for analgesics and the severity of pain, and is helpful to achieve a weaker feeling and perception of the pain. Taken together, its use is recommended, as it is effective, easy to use, has no side effects, comfortable, cost-effective, practical, and useful for patients.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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